Appendix C

The Representative Reaches

The Reference Reaches

The Representative Reaches

Representative reaches were delineated and studied as their morphology, hydraulics, stability and sediment supply typify conditions found in such reaches. Once basic relations were measured, predicted, quantified, and documented, the data was extrapolated to the same stream type and valley type in a similar condition as observed elsewhere. Detailed site investigations were performed on each representative reach that emulate the full range of the various stream types, valley types, and stability conditions that occurr within the Waldo Canyon Fire burn area. Basic relations used in the characterization of each representative reach were then extrapolated and used to characterize the remainder of the burn area. Approximately 117 miles (about 50%) of the streams in the watersheds affected by Waldo Canyon Fire were traversed obtaining direct observations of stream types, streambank erosion rates, and associated stability. The remaining 50% of the reaches utilized extrapolated relations due to similar boundary conditions and controlling variables. Each reach and its attendant watershed were evaluated using the WRENSS water yield model to predict pre- and post-fire water yields. The FLOWSED and POWERSED models were applied to each representative reach to obtain both pre- and post-fire sediment yields due to changes in streamflow, sediment transport capacity, and bed stability. The sediment from streambank erosion, using the BANCS model, was also determined in addition to sediment transport competency using a revised Shields relation.

The data, analysis, and results of each representative reach are summarized in this Appendix and their individual locations are mapped in **Figure C-1** and **Figure C-2**. A summary for all representative reaches of their morphology, dimension, pattern, and profile can be observed in the main report in **Table 9**. The stability summary for all representative reaches is shown in **Table 10**, while the streambank erosion data from the BANCS model and the overall stability ratings and sediment supply potential are summarized in **Table 11**. The POWERSED model was run for each representative reach (other than A stream types) to determine sediment transport capacity and associated bed stability. The stability conversion using a numerical index obtained from **Worksheet 5-29** documents the category ratings assigned for each representative reach (**Table 8**). A review of each representative reach in the aforementioned tables gives insight into the various and disproportionate sediment yields and corresponding stability summaries. The following summaries provide the detailed documentation for each reach.

The Reference Reaches

The following reference reach descriptions and summaries represent a range of stable stream types used for extrapolation to unstable reaches of the same potential stream type in the same valley type. Because these streams represent the stable morphology there is not a *departure* for these stream types as they are the stream type of choice for a given valley type. The locations of each reference reach are shown in **Figure C-1** and **Figure C-2**. For stream types that are bedrock-controlled, such as the A4/1a+ reference reach, stability ratings are not provided due to the obvious stable conditions for such stream types. Where the boundary conditions and controlling variables provide adjustment opportunities for the stream reach, stability ratings are documented using the worksheets from the *WARSSS* textbook (Rosgen, 2006/2009).

Also included with each reference reach is a photograph and description of the dimension, pattern, profile, and materials associated with the physical character of each reach. Typical surveyed cross-sections, longitudinal profiles, channel materials (pebble counts), stream classification data, hydraulics, and dimensionless relations of the reach morphology for extrapolation to other potential stable stream types are shown. Such detailed data associated with each reference reach is extrapolated by the use of scaling factors (normalization parameters for bankfull conditions) to establish dimensional relations for departure analysis and natural channel design.

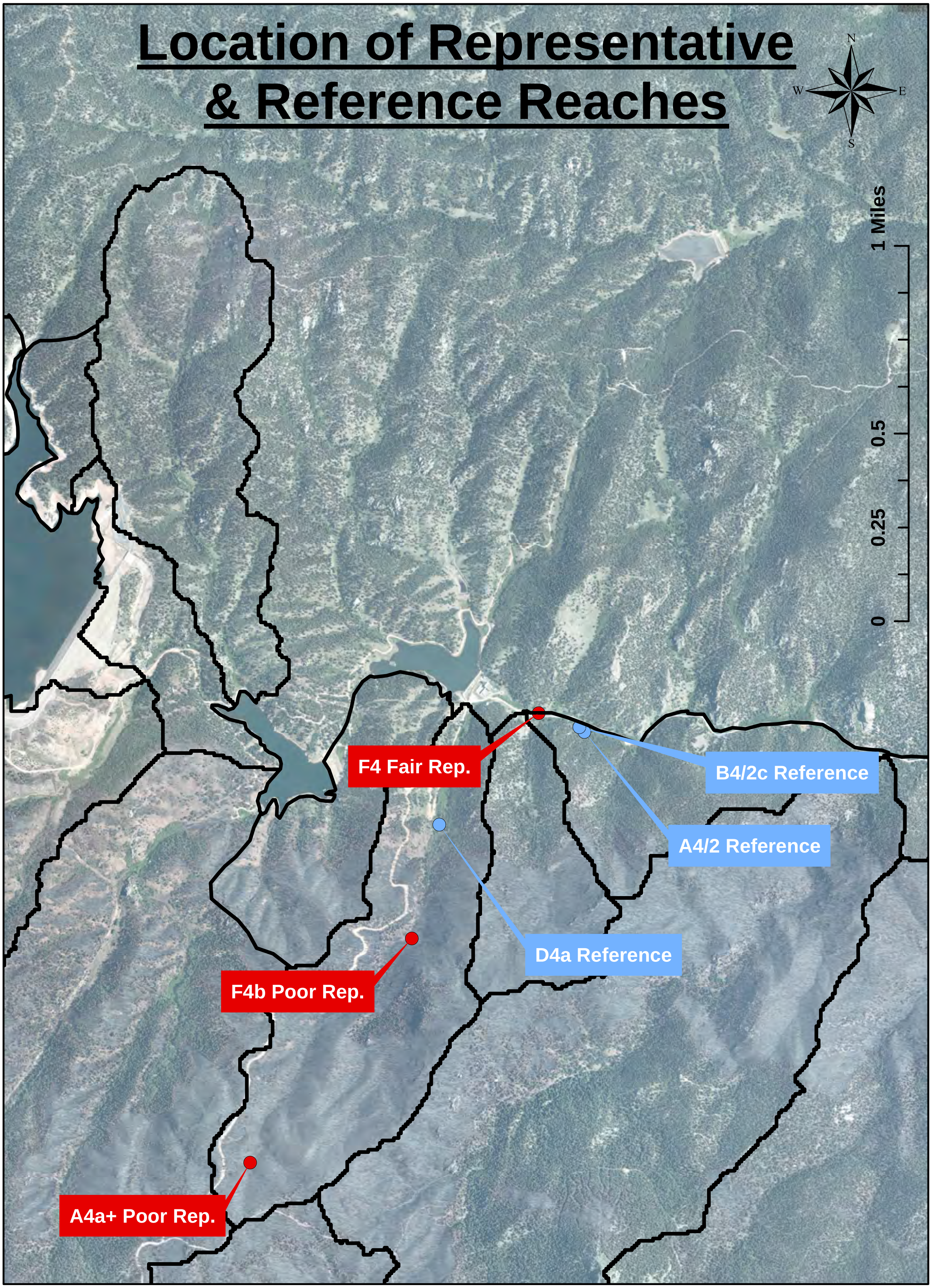


Figure C-1. Location of the Waldo Canyon Fire representative and reference reaches.

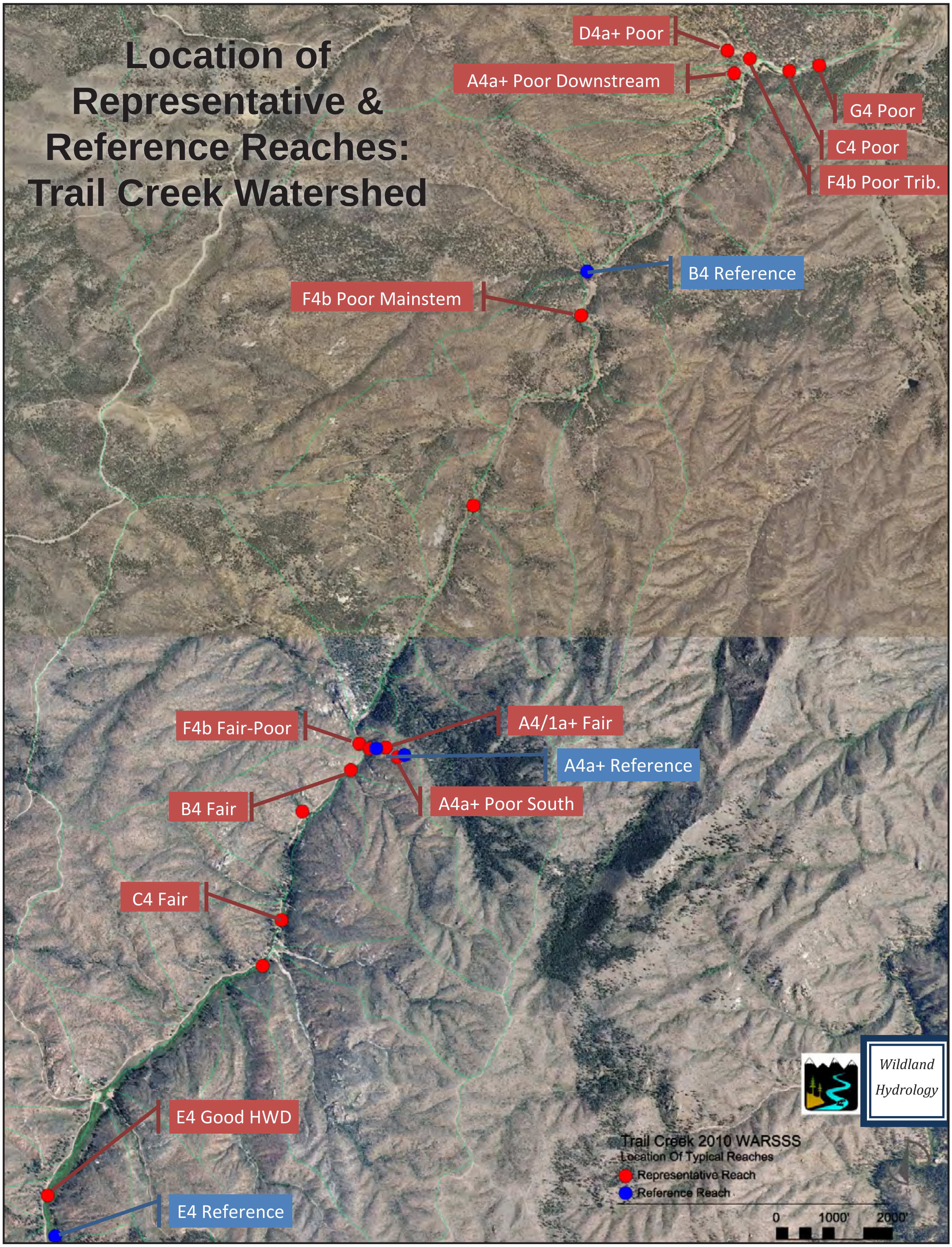


Figure C-2. Location of the reference and representative reaches within the Trail Creek Watershed.

Appendix C1

A4/1a+ Stream Type

Fair Stability Reach

Table of Contents

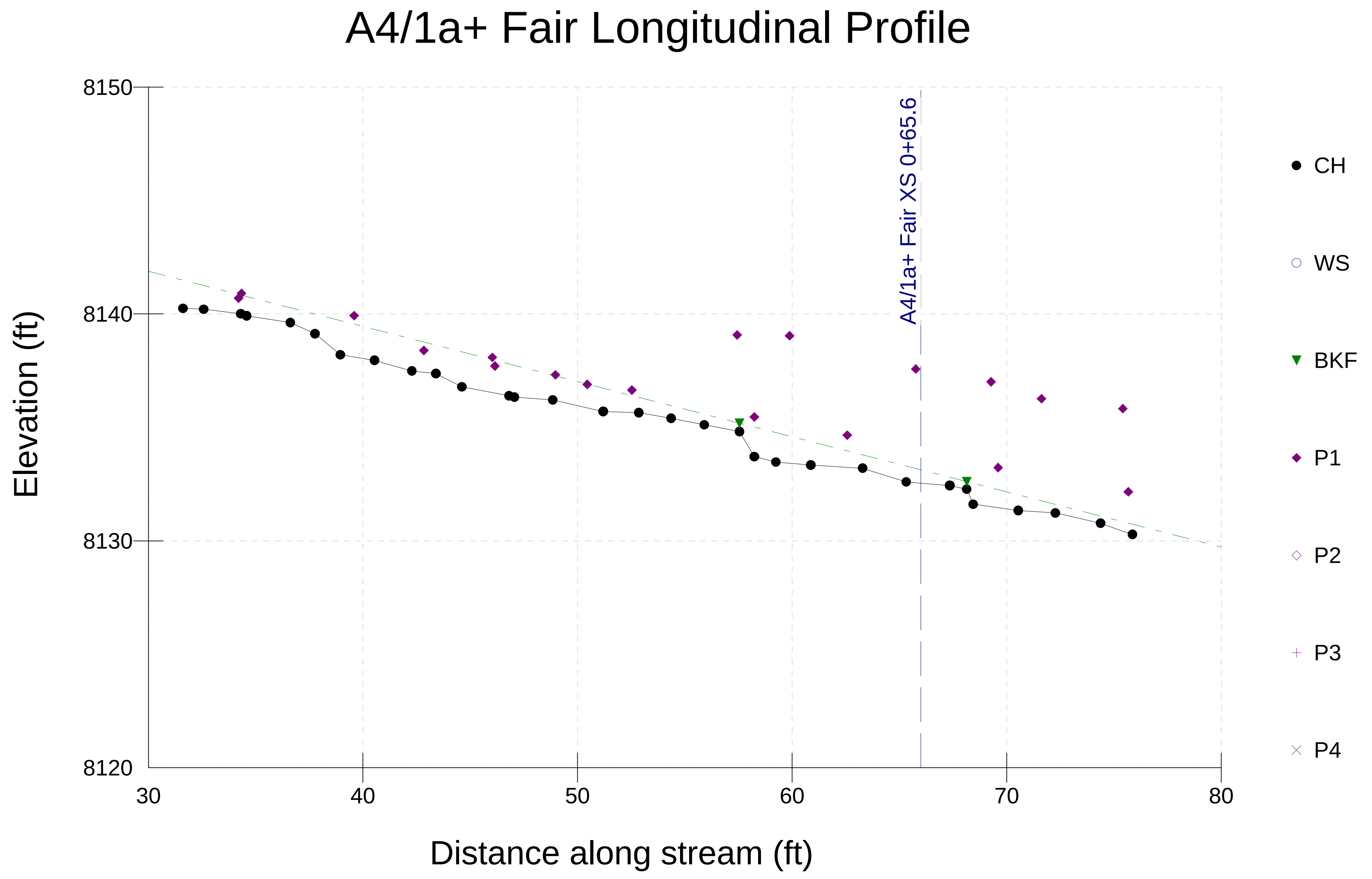
Appendix C1: A4/1a+ Fair Reach

A4/1a+ Fair Reach Location & Overview

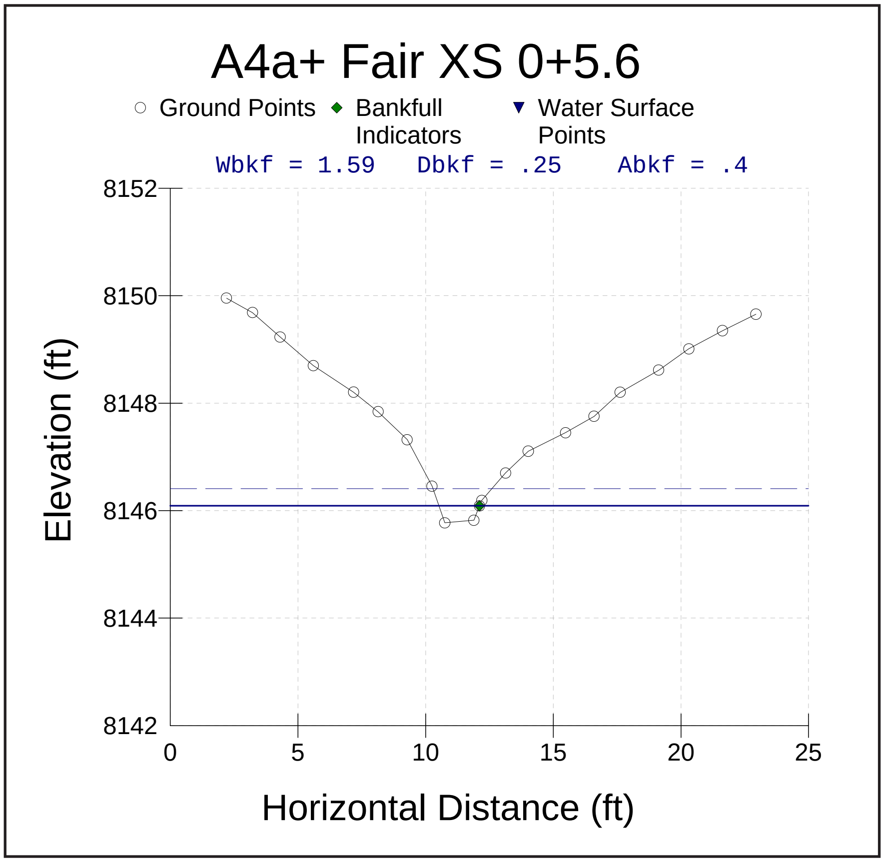
The A4/1a+ Fair reach is located within the Trail Creek Watershed (**Figure C-2**). Although this is a bedrock-controlled, entrenched, gravel-bed channel, the stability rating is "Fair," trending toward a higher sediment supply than the A4a+ reference reach. The streambank erosion rate is *0.0055 tons/yr/ft* compared to *0.0017 tons/yr/ft* for the reference condition. Although the streambank erosion rate of *0.0055 tons/yr/ft* is not as high as other impaired reaches, this rate is larger than its reference condition and the overall condition is rated "Fair." This rating indicates a potential increase in flow-related sediment based on increased post-fire streamflow peak flows. The stability indices document that the streambed is stable, typical of a bedrock-controlled channel, although the stream is moderately incised.

The photograph depicts the typical character of this ephemeral, 2nd order, representative A4/1a+ Fair stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates and stability condition.

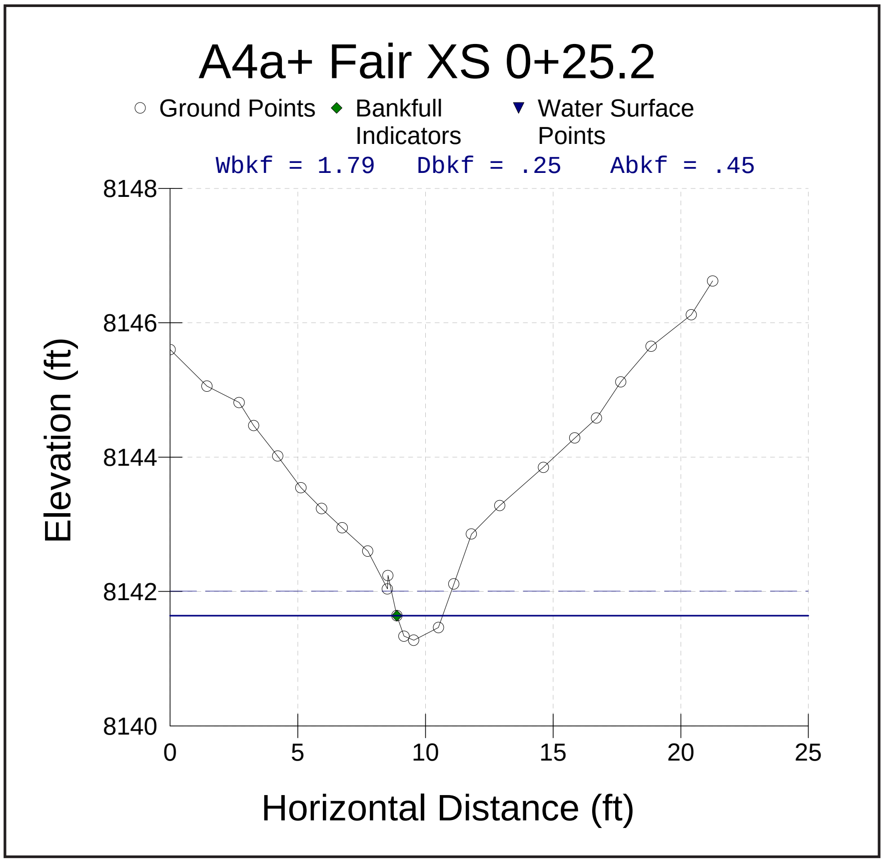
Survey Summary



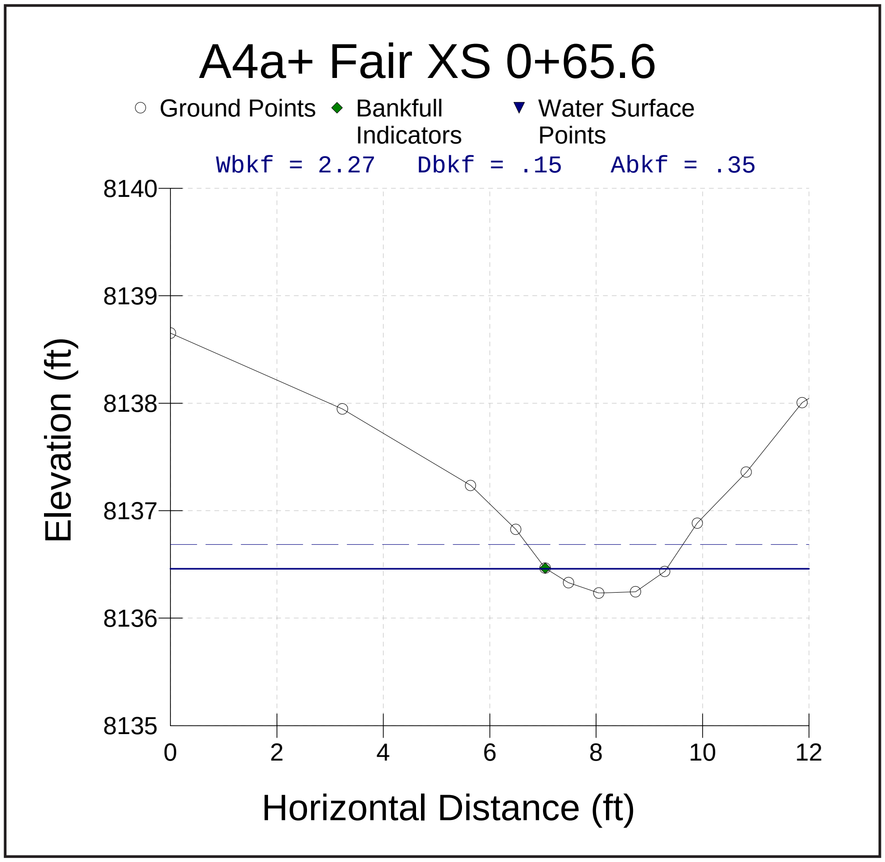
Longitudinal Profile (graph generated from RIVERMorph^{TM})



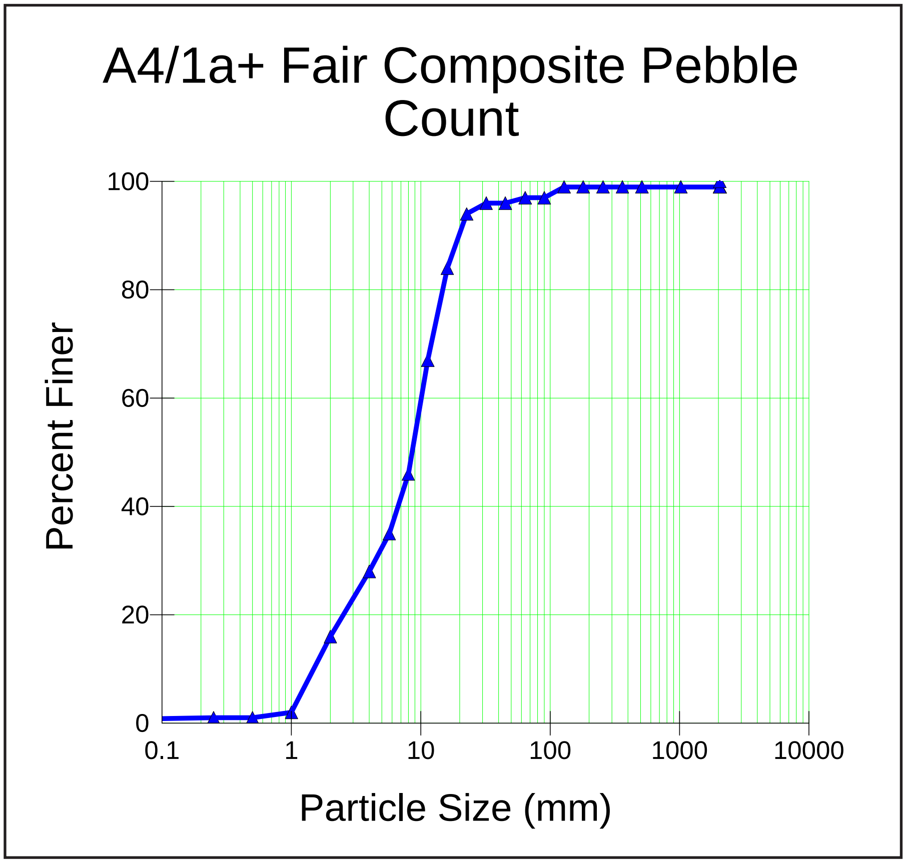
Cross-section 0+5.6 (graph generated from RIVERMorph^{TM})



Representative Cross-section 0+25.2 (graph generated from RIVERMorph^{TM})



Cross-section 0+65.6 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS **Worksheets**

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, A4/1a+ Fair Reach**			Location:	**XS 0+25.2, Pike N.F., Colorado**
Date:	**9/2/2010**	Stream Type:	**A4/1a+**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**			HUC:	_ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**0.45**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.25**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**1.79**	W_{bkf} (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**2.29**	W_p (ft)
D_{84} at Riffle	**16.0**	Dia. (mm)	D_{84} (mm) / 304.8	**0.05**	D_{84} (ft)
Bankfull SLOPE	**0.2430**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.20**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.74**	R / D_{84}
Drainage Area	**0.0049**	DA (mi^2)	Shear Velocity $u* = (gRS)^{½}$	**1.239**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log \{ R / D_{84} \}] u*$	**7.52**	ft / sec	**3.39**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.095**	**2.61**	ft / sec	**1.18**	cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **b) Manning's *n* from Stream Type** (Fig. 5-9) $n =$		ft / sec		cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **c) Manning's *n* from Jarrett (USGS):** $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.296**	**0.84**	ft / sec	**0.38**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, A4/1a+ Fair Reach**

Basin: Drainage Area: acres **0.0049** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+25.2** Date: **9/2/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**1.79**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.25**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**0.45**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**7.2**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.37**	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.	**2.34**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.31**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**8.63 mm over bedrock**	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.	**0.2430**	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 (S_{val} / S).	**1.10**	

Stream Type **A4/1a+** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010** Valley Type: **I** Stream Type: **A4/1a+**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, * **	**Mean**	**Min**	**Max**		**Riffle Dimensions & Dimensionless Ratios******	**Mean**	**Min**	**Max**
Riffle Width (W_{bkf})	**1.88**	**1.59**	**2.27**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**0.40**	**0.35**	**0.45**
Mean Riffle Depth (d_{bkf})	**0.22**	**0.15**	**0.25**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**9.55**	**6.36**	**15.13**
Maximum Riffle Depth (d_{max})	**0.31**	**0.23**	**0.37**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	**1.43**	**1.28**	**1.53**
Width of Flood-Prone Area (W_{fpa})	**2.53**	**2.31**	**2.93**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.35**	**1.29**	**1.45**
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, * **	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios******	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010** Valley Type: **I** Stream Type: **A4/1a+**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**0.84**	ft/sec	Estimation Method	**Manning's n from Jarrett**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**0.38**	cfs	Drainage Area	**0.0049**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**2.8**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.50**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.2673**	ft/ft	Average Water Surface Slope (S)	**0.2430**	ft/ft	Sinuosity (S_{val} / S)	**1.10**
Stream Length (SL)		ft	Valley Length (VL)		ft	Sinuosity (SL / VL)	

Low Bank Height (LBH)	start	**1.30**	ft	Max Bankfull Depth (d_{max})	start	**0.84**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.5**
	end		ft		end		ft		end	

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

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

Channel Materials

	Reach[b]	Riffle[c]	Bar
% Silt/Clay	**0**		
% Sand	**16**		
% Gravel	**81**		
% Cobble	**2**		
% Boulder	**0**		
% Bedrock	**1**		

	Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
D_{16}	**2**				mm
D_{35}	**6**				mm
D_{50}	**9**				mm
D_{84}	**16**				mm
D_{95}	**27**				mm
D_{100}	**Bedrock**				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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, A4/1a+ Fair Reach**

Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **9/2/2010**

Existing species composition: **Aspen, Rose, Chokecherry, Ribes, Sedge, Grasses,Raspberries, Mullen**

Potential species composition: **More Mature Aspen, Chokecherry, Raspberry, Rose, Ponderosa Pine**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	1%	1%	Aspen	100%
					100%
2. Understory	Shrub layer	▨	39%	Rose	20%
				Chokecherry	10%
				Raspberry	70%
					100%
3. Ground level	Herbaceous	▨	39%	Forbs	
				Bunchgrass	
				Toadflax	
				Thistle	
					100%
	Leaf or needle litter	▨	1%		
	Bare ground	▨	20%		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Noxious weeds out of riparian but within potential

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

List ALL COMBINATIONS that APPLY...............☞	**E1**	**E2**	**E8**					

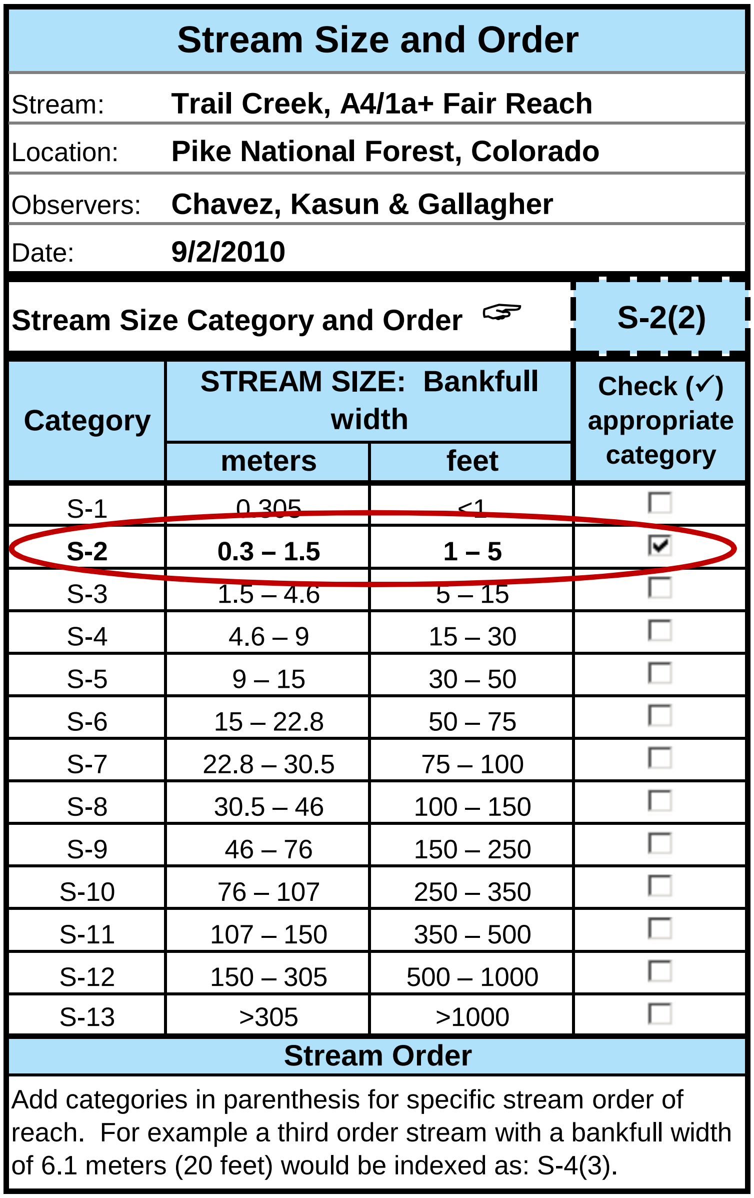
General Category

[✓ 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 5-8. Stream order & stream size.



Stream Size and Order

Stream: **Trail Creek, A4/1a+ Fair Reach**
Location: **Pike National Forest, Colorado**
Observers: **Chavez, Kasun & Gallagher**
Date: **9/2/2010**

Stream Size Category and Order ☞ **S-2(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 5-9. Meander patterns.

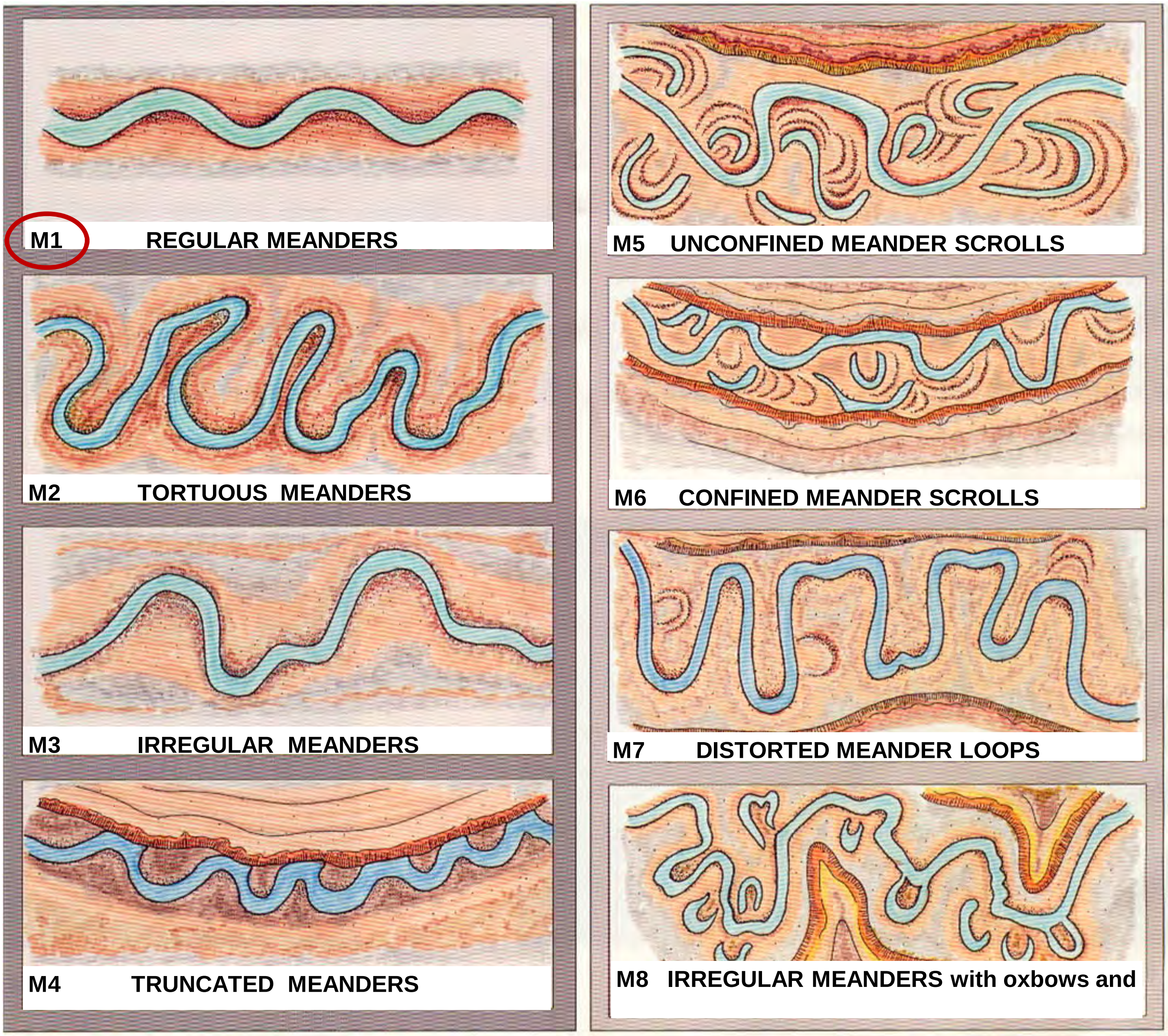
Meander Patterns

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, CO**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

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 5-10. Depositional patterns.

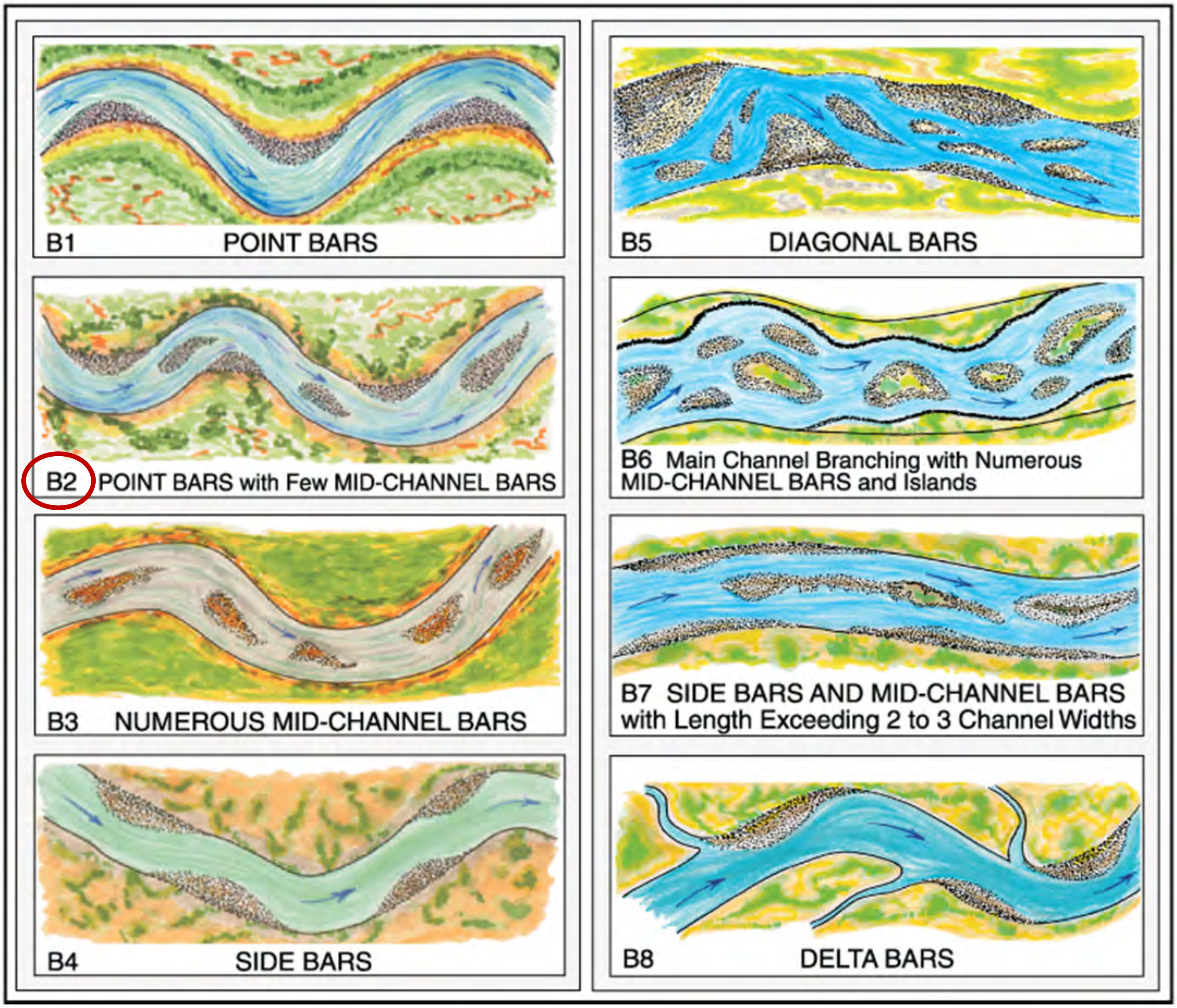
Depositional Patterns

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

List ALL CATEGORIES that APPLY ☞	**B2**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

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.	☐

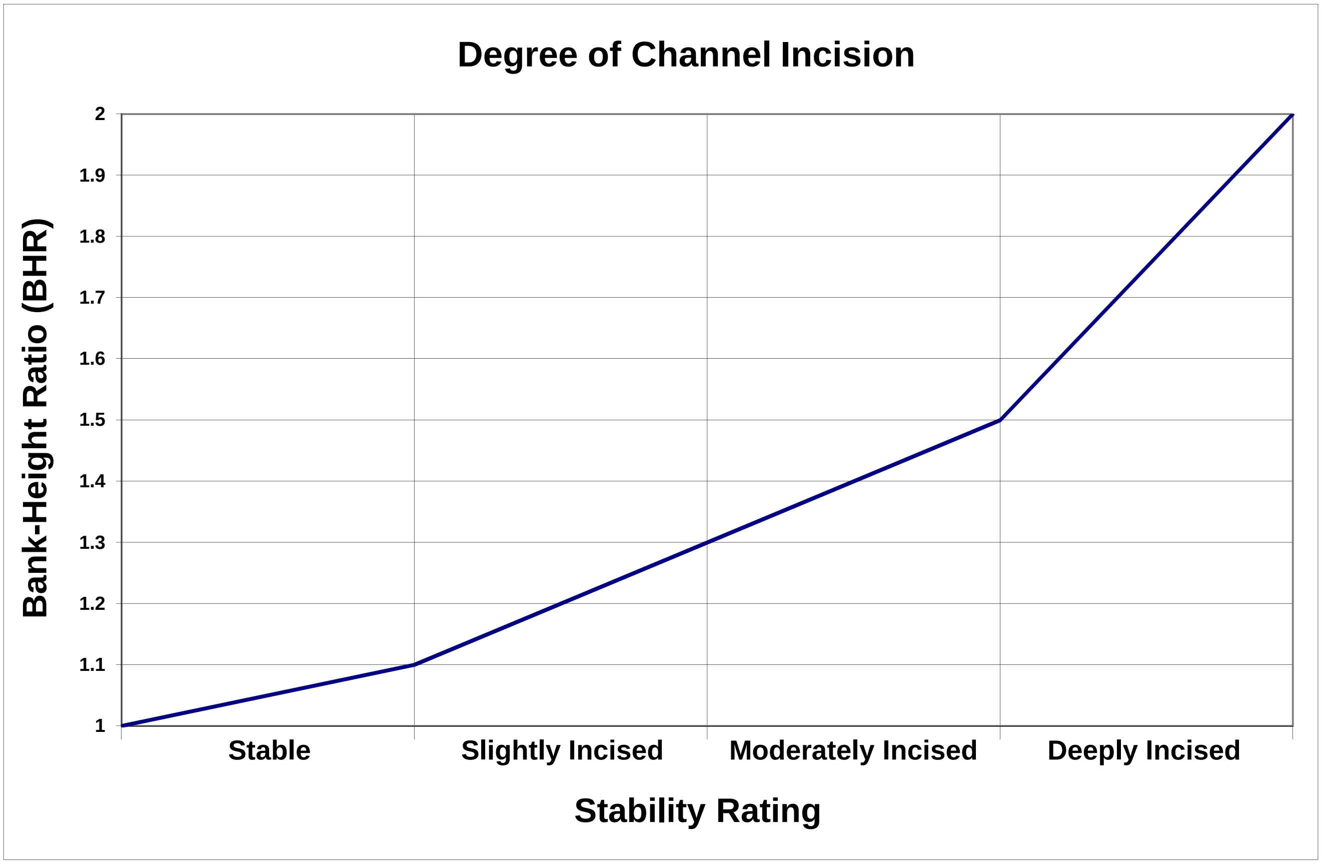
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height: **1.3**
Max Bankfull Depth: **0.84**

Bank-Height Ratio: **1.5**

Degree of Channel Incision Stability Rating ☞ **Mod. to Deeply Incised**



Worksheet 5-13. Width/depth ratio state.

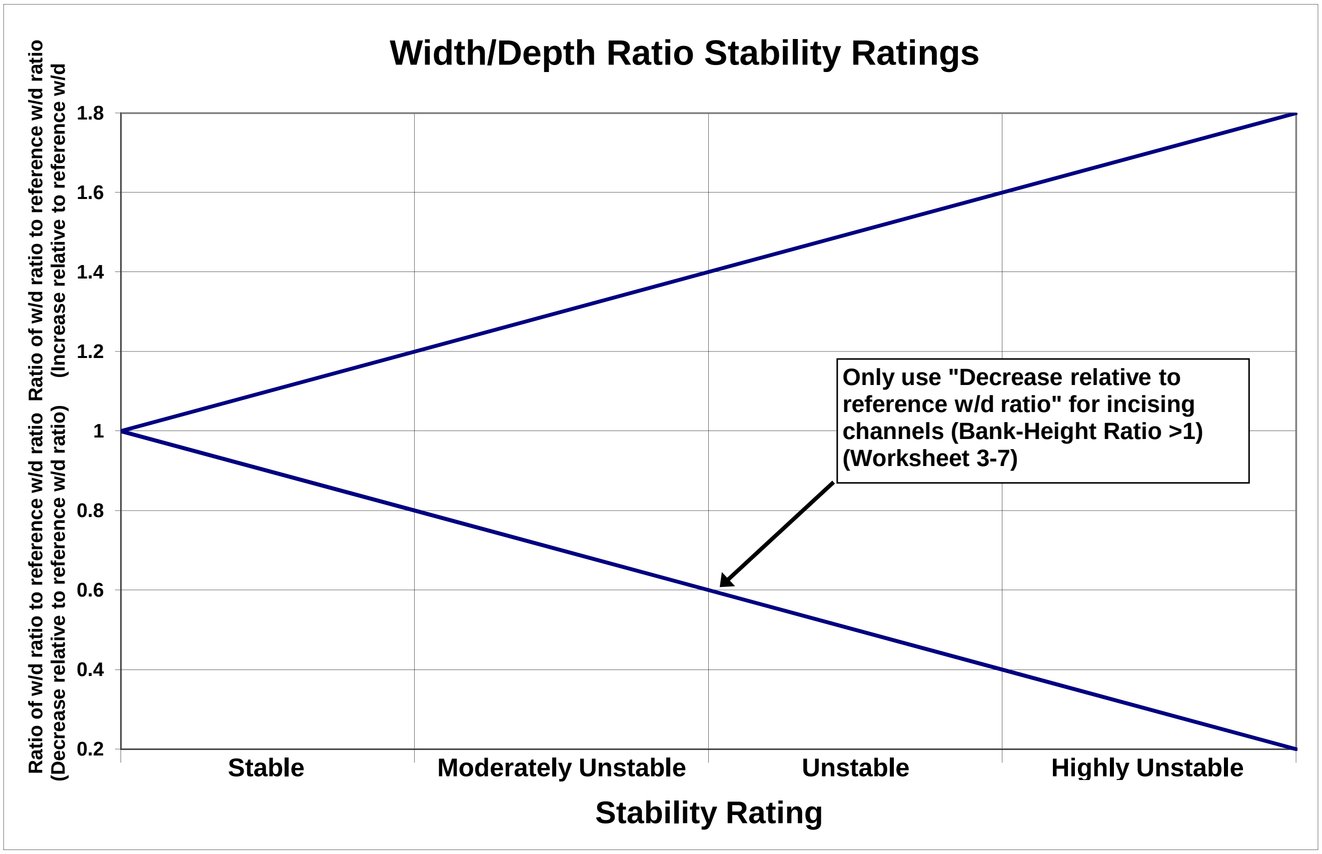
Width/Depth Ratio State

Existing Width/Depth Ratio: **7.2**

Reference Width/Depth Ratio: **10.95**

Ratio of existing W/d to reference W/d: **0.66**

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



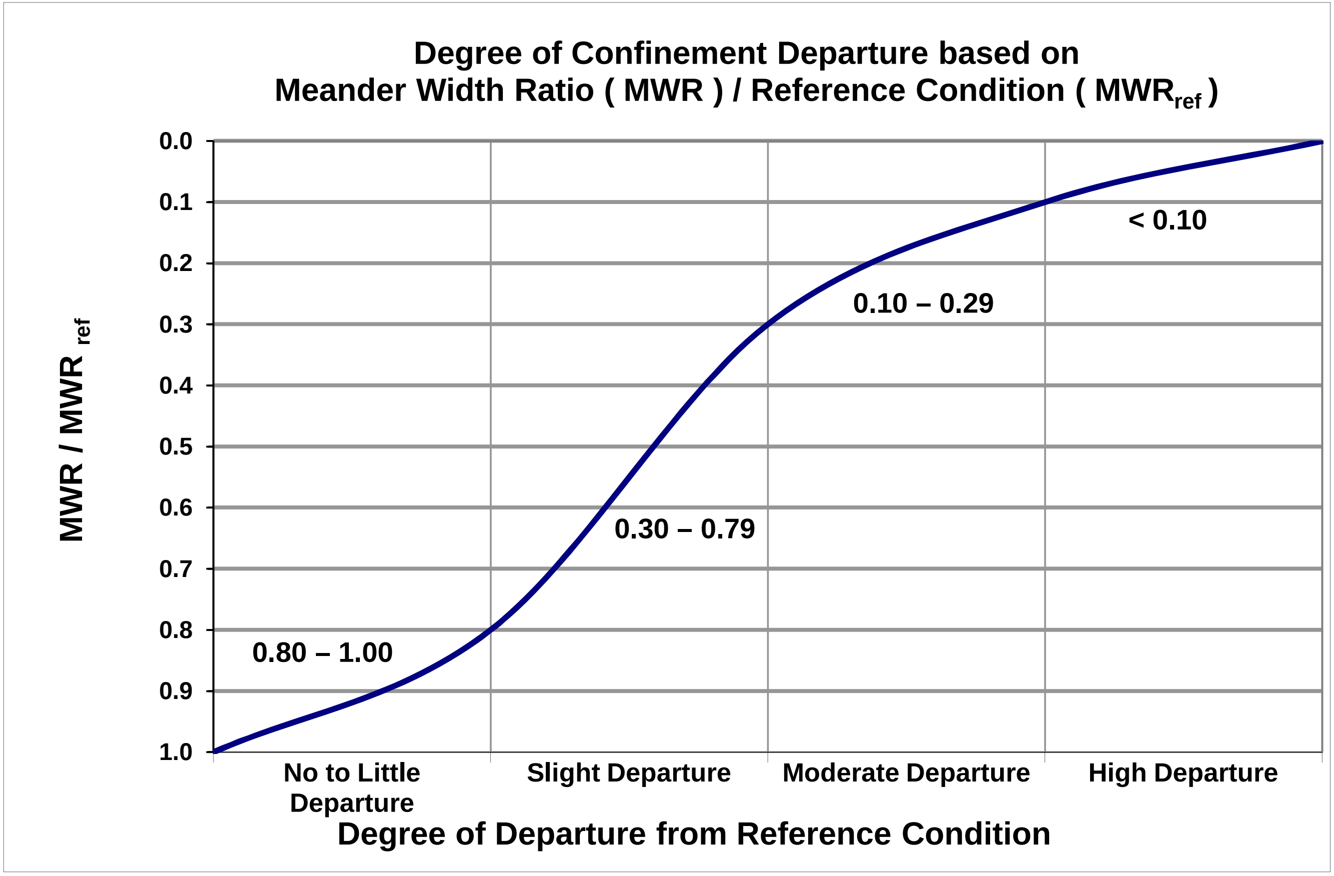
Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**1.5**
Reference Meander Width Ratio (MWR_{ref}):	**1.52**

Ratio of MWR to MWR_{ref}: **0.99**

Degree of Confinement Stability Rating ☞ **No Departure**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, A4/1a+ Fair Reach **Location:** Pike National Forest **Valley Type:** I **Observers:** Chavez, Kasun & Gallagher **Date:** 9/2/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	[✓ 4]	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	[✓ 7]	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 4]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	[✓ 9]	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	[✓ 4]
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 7]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 3]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	[✓ 5]	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	[✓ 6]	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	[✓ 6]	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ 14]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	[✓ 18]	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	0	Good total =	31	Fair total =	33	Poor total =	33

Stream type	A1	A2	A3	[✓ A4]	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	97
Existing stream type =	A4/1a+
*Potential stream type =	A4/1a+
Modified channel stability rating =	Fair

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, A4/1a+ Fair Reach** Location: **Pike National Forest, Colorado**

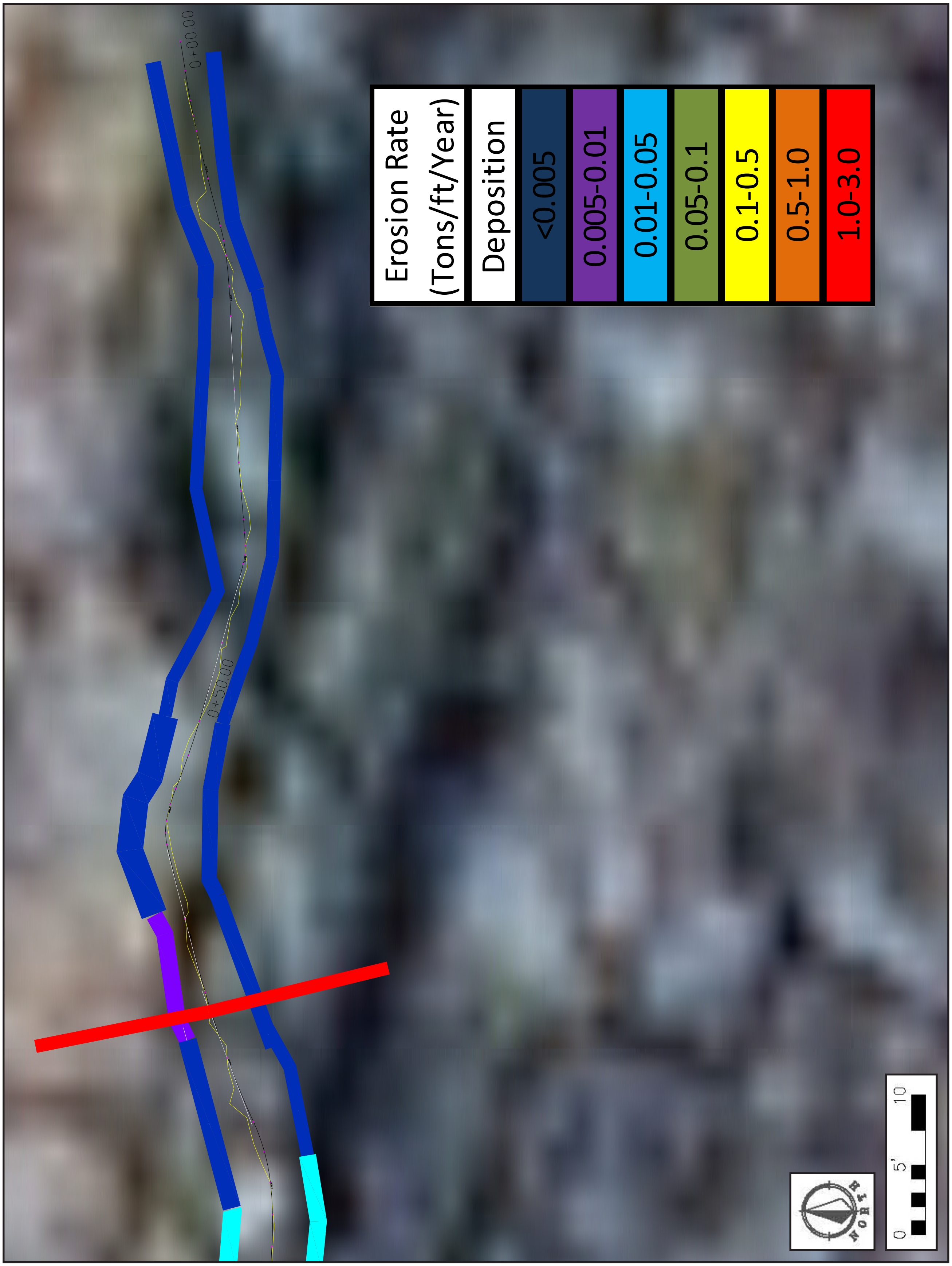
Graph Used: **Colorado** Total Stream Length (ft): **77** Date: **9/2/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I** Stream Type: **A4/1a+**

(1) Station (ft)	(2) BEHI rating (Worksheet 5-16) (adjective)	(3) NBS rating (Worksheet 5-17) (adjective)	(4) Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. **0+00 to 0+12 Left**	**Low**	**Low**	**0.03566**	**12.0**	**1.2**	**0.51**	**0.00206**
2. **0+00 to 0+27 Right**	**Low**	**Low**	**0.03566**	**27.0**	**1.2**	**1.16**	**0.00206**
3. **0+12 to 0+27 Left**	**Moderate**	**Low**	**0.15287**	**15.0**	**1.2**	**2.75**	**0.00883**
4. **0+27 to 0+57 Right**	**Low**	**Low**	**0.03566**	**30.0**	**0.8**	**0.86**	**0.00137**
5. **0+27 to 0+57 Left**	**Low**	**Low**	**0.03566**	**30.0**	**0.8**	**0.86**	**0.00137**
6. **0+57 to 0+ 67 Right**	**Low**	**Low**	**0.03566**	**10.0**	**2.0**	**0.71**	**0.00343**
7. **0+57 to 0+77 Left**	**Low**	**Low**	**0.03566**	**20.0**	**1.3**	**0.93**	**0.00223**
8 **0+67 to 0+71 Right**	**Moderate**	**Low**	**0.15287**	**4.0**	**1.3**	**0.79**	**0.00957**
9 **0+71 to 0+77 Right**	**Low**	**Low**	**0.03566**	**6.0**	**1.3**	**0.28**	**0.00223**
10							
11							
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	**Total Erosion (ft^3/yr)**	**8.85**
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	**Total Erosion (yds^3/yr)**	**0.33**
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	**Total Erosion (tons/yr)**	**0.43**
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	**Total Erosion (tons/yr/ft)**	**0.0055**

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	0.38	0.001764	0.0304
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	1.0													
0.10%	0.8	0.05%	0.09%	0.34	0.9	2.363	7.461	0.00	6.670	1.12	0.3	0.00	0.38	0.38
0.25%	0.7	0.08%	0.15%	0.55	0.8	2.036	5.232	0.00	4.809	0.81	0.4	0.00	0.44	0.44
0.50%	0.6	0.13%	0.25%	0.91	0.7	1.761	3.706	0.00	3.494	0.59	0.6	0.00	0.54	0.54
0.75%	0.5	0.13%	0.25%	0.91	0.6	1.513	2.592	0.00	2.502	0.42	0.5	0.00	0.38	0.38
1%	0.5	0.13%	0.25%	0.91	0.5	1.300	1.817	0.00	1.790	0.30	0.5	0.00	0.27	0.27
1.5%	0.4	0.25%	0.50%	1.83	0.4	1.120	1.289	0.00	1.289	0.22	0.8	0.00	0.40	0.40
2%	0.3	0.25%	0.50%	1.83	0.4	0.949	0.886	0.00	0.893	0.15	0.7	0.00	0.27	0.27
3%	0.3	0.50%	1.00%	3.65	0.3	0.795	0.600	0.00	0.602	0.10	1.1	0.00	0.37	0.37
4%	0.2	0.50%	1.00%	3.65	0.3	0.674	0.424	0.00	0.415	0.07	0.9	0.00	0.25	0.25
5%	0.2	0.50%	1.00%	3.65	0.2	0.587	0.322	0.00	0.304	0.05	0.8	0.00	0.19	0.19
10%	0.1	2.50%	5.00%	18.25	0.2	0.450	0.200	0.00	0.165	0.03	3.1	0.00	0.51	0.51
20%	0.1	5.00%	10.00%	36.50	0.1	0.269	0.103	0.00	0.045	0.01	3.7	0.00	0.28	0.28
30%	0.0	5.00%	10.00%	36.50	0.1	0.158	0.075	0.00	0.006	0.00	2.2	0.00	0.04	0.04
40%	0.0	5.00%	10.00%	36.50	0.0	0.108	0.068	0.00	0.000	0.00	1.5	0.00	0.00	0.00
50%	0.0	5.00%	10.00%	36.50	0.0	0.079	0.066	0.00	0.000	0.00	1.1	0.00	0.00	0.00
60%	0.0	5.00%	10.00%	36.50	0.0	0.061	0.065	0.00	0.000	0.00	0.8	0.00	0.00	0.00
70%	0.0	5.00%	10.00%	36.50	0.0	0.047	0.064	0.00	0.000	0.00	0.7	0.00	0.00	0.00
80%	0.0	5.00%	10.00%	36.50	0.0	0.039	0.064	0.00	0.000	0.00	0.5	0.00	0.00	0.00
90%	0.0	5.00%	10.00%	36.50	0.0	0.032	0.064	0.00	0.000	0.00	0.4	0.00	0.00	0.00
100%	0.0	5.00%	10.00%	36.50	0.0	0.016	0.064	0.00	0.000	0.00	0.2	0.00	0.00	0.00
									Annual Totals:		20.9 (cfs) 41.5 (acre-ft)	0.001 (tons/yr)	4.32 (tons/yr)	4.33 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	y = -0.0113+1.0139$x^{2.1929}$	0.38	0.001775	31.00
2. Suspended Sediment	"Good/Fair" Pagosa	y = 0.0636+0.9326$x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	1.0													
0.10%	0.8	0.05%	0.09%	0.34	0.9	2.410	7.819	0.60	6.964	1.18	0.3	0.21	0.40	0.61
0.25%	0.7	0.08%	0.15%	0.55	0.8	2.083	5.522	0.37	5.055	0.85	0.4	0.20	0.47	0.67
0.50%	0.6	0.13%	0.25%	0.91	0.7	1.807	3.943	0.23	3.701	0.63	0.6	0.21	0.57	0.78
0.75%	0.5	0.13%	0.25%	0.91	0.6	1.560	2.784	0.14	2.676	0.45	0.5	0.13	0.41	0.54
1%	0.5	0.13%	0.25%	0.91	0.5	1.346	1.973	0.08	1.935	0.33	0.5	0.08	0.30	0.38
1.5%	0.4	0.25%	0.50%	1.83	0.4	1.167	1.415	0.05	1.410	0.24	0.8	0.10	0.44	0.53
2%	0.3	0.25%	0.50%	1.83	0.4	0.995	0.984	0.03	0.991	0.17	0.7	0.06	0.31	0.36
3%	0.3	0.50%	1.00%	3.65	0.3	0.840	0.677	0.02	0.681	0.12	1.2	0.07	0.42	0.49
4%	0.3	0.50%	1.00%	3.65	0.3	0.717	0.483	0.01	0.478	0.08	1.0	0.04	0.30	0.34
5%	0.2	0.50%	1.00%	3.65	0.2	0.626	0.366	0.01	0.352	0.06	0.9	0.03	0.22	0.24
10%	0.1	2.50%	5.00%	18.25	0.2	0.480	0.223	0.00	0.191	0.03	3.3	0.06	0.59	0.65
20%	0.1	5.00%	10.00%	36.50	0.1	0.282	0.108	0.00	0.052	0.01	3.9	0.04	0.32	0.35
30%	0.0	5.00%	10.00%	36.50	0.1	0.160	0.075	0.00	0.007	0.00	2.2	0.01	0.04	0.06
40%	0.0	5.00%	10.00%	36.50	0.0	0.108	0.068	0.00	0.000	0.00	1.5	0.01	0.00	0.01
50%	0.0	5.00%	10.00%	36.50	0.0	0.079	0.066	0.00	0.000	0.00	1.1	0.01	0.00	0.01
60%	0.0	5.00%	10.00%	36.50	0.0	0.061	0.065	0.00	0.000	0.00	0.8	0.00	0.00	0.00
70%	0.0	5.00%	10.00%	36.50	0.0	0.047	0.064	0.00	0.000	0.00	0.7	0.00	0.00	0.00
80%	0.0	5.00%	10.00%	36.50	0.0	0.039	0.064	0.00	0.000	0.00	0.5	0.00	0.00	0.00
90%	0.0	5.00%	10.00%	36.50	0.0	0.032	0.064	0.00	0.000	0.00	0.4	0.00	0.00	0.00
100%	0.0	5.00%	10.00%	36.50	0.0	0.016	0.064	0.00	0.000	0.00	0.2	0.00	0.00	0.00
									Annual Totals:		21.7 (cfs) 43.0 (acre-ft)	1.2 (tons/yr)	4.8 (tons/yr)	6.0 (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, A4/1a+ Fair Reach**	Stream Type:	**A4/1a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

Enter Required Information for Existing Condition

9.0	D_{50}	Riffle bed material D_{50} (mm)			
	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.42	D_{max}	Largest particle from **Bed Material** (ft)	**128**	**(mm)**	304.8 mm/ft
0.2430	S	Existing bankfull water surface slope (ft/ft)			
0.25	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

3.79		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 **290**	CO **400**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **2.0**	CO **0.9**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.13**	CO **0.06**	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 **0.1282**	CO **0.0577**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, A4/1a+ Fair Reach**	Stream Type: **A4/1a+**
Location: **Pike National Forest, CO**	Valley Type: **I**
Observers: **Chavez, Kasun & Gallagher**	Date: **9/2/2010**
Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, A4/1a+ Fair Reach**	Stream Type:	**A4/1a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**2**
	0.66 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Depositional Patterns (Worksheet 5-10)**	B1, **B2**	B4, B8	B3	B5, B6, B7	**2**
	B2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4		M2, M5, M6, M7, M8		**1**
	M1 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, **L/L**, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
	L/L [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	0.99 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**8**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, A4/1a+ Fair Reach**	Stream Type:	**A4/1a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

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 5-22)**	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) (Worksheet 5-20)**	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 5-13)**	< 1.2 **0.7** [✓ (2)]	1.2 – 1.4 (4)	1.4 – 1.6 (6)	>1.6 (8)	**2**
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation **at potential** [✓ (2)]	(E→C) (4)	(C→High W/d C), (B→High W/d B), (C→F) (6)	(C→D), (F→D) (8)	**2**
5 **Depositional Patterns (Worksheet 5-10)**	B1 (1)	**B2**, B4 **B2** [✓ (2)]	B3, B5 (3)	B6, B7, B8 (4)	**2**
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, **D3** **D3** [✓ (1)]	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	**1**
				Total Points	**11**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream: **Trail Creek, A4/1a+ Fair Reach** Stream Type: **A4/1a+**
Location: **Pike National Forest, Colorado** Valley Type: **I**
Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

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 5-22)**	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	**4**
	(2)	[✓ **(4)**]	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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	**4**
	(2)	[✓ **(4)**]	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**7**
	(2)	**(4)**	**(6)**	**1.5** [✓ **(7)**] **(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**4**
	(2)	**1.5 BHR, 7.2 W/d** [✓ **(4)**]	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	0.99 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**20**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☑	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, A4/1a+ Fair Reach** Stream Type: **A4/1a+**

Location: **Pike National Forest, Colorado** Valley Type: **I**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

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 5-24)**	**Stream Type at Potential**, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **at potential** [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* [✓ **(2)**]	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* [✓ **(6)**]	*Degradation* **(8)**	**6**
				Total Points	**12**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, A4/1a+ Fair Reach**	Stream Type:	**A4/1a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	[✓ 1]	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	1	3
	Slightly Incised	2	
	Mod. Incised	[✓ 3]	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	2
	Slight Increase	[✓ 2]	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	1	2
	Fair: Mod. Unstable	[✓ 2]	
	Poor: Unstable	4	
		Total Points	**9**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	*Low* 5 ☐	*Moderate* 6 – 10 ☑	*High* 11 – 15 ☐	*Very High* 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, A4/1a+ Fair Reach**					Location: **Pike National Forest, Colorado**								
Observers:	**Chavez, Kasun & Gallagher**		Date: **9/2/2010**			Stream Type: **A4/1a+**			Valley Type: **I**					
Channel Dimension (XS 0+25.2)	Mean Bankfull Depth (ft):	**0.25**	Bankfull Width (ft):	**1.79**	Cross-Sectional Area (ft^2):	**0.45**	Width of Flood-Prone Area (ft):	**2.34**	Entrenchment Ratio:	**1.31**				
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**1.5**	Sinuosity:	**1.1**			
River Profile & Bed Features	Check:	☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed								
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope					
									Valley:	**0.2673**	Water Surface:	**0.243**		
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:	Potential Composition/Density:	Remarks: Condition, Vigor & Usage of Existing Reach:										
		Aspen/Shrubs/Mullen/Grass	**Mature Aspen/P.Pine/Shrub**	**Within Potential if Noxious Weeds Eradicated**										
	Flow Regime:	**E1, E2, E8**	Stream Size & Order:	**S-2(2)**	Meander Patterns:	**M1**	Depositional Patterns:	**B2**	Debris/Channel Blockages:	**D3**				
	Degree of Incision (Bank-Height Ratio):	**1.5**	Degree of Incision Stability Rating:	**Moderate To Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**97 (Fair)**								
	Width/depth Ratio (W/d):	**7.2**	Reference W/d Ratio (W/d_{ref}):	**11**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**0.66**	W/d Ratio State Stability Rating:	**Moderately Unstable**						
	Meander Width Ratio (MWR):	**1.5**	Reference MWR_{ref}:	**1.52**	Degree of confinement (MWR / MWR_{ref}):	**0.99**	MWR / MWR_{ref} Stability Rating:	**No Departure from Reference**						
Bank Erosion Summary	Length of Reach Studied (ft):	**77**	Annual Streambank Erosion Rate: **0.43** (tons/yr)	**0.0055** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:								
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity	Remarks:										
Entrainment/ Competence	Largest Particle from **Bed Material** (mm):	**128**	$\tau =$	**3.79**	$\tau^* =$	**N/A**	Existing Depth:	**0.25**	Required Depth:	**0.13**	Existing Slope:	**0.243**	Required Slope:	**0.128**
Successional Stage Shift	**A4/1a+** ⟶ **A4/1a+** ⟶ ⟶ ⟶ ⟶	Existing Stream State (Type):	**A4/1a+**	Potential Stream State (Type):	**A4/1a+**									
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:									
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:									
Vertical Stability (Degradation)	☐ *Not Incised*	☐ *Slightly Incised*	☑ *Mod. Incised*	☐ *Degradation*	Remarks/causes:									
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:									
Sediment Supply (Channel Source)	☐ *Low*	☑ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:									

Appendix C2

A4a+ Stream Type

Poor Stability Reach

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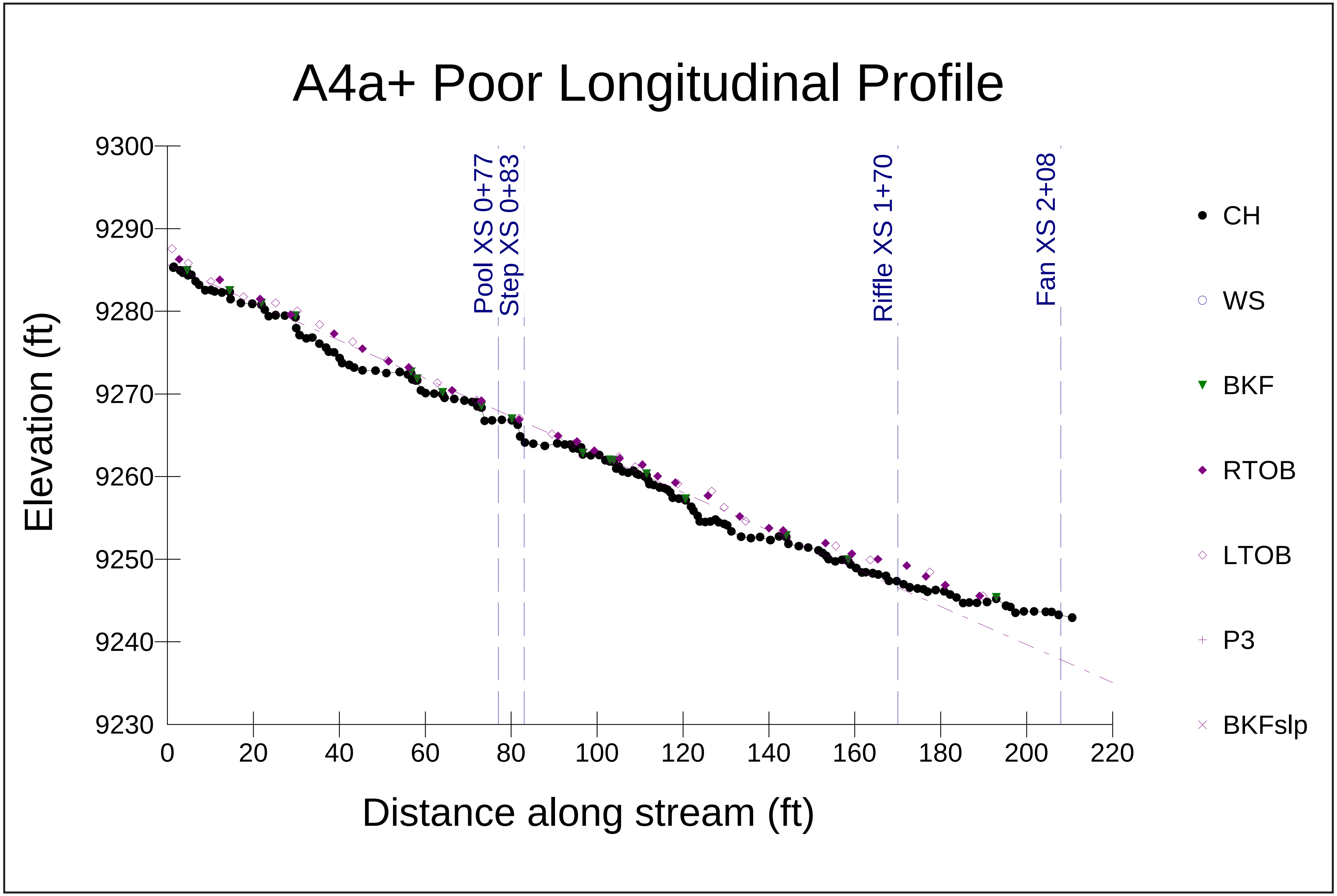
Appendix C2: A4a+ Poor Stability Reach

A4a+ Poor Reach Location & Overview

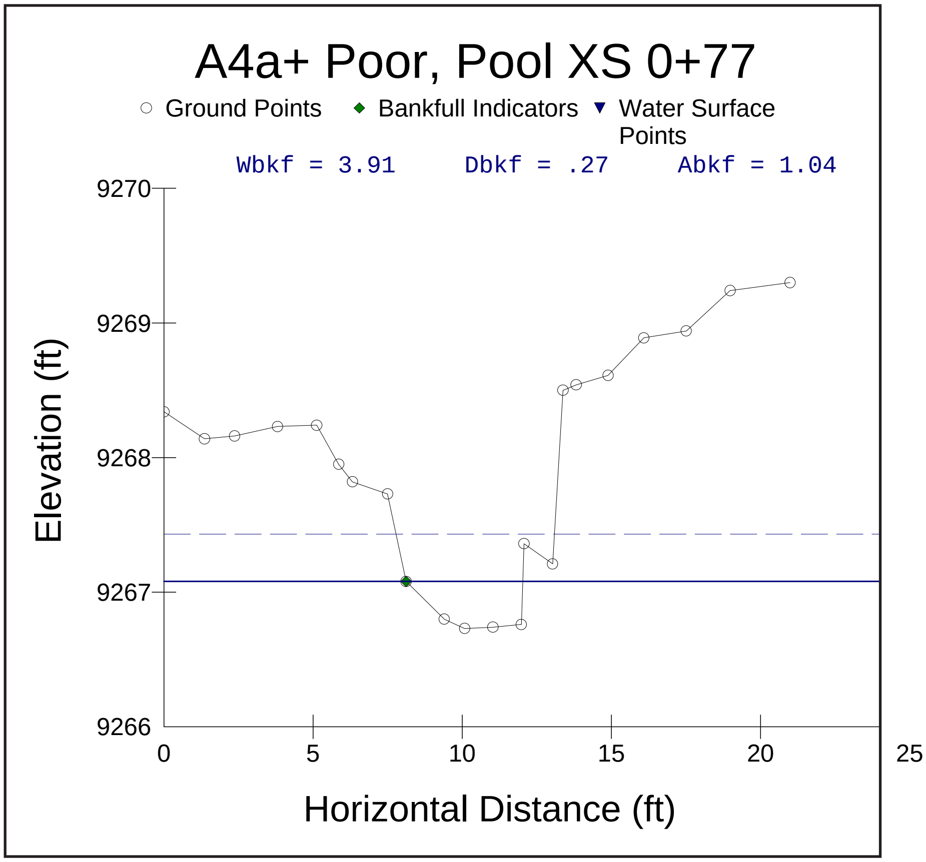
The A4a+ Poor reach is a 1st order, ephemeral stream with a high sediment supply due to poor road drainage concentrating flow into the channel. This reach is located on Northfield Gulch shown in **Figure C-1**. The photograph depicts the advancing headcut documenting both bed instability and accelerated streambank erosion. The stability rating is "Poor" due to degradation, active incision, and lateral instability. The sediment supply also rates as *High* due to the same processes, including a *Moderate Increase* in channel enlargement. The streambank erosion rate is *0.0617 tons/yr/ft*, more than one order of magnitude higher than its reference reach condition (**Worksheet 5-18**). The increase in water yield using the WRENSS model for this small, ephemeral channel of 0.22 cfs is *5.4 acre-ft*. This increase corresponds with an increase in bedload using the FLOWSED model of *0.5 tons/yr* and *8.6 tons/yr* of suspended sediment. Post-fire increase in peak flow is likely to exacerbate the "Poor" condition in this reach. With the removal of vegetation post-fire, the reach is expected to continue on a downward trend without mitigation.

The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

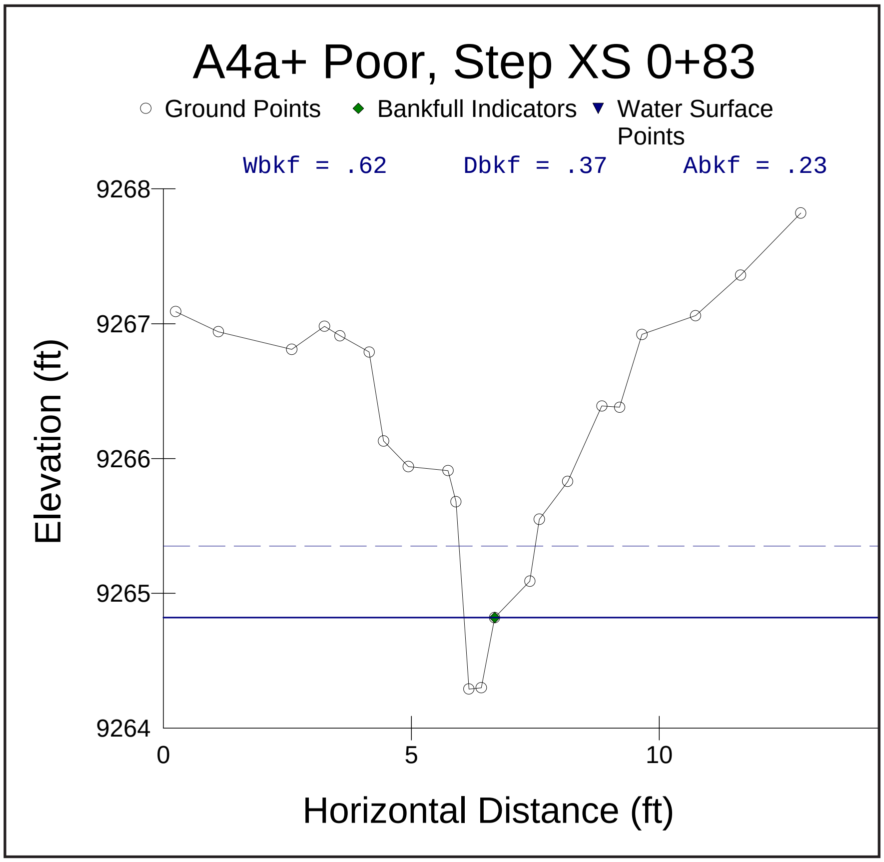
Survey Summary



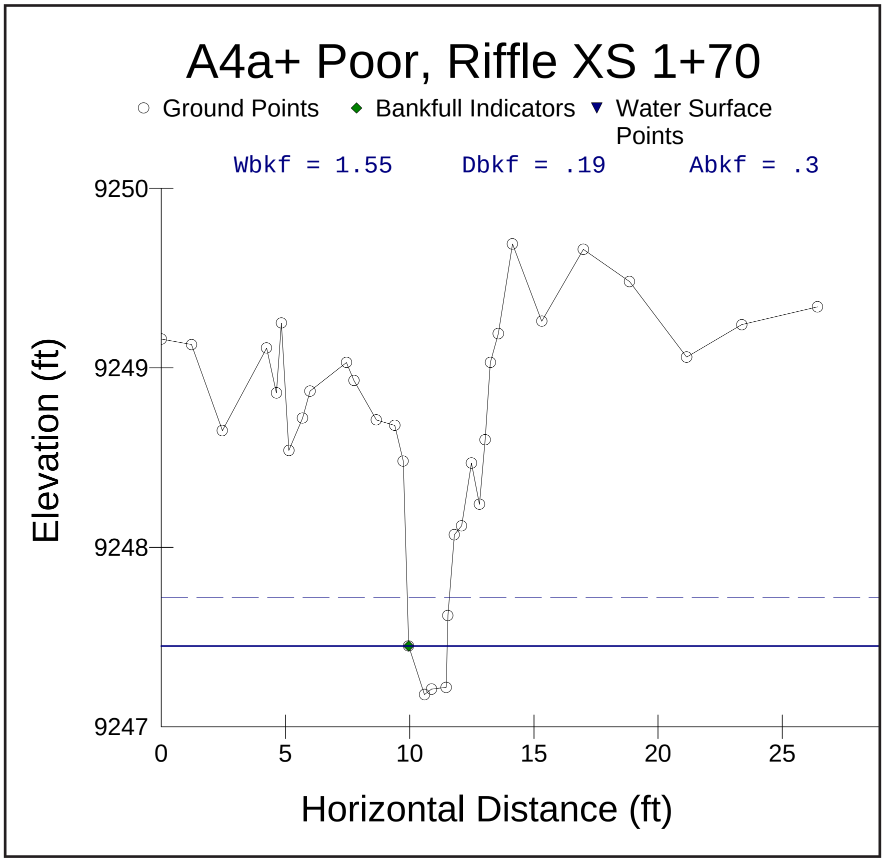
Longitudinal Profile (graph generated from RIVERMorph^{TM})



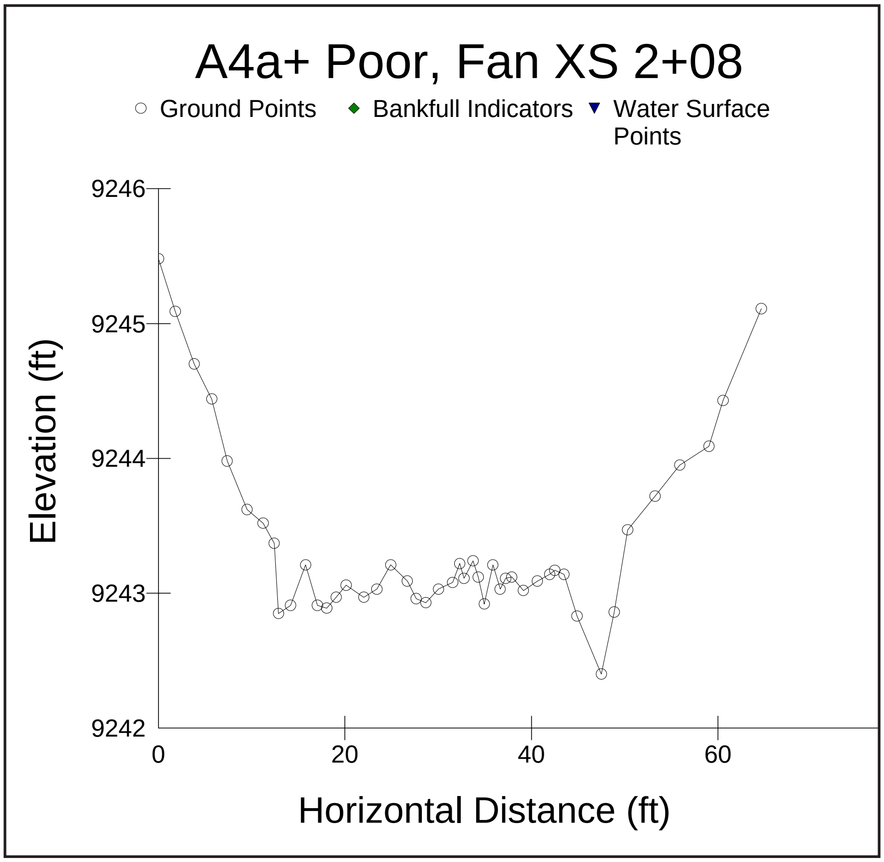
Cross-section 0+77 (graph generated from RIVERMorph^{TM})



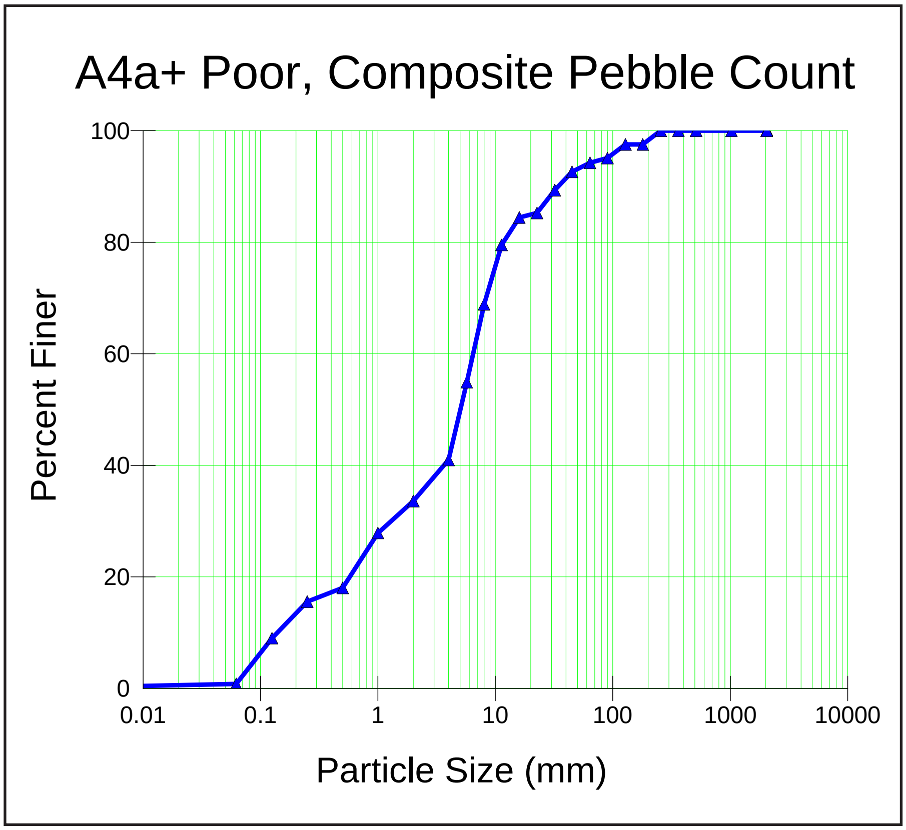
Cross-section 0+83 (graph generated from RIVERMorph^{TM})



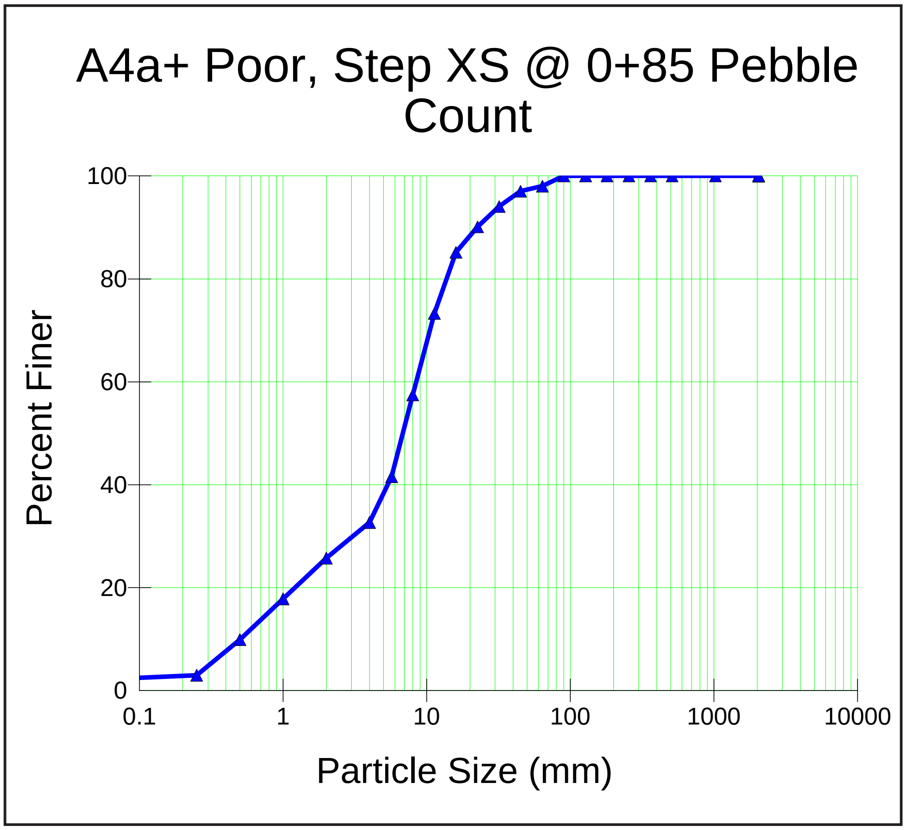
Representative Cross-section 1+70 (graph generated from RIVERMorph^{TM})



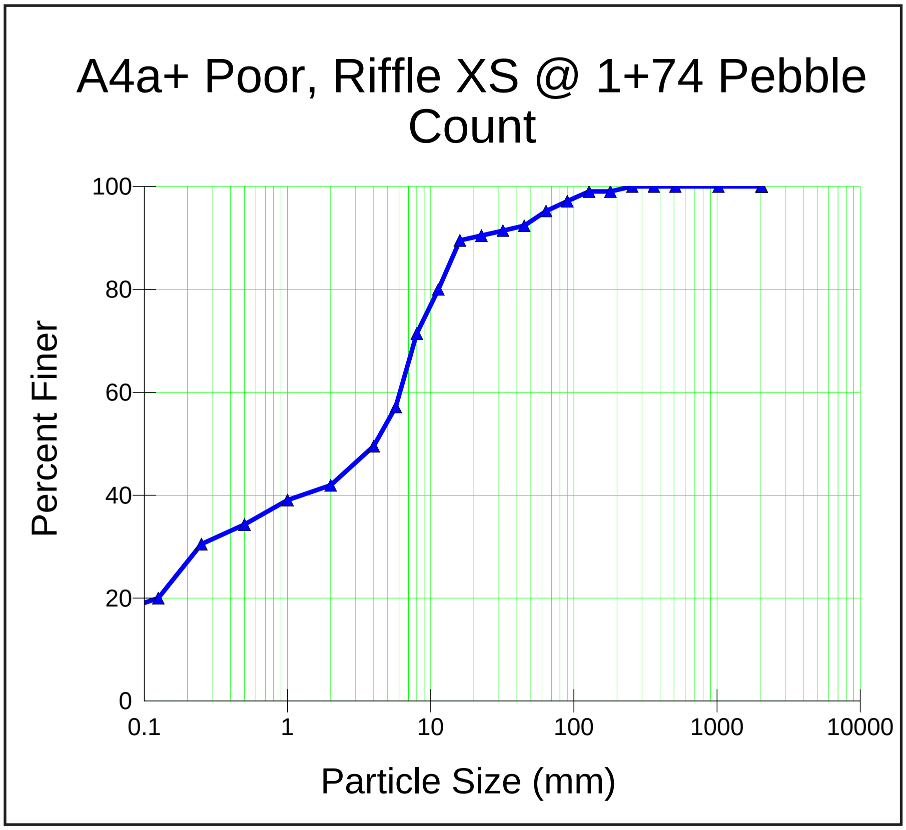
Cross-section 2+08 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph™)



Step Pebble Count (graph generated from RIVERMorph™)



Active Bed Riffle Pebble Count (graph generated from RIVERMorph™)

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Northfield Gulch**		Location:	**A4a+ Poor XS 1+70**	
Date:	**11/8/2012**	Stream Type: **A4a+**	Valley Type:	**I**	
Observers:	**Lee, Sumner, Jara, Leah**		HUC:		

INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	**0.30**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.15**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**1.6**	**W_{bkf}** (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**1.85**	**W_p** (ft)
D_{84} at Riffle	**13.3**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.04**	**D_{84}** (ft)
Bankfull SLOPE	**0.23**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.16**	**R** (ft)
Gravitational Acceleration	**32.2**	**g** (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.72**	**R / D_{84}**
Drainage Area	**0.02**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**1.095**	**u*** (ft/sec)

ESTIMATION METHODS	**Bankfull VELOCITY**		**Bankfull DISCHARGE**	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**6.81**	ft / sec	**2.04**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.2971**	**0.73**	ft / sec	**0.22**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.15**	**1.44**	ft / sec	**0.43**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.298**	**0.71**	ft / sec	**0.21**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**7.71**	ft / sec	**2.3**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ______ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **NorthfieldGulch, Reach - A4a+ Poor**

Basin: Drainage Area: **14** acres **0.02** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 1+70** Date: **11/08/2012**

Observers: **Lee, Sumner, Jara, Leah** Valley Type: **I**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**1.55**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.19**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**0.3**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**8.16**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.27**	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.	**1.7**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.1**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**5.1**	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.	**0.22974**	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 (S_{val} / S).	**1.09**	

Stream Type **A4a+** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/08/12** Valley Type: **I** Stream Type: **A4a+**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**1.6**	**1.6**	**1.6**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**0.3**	**0.3**	**0.3**
Mean Riffle Depth (d_{bkf})	**0.19**	**0.19**	**0.19**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**8.2**	**8.2**	**8.2**
Maximum Riffle Depth (d_{max})	**0.27**	**0.27**	**0.27**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.421**	**1.421**	**1.421**
Width of Flood-Prone Area (W_{fpa})				ft	Entrenchment Ratio (W_{fpa} / W_{bkf})			
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	**3.9**	**3.9**	**3.9**	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	**2.523**	**2.523**	**2.523**
Mean Pool Depth (d_{bkfp})	**0.27**	**0.27**	**0.27**	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	**1.421**	**1.421**	**1.421**
Pool Cross-Sectional Area (A_{bkfp})	**1.0**	**1.0**	**1.0**	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	**3.467**	**3.467**	**3.467**
Maximum Pool Depth (d_{maxp})	**0.35**	**0.35**	**0.35**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**1.842**	**1.842**	**1.842**
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

Step Dimensions**	Mean	Min	Max		Step Dimensionless Ratios****	Mean	Min	Max
Step Width (W_{bkfs})	**0.6**	**0.6**	**0.6**	ft	Step Width to Riffle Width (W_{bkfs} / W_{bkf})	**0.400**	**0.400**	**0.400**
Mean Step Depth (d_{bkfs})	**0.37**	**0.37**	**0.37**	ft	Mean Step Depth to Riffle Depth (d_{bkfs} / d_{bkf})	**1.947**	**1.947**	**1.947**
Step Cross-Sectional Area (A_{bkfs})	**0.2**	**0.2**	**0.2**	ft	Step Area to Riffle Area (A_{bkfs} / A_{bkf})	**0.767**	**0.767**	**0.767**
Maximum Step Depth (d_{maxs})	**0.53**	**0.53**	**0.53**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**2.789**	**2.789**	**2.789**
Step Width/Depth Ratio (W_{bkfs} / d_{bkfs})	**1.7**	**1.7**	**1.7**					

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Northfield Gulch A4a+ Poor**			Location:	**Pike National Forest, Colorado**		
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/8/2012**	Valley Type:	**I**	Stream Type:	**A4a+**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**0.73**	ft/sec	Estimation Method	**Friction Factor**
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**0.22**	cfs	Drainage Area	**0.02** mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**16.2**	**9.2**	**28.7**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**10.45**	**5.94**	**18.51**
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.2504**	ft/ft	Average Water Surface Slope (S)	**0.2297**	ft/ft	Sinuosity (S_{val} / S)	**1.09**
Stream Length (SL)	**201.1**	ft	Valley Length (VL)	**184.3**	ft	Sinuosity (SL / VL)	**1.09**

Low Bank Height (LBH)	start	**0.74** ft	Max Bankfull Depth (d_{max})	start	**0.20**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**3.7**	
	end	**1.85** ft		end	**0.20**	ft		end	**9.3**	

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

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

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0.82**	**0.00**		D_{16}	**0.29**	**0.11**			mm
% Sand	**32.79**	**41.90**		D_{35}	**2.38**	**0.57**			mm
% Gravel	**60.65**	**53.34**		D_{50}	**5.10**	**4.11**			mm
% Cobble	**5.74**	**4.76**		D_{84}	**15.59**	**13.27**			mm
% Boulder	**0.00**	**0.00**		D_{95}	**87.46**	**62.41**			mm
% Bedrock	**0.00**	**0.00**		D_{100}	**256.00**	**255.99**			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Northfield Gulch, A4a+ Poor**

Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **11/08/2012**

Existing species composition: **Burnt trees & young aspen**

Potential species composition: **Aspen, Doug-fir, Ponderosa pine, Spruce**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**0%**	**30%**	**Spruce**	**30%**
				Ponderosa Pine	**30%**
				Aspen	**40%**
					0%
					0%
					0%
					100%
2. Understory	Shrub layer	▨	**1%**	**Young Aspen**	**100%**
					0%
					0%
					0%
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	**0%**		
	Leaf or needle litter	▨	**0%**		
	Bare ground	▨	**69%**		
			Column total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Remarks:
Condition, vigor and/or usage of existing reach:
Burnt tress dominate landscape, few young aspen repopulating.

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/8/2012**

List ALL COMBINATIONS that APPLY...............☞	**E1**	**E2**	**E8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Northfield Gulch A4a+ Poor**

Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah**

Date: **11/8/2012**

Stream Size Category and Order ☞ **S-2(1)**

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 5-9. Meander patterns.

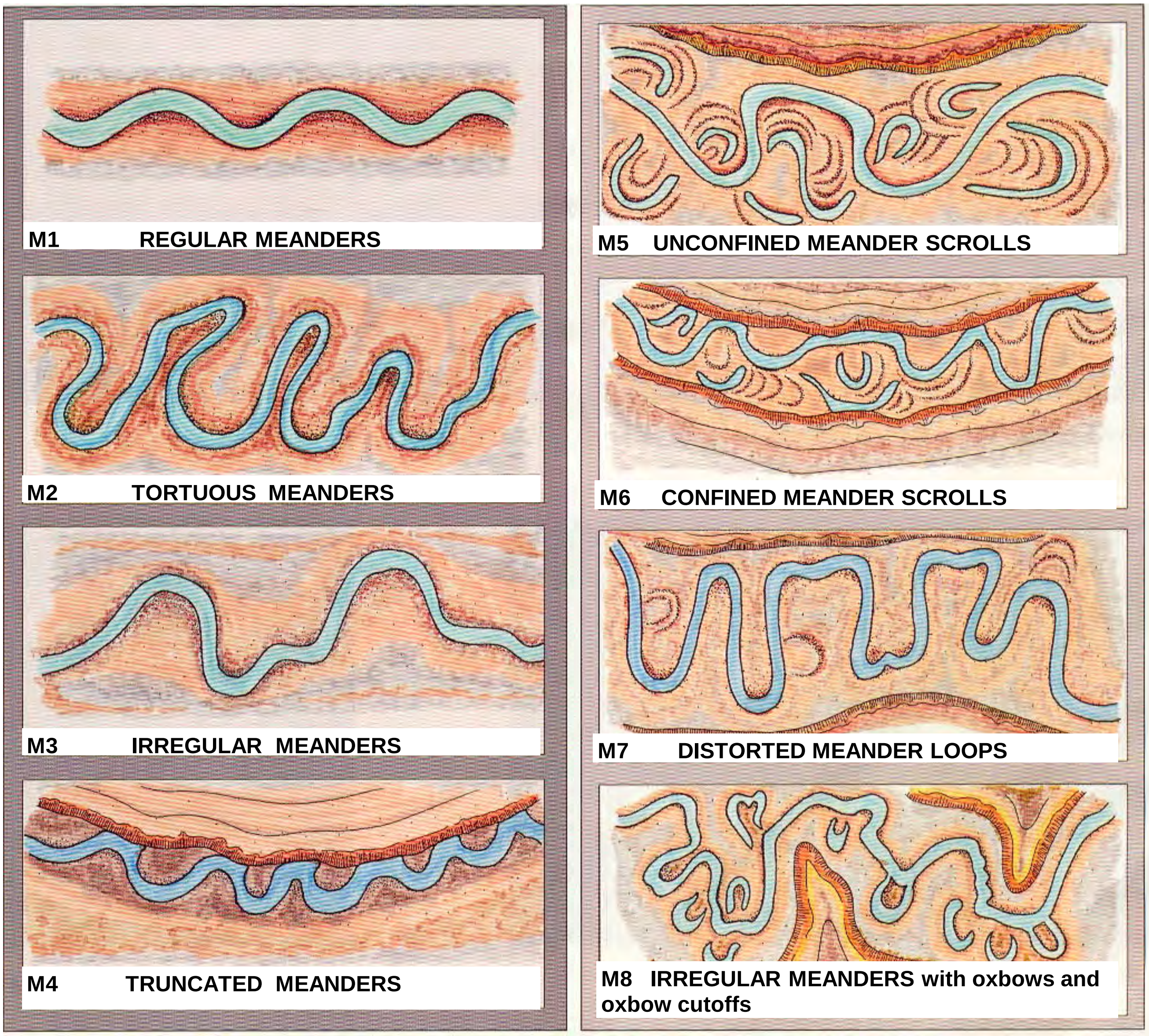
Meander Patterns

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, CO**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/8/2012**

List ALL CATEGORIES that APPLY ☞	**N/A**				

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



Worksheet 5-10. Depositional patterns.

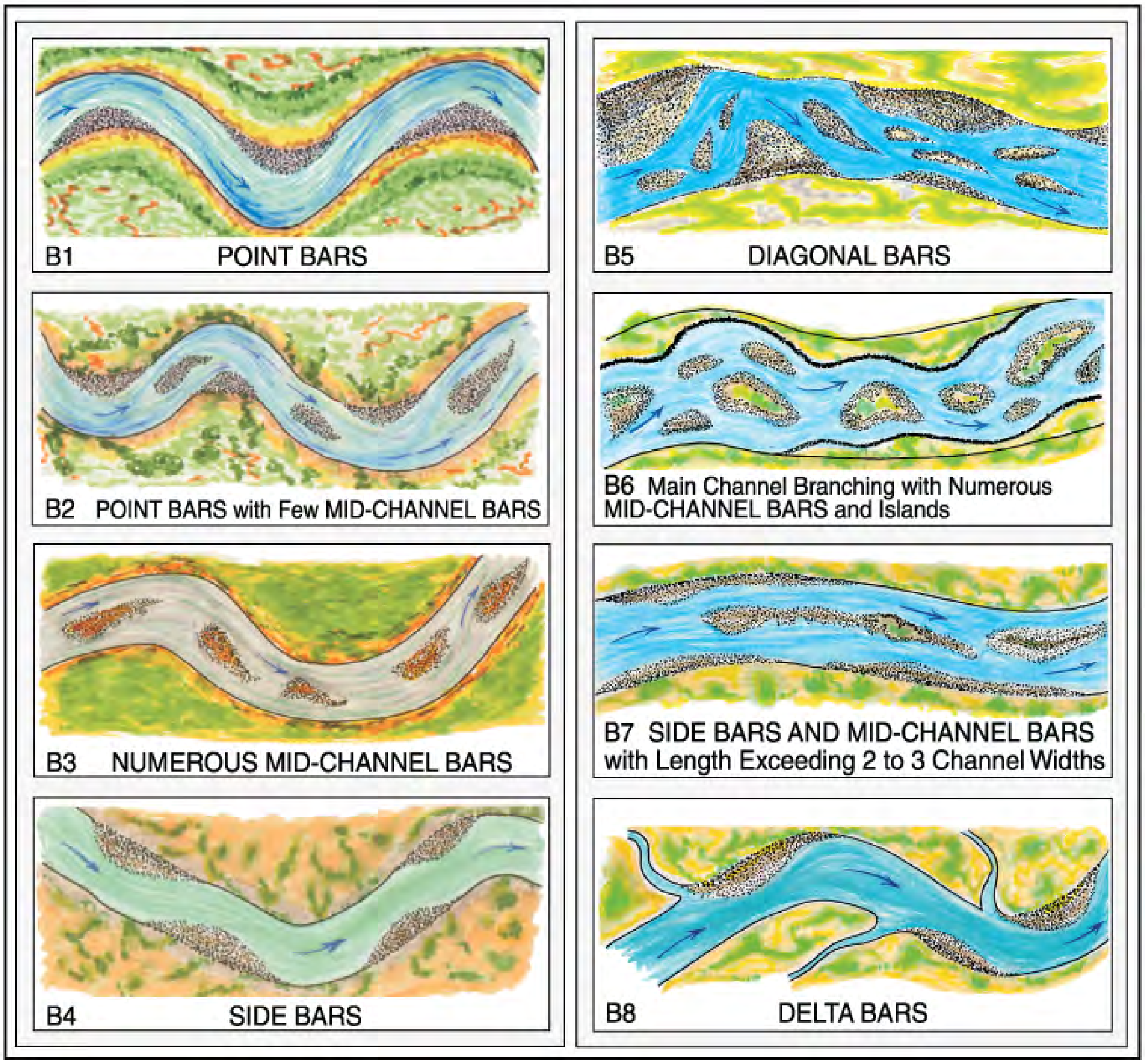
Depositional Patterns

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/8/2012**

List ALL CATEGORIES that APPLY ☞	**NA**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/8/2012**

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.	☐

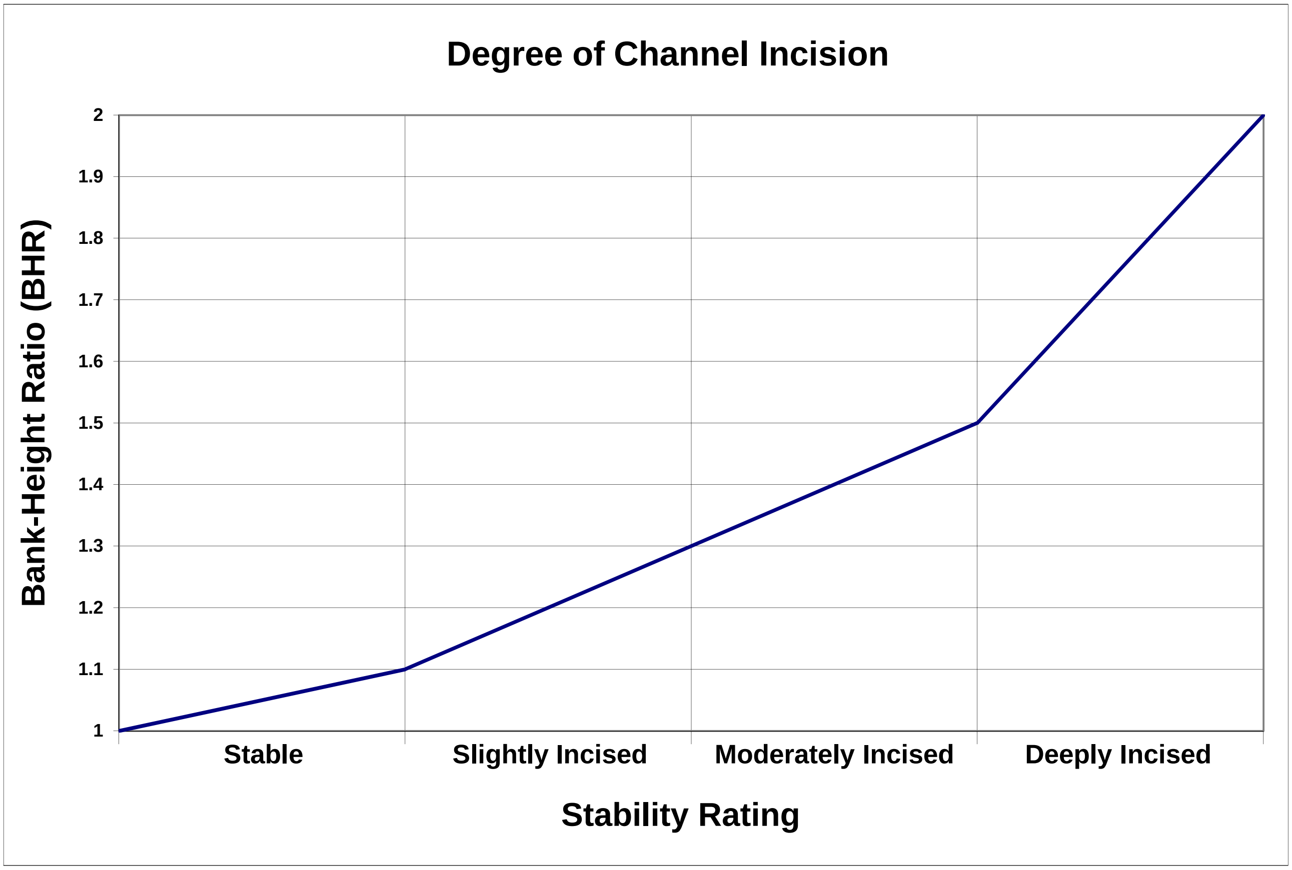
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**0.74**
Max Bankfull Depth:	**0.2**

Bank-Height Ratio:	**3.7**

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



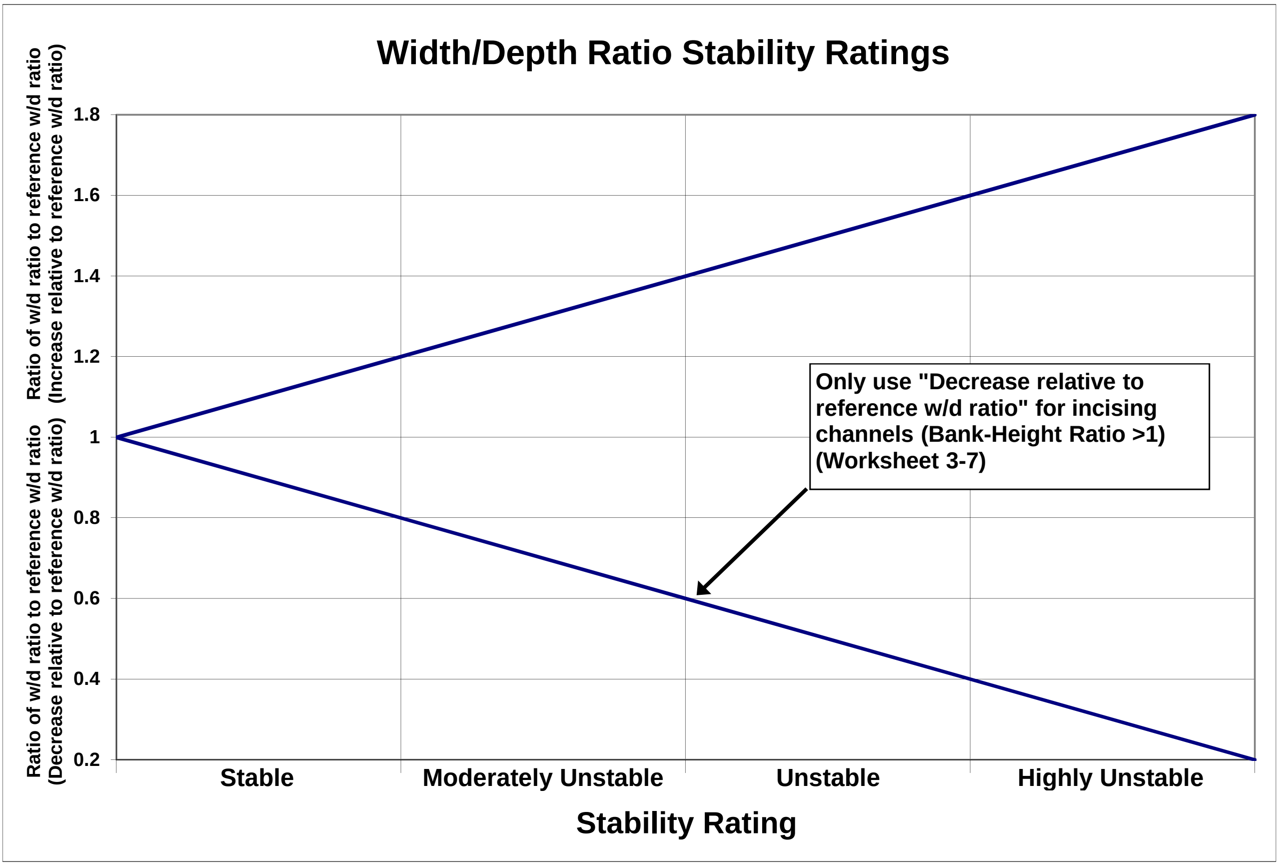
Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**8.16**
Reference Width/Depth Ratio:	**11**

Ratio of existing W/d to reference W/d: **0.74**

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

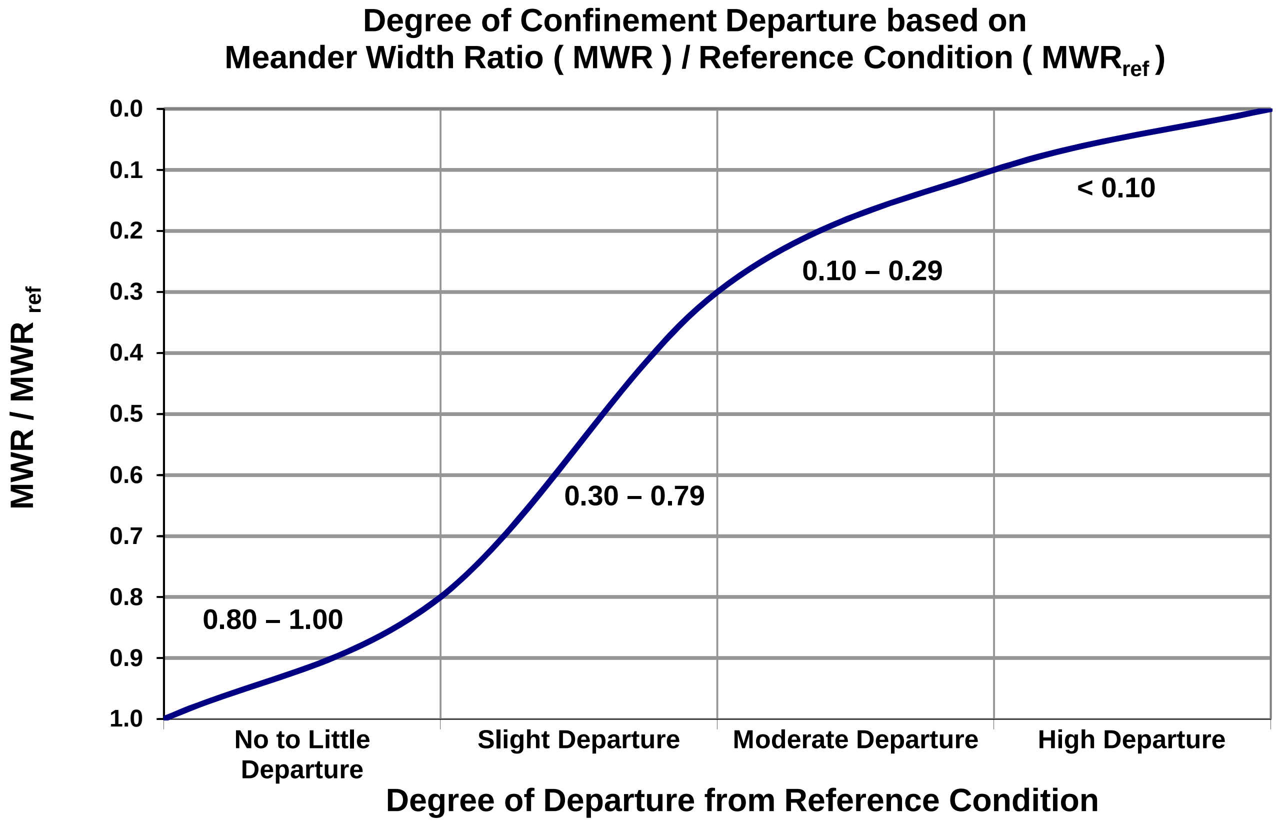
Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**10.5**
Reference Meander Width Ratio (MWR_{ref}):	**1.5**

Ratio of MWR to MWR_{ref}:	**7.00**

Degree of Confinement Stability Rating ☞	**Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Northfield Gulch A4a+ Poor **Location:** Pike National Forest, CO **Valley Type:** I **Observers:** Lee, Sumner, Jara, Leah **Date:** 11/8/2012

Location	Key	Category	Excellent Description	Excellent Rating	Good Description	Good Rating	Fair Description	Fair Rating	Poor Description	Poor Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	13	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	2	Good total =	8	Fair total =	19	Poor total =	104

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	133
Existing stream type =	A4a+
*Potential stream type =	A4a+
Modified channel stability rating =	Poor

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Northfield Gulch A4a+ Poor** Location: **A4a+ Poor**

Graph Used: **Colorado** Total Stream Length (ft): **190** Date: **11/8/2012**

Observers: **Lee, Sumner, Jaram Leah** Valley Type: **I** Stream Type: **A4a+**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. L0+00 to 0+04	Moderate	Moderate	0.303	4.0	2.3	2.79	0.03360
2. L0+04 to 0+27	Moderate	Low	0.173	23.0	1.0	3.90	0.00820
3. L0+27 to 0+51	Very High	Very High	0.872	24.0	2.8	58.60	0.11760
4. L0+51 to 0+73	Moderate	Moderate	0.253	22.0	1.2	6.68	0.01460
5. L0+73 to 0+83	Low	Low	0.036	10.0	1.0	0.36	0.00170
6. L0+83 to 0+92	High	Very High	0.872	9.0	1.4	10.99	0.05880
7. L0+92 to 1+02	Very Low	Low	0.004	10.0	0.7	0.03	0.00013
8. L1+02 to 1+21	Low	Low	0.036	19.0	1.2	0.81	0.00210
9. L1+21 to 1+39	Very High	Very High	0.872	18.0	3.8	59.65	0.15950
10. L1+39 to 1+48	High	Moderate	0.380	8.0	1.6	4.86	0.02930
11. L1+48 to 1+68	Moderate	Low	0.153	20.0	1.2	3.67	0.00880
12. L1+68 to 1+90	High	Moderate	0.380	19.0	1.7	12.27	0.03110
13. R0+00 to 0+28	Low	Low	0.036	28.0	0.8	0.80	0.00140
14. R0+28 to 0+44	Low	Low	0.036	16.0	2.2	1.26	0.00380
15. R0+44 to 0+67	Low	Very Low	0.018	23.0	1.7	0.68	0.00140
16 R0+67 to 0+74	Very Low	Very Low	0.002	7.0	0.7	0.01	0.00272
17 R0+74 to 0+83	Moderate	Low	0.153	9.0	1.8	2.48	0.01330
18 R0+83 to 0+93	High	Low	0.250	10.0	2.3	5.75	0.02770
19 R0+93 to 1+07	Low	Low	0.036	14.0	0.7	0.35	0.00120
20 R1+07 to 1+21	Moderate	Low	0.153	14.0	1.2	2.57	0.00880
21 R1+21 to 1+37	Very High	Very High	0.872	16.0	3.8	53.02	0.15950

Worksheet 5-18, con't. Annual streambank erosion estimates.

Stream: **Northfield Gulch A4a+ Poor** Location: **A4a+ Poor**

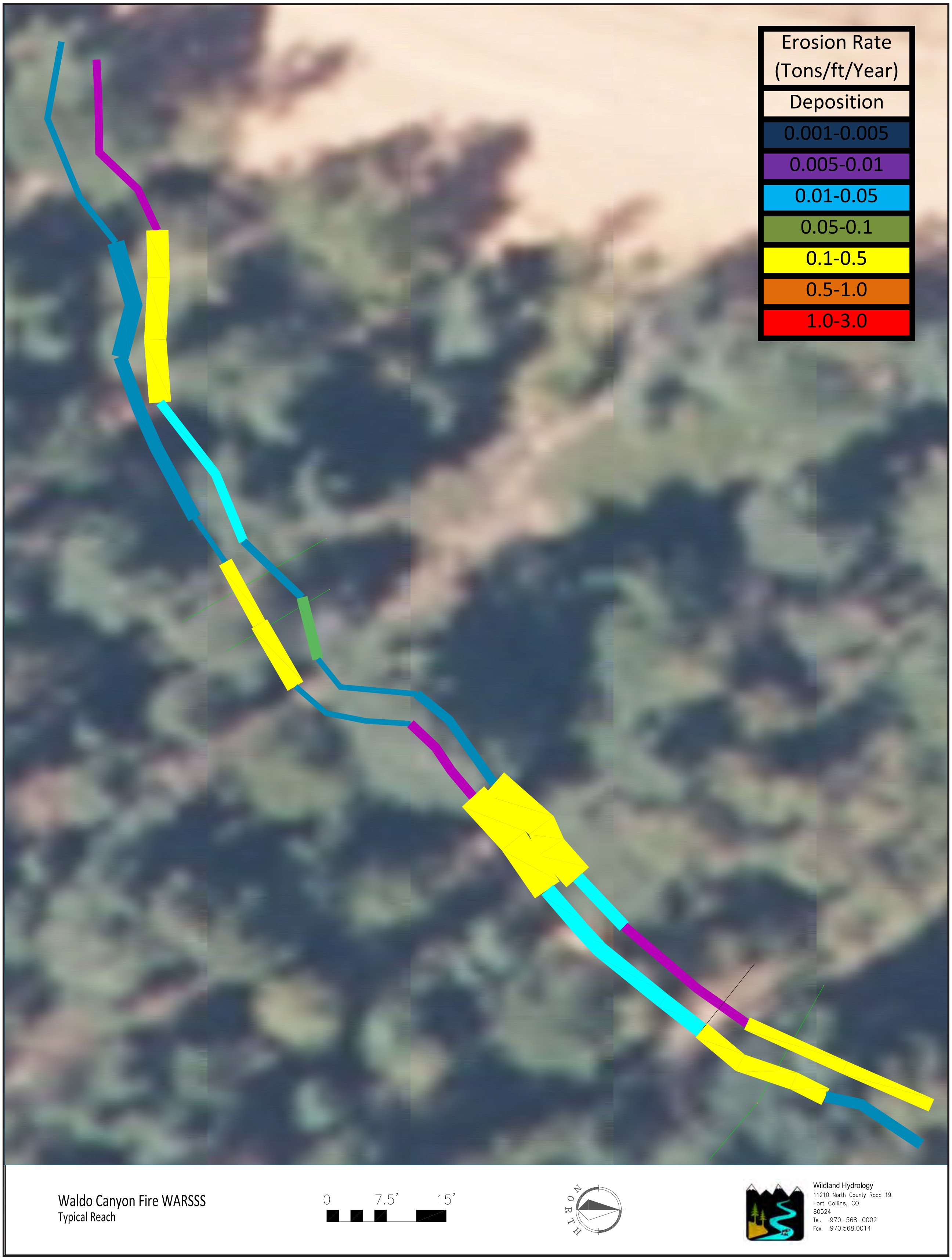
Graph Used: **Colorado** Total Stream Length (ft): **190** Date: **11/8/2012**

Observers: **Lee, Sumner, Jaram Leah** Valley Type: **I** Stream Type: **A4a+**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	Study bank height (ft)	Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
22	R1+37 to 1+43	High	Moderate	0.380	6.0	2.0	4.56	0.03660
23	R1+43 to 1+64	Low	Low	0.036	21.0	1.0	0.75	0.00170
24	R1+64 to 1+82	Moderate	Low	0.153	18.0	2.3	6.33	0.01690
25	R1+82 to 1+90	Low	Low	0.036	8.0	1.4	0.40	0.00240
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total Erosion (ft^3/yr)	243.55
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	Total Erosion (yds^3/yr)	9.02
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	Total Erosion (tons/yr)	11.73
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	Unit Erosion Rate (tons/yr/ft)	0.0617

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Stream: **Waldo Reference and Representative Reaches** Location: **A4a+ Poor (Northfield)** Date: **11/08/2012**

Observers: **L,L,S,J** Gage Station #: **N/A** Stream Type: **A4a+** Valley Type: **II**

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	0.17	0.0026	0.050891
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve			
3. User-defined relations (bedload)						Notes: Pre-Fire Flow Duration Curve, Good/Fair Sediment Curves, Good/Fair Regional Sediment Curves		
4. User-defined relations (suspended sediment)								

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment [(5)×(9)]	(14) Bedload sediment [(5)×(11)]	(15) 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	0.0													
90.000	0.0	95.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
80.000	0.0	85.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
70.000	0.0	75.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
60.000	0.0	65.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
50.000	0.0	55.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
40.000	0.0	45.00	10.00	36.50	0.0	0.06	7.7	0.0	0.0051	0.00	0.10	0.00	0.00	0.00
30.000	0.0	35.00	10.00	36.50	0.0	0.18	7.8	0.0	0.0055	0.00	0.30	0.00	0.00	0.00
20.000	0.0	25.00	10.00	36.50	0.0	0.24	7.8	0.0	0.0061	0.00	0.40	0.00	0.00	0.00
10.000	0.1	15.00	10.00	36.50	0.1	0.35	8.4	0.0	0.0081	0.00	0.60	0.00	0.00	0.00
5.000	0.1	7.50	5.00	18.25	0.1	0.59	11.9	0.0	0.0156	0.04	0.50	0.00	0.73	0.73
4.000	0.1	4.50	1.00	3.65	0.1	0.76	18.2	0.0	0.0246	0.09	0.13	0.00	0.33	0.33
3.000	0.2	3.50	1.00	3.65	0.2	0.88	25.5	0.0	0.0326	0.09	0.15	0.00	0.33	0.33
2.000	0.2	2.50	1.00	3.65	0.2	1.00	35.9	0.0	0.0423	0.13	0.17	0.00	0.47	0.47
1.500	0.2	1.75	0.50	1.83	0.2	1.18	58.3	0.0	0.0598	0.22	0.10	0.00	0.40	0.40
1.000	0.3	1.25	0.50	1.83	0.2	1.35	92.7	0.0	0.0816	0.26	0.12	0.00	0.47	0.47
0.900	0.3	0.95	0.10	0.37	0.3	1.59	146.9	0.0	0.1109	0.39	0.03	0.00	0.14	0.14
0.800	0.3	0.85	0.10	0.37	0.3	1.65	146.9	0.0	0.1109	0.43	0.03	0.00	0.16	0.16
0.700	0.3	0.75	0.10	0.37	0.3	1.76	146.9	0.0	0.1109	0.52	0.03	0.00	0.19	0.19
0.600	0.3	0.65	0.10	0.37	0.3	1.88	146.9	0.0	0.1109	0.56	0.03	0.00	0.20	0.20
0.500	0.4	0.55	0.10	0.37	0.3	2.00	146.9	0.0	0.1109	0.65	0.03	0.00	0.24	0.24
0.250	0.4	0.38	0.25	0.91	0.4	2.24	146.9	0.0	0.1109	0.86	0.10	0.00	0.78	0.78
0.100	0.5	0.18	0.15	0.55	0.4	2.53	146.9	0.0	0.1109	1.12	0.06	0.00	0.61	0.61
0.050	0.5	0.08	0.05	0.18	0.5	2.82	146.9	0.0	0.1109	1.43	0.02	0.00	0.26	0.26
0.010	0.5	0.03	0.04	0.15	0.5	3.06	146.9	0.0	0.1109	1.68	0.02	0.00	0.25	0.25
0.005	0.5	0.01	0.01	0.02	0.5	3.18	146.9	0.0	0.1109	1.81	0.00	0.00	0.03	0.03
0.001	0.5	0.00	0.00	0.01	0.5	3.18	146.9	0.0	0.1109	1.81	0.00	0.00	0.03	0.03
											Annual totals:	0.0 (tons/yr)	5.6 (tons/yr)	5.6 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Stream: **Waldo Reference and Representative Reaches** Location: **A4a+ Poor (Northfield)** Date: **11/08/2012**

Observers: **L,L,S,J** Gage Station #: **N/A** Stream Type: **A4a+** Valley Type: **II**

Equation type	Intercept	Coefficient	Exponent	Form (e.g., linear, non-linear, etc.)	Equation name
1. Bedload (dimensionless)	**0.07176**	**1.02176**	**2.37716**	**Non-Linear**	**Pagosa Springs Reference Curve**
2. Suspended sediment (dimensionless)	**0.0989**	**0.9213**	**3.659**	**Non-Linear**	**Pagosa Springs Reference Curve**
3. User-defined relations (bedload)					
4. User-defined relations (suspended sediment)					

Bankfull discharge (cfs)	Bankfull bedload (kg/s)	Bankfull suspended (mg/l)
0.17	**0.0305**	**77.5349**

Notes:

Post-Fire Flow Duration Curve, Poor Sediment Curves, Poor Regional Sediment Curves

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment **[(5)×(9)]**	(14) Bedload sediment **[(5)×(11)]**	(15) 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	**0.0**													
90.000	**0.0**	**95.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
80.000	**0.0**	**85.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
70.000	**0.0**	**75.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
60.000	**0.0**	**65.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
50.000	**0.0**	**55.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
40.000	**0.0**	**45.00**	**10.00**	**36.50**	**0.0**	**0.06**	**7.7**	**0.0**	**0.0051**	**0.22**	**0.10**	**0.00**	**8.03**	**8.03**
30.000	**0.0**	**35.00**	**10.00**	**36.50**	**0.0**	**0.18**	**7.8**	**0.0**	**0.0055**	**0.22**	**0.30**	**0.00**	**8.03**	**8.03**
20.000	**0.1**	**25.00**	**10.00**	**36.50**	**0.0**	**0.24**	**7.8**	**0.0**	**0.0061**	**0.26**	**0.40**	**0.00**	**9.49**	**9.49**
10.000	**0.1**	**15.00**	**10.00**	**36.50**	**0.1**	**0.41**	**8.8**	**0.0**	**0.0095**	**0.39**	**0.70**	**0.00**	**14.24**	**14.24**
5.000	**0.1**	**7.50**	**5.00**	**18.25**	**0.1**	**0.71**	**15.8**	**0.0**	**0.0213**	**0.91**	**0.60**	**0.18**	**16.61**	**16.79**
4.000	**0.2**	**4.50**	**1.00**	**3.65**	**0.2**	**0.88**	**25.5**	**0.0**	**0.0326**	**1.38**	**0.15**	**0.04**	**5.04**	**5.08**
3.000	**0.2**	**3.50**	**1.00**	**3.65**	**0.2**	**1.00**	**35.9**	**0.0**	**0.0423**	**1.81**	**0.17**	**0.07**	**6.61**	**6.68**
2.000	**0.2**	**2.50**	**1.00**	**3.65**	**0.2**	**1.18**	**58.3**	**0.0**	**0.0598**	**2.59**	**0.20**	**0.11**	**9.45**	**9.56**
1.500	**0.2**	**1.75**	**0.50**	**1.83**	**0.2**	**1.29**	**79.1**	**0.1**	**0.0736**	**3.20**	**0.11**	**0.09**	**5.84**	**5.93**
1.000	**0.3**	**1.25**	**0.50**	**1.83**	**0.3**	**1.59**	**146.9**	**0.1**	**0.1109**	**5.05**	**0.14**	**0.22**	**9.22**	**9.44**
0.900	**0.3**	**0.95**	**0.10**	**0.37**	**0.3**	**1.71**	**146.9**	**0.2**	**0.1109**	**5.92**	**0.03**	**0.06**	**2.16**	**2.22**
0.800	**0.3**	**0.85**	**0.10**	**0.37**	**0.3**	**1.82**	**146.9**	**0.2**	**0.1109**	**6.91**	**0.03**	**0.08**	**2.52**	**2.60**
0.700	**0.3**	**0.75**	**0.10**	**0.37**	**0.3**	**1.94**	**146.9**	**0.3**	**0.1109**	**7.99**	**0.03**	**0.11**	**2.92**	**3.03**
0.600	**0.4**	**0.65**	**0.10**	**0.37**	**0.4**	**2.06**	**146.9**	**0.4**	**0.1109**	**9.16**	**0.03**	**0.14**	**3.34**	**3.48**
0.500	**0.4**	**0.55**	**0.10**	**0.37**	**0.4**	**2.18**	**146.9**	**0.5**	**0.1109**	**10.41**	**0.04**	**0.18**	**3.80**	**3.98**
0.250	**0.4**	**0.38**	**0.25**	**0.91**	**0.4**	**2.41**	**146.9**	**0.8**	**0.1109**	**13.26**	**0.10**	**0.71**	**12.10**	**12.81**
0.100	**0.5**	**0.18**	**0.15**	**0.55**	**0.5**	**2.71**	**146.9**	**1.3**	**0.1109**	**17.37**	**0.07**	**0.73**	**9.51**	**10.24**
0.050	**0.5**	**0.08**	**0.05**	**0.18**	**0.5**	**3.06**	**146.9**	**2.4**	**0.1109**	**23.16**	**0.03**	**0.43**	**4.23**	**4.66**
0.010	**0.6**	**0.03**	**0.04**	**0.15**	**0.6**	**3.24**	**146.9**	**3.0**	**0.1109**	**26.44**	**0.02**	**0.44**	**3.86**	**4.30**
0.005	**0.6**	**0.01**	**0.01**	**0.02**	**0.6**	**3.35**	**146.9**	**3.6**	**0.1109**	**28.77**	**0.00**	**0.07**	**0.53**	**0.60**
0.001	**0.6**	**0.00**	**0.00**	**0.01**	**0.6**	**3.35**	**146.9**	**3.6**	**0.1109**	**28.77**	**0.00**	**0.05**	**0.42**	**0.47**
											Annual totals:	**3.7** (tons/yr)	**178.1** (tons/yr)	**181.8** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Northfield Gulch A4a+ Poor**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/08/2012**

Enter Required Information for Existing Condition

4.1	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.312	D_{max}	Largest particle from **Bed Material** (ft)	**95**	**(mm)**	304.8 mm/ft
0.13000	S	Existing bankfull water surface slope (ft/ft)			
0.19	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	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:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
23.11	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**2**

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

N/A	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

N/A	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

1.541		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 **122.4**	CO **209**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.209**	CO **0.528**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.15**	CO **0.07**	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 **0.1020**	CO **0.0445**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Northfield Gulch A4a+ Poor** Stream Type: **A4a+**

Location: **Pike National Forest, CO** Valley Type: **I**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/08/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Northfield Gulch A4a+ Poor**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/08/2012**

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 5-13)**	< 1.2 **(2)**	1.2 – 1.4 [✓ **(4)**]	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**4**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**N/A**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**N/A**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL [✓ **(6)**]	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**6**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**11**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☑	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Northfield Gulch A4a+ Poor**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/08/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 (7)	2
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2 (2)	1.2 – 1.4 [✓ (4)]	1.4 – 1.6 (6)	>1.6 (8)	4
4 **Stream Succession States (Worksheet 5-24)**	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) (6)	(C→D), (F→D) (8)	2
5 **Depositional Patterns (Worksheet 5-10)**	B1 (1)	B2, B4 (2)	B3, **B5** (3)	**B6, B7**, B8 [✓ (4)]	NA
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3 [✓ (1)]	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	1
				Total Points	**11**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Northfield Gulch A4a+ Poor**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/08/2012**

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 5-22)**	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	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**2**
	(1)	[✓ **(2)**]	**(3)**	**(4)**	
				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*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Northfield Gulch A4a+ Poor** Stream Type: **A4a+**
Location: **Pike National Forest, Colorado** Valley Type: **I**
Observers: **Lee, Sumner, Jara, Leah** Date: **11/08/2012**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) [✓ **(8)**]	**8**
2	**Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* [✓ **(4)**]	*Unstable* **(6)**	*Highly Unstable* **(8)**	**4**
3	**Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4	**Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* [✓ **(8)**]	**8**
					Total Points	**22**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream: **Northfield Gulch A4a+ Poor** Stream Type: **A4a+**
Location: **Pike National Forest, Colorado** Valley Type: **I**
Observers: **Lee, Sumner, Jara, Leah** Date: **11/08/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	***Stable***	**1**	**2**
	Mod. Unstable	**[✓ 2]**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	***No Deposition***	**1**	**2**
	Mod. Deposition	**[✓ 2]**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	***Not Incised***	**1**	**4**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**[✓ 4]**	
4 Channel Enlargement Prediction (Worksheet 5-28)	***No Increase***	**1**	**3**
	Slight Increase	**2**	
	Mod. Increase	**[✓ 3]**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 5-15)	***Good: Stable***	**1**	**4**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**[✓ 4]**	
		Total Points	**15**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Northfield Gulch A4a+ Poor**					Location:	**Pike National Forest, Colorado**			
Observers:	**Lee, Sumner, Jara, Leah**		Date:	**11/8/2012**		Stream Type:	**A4a+**		Valley Type:	**I**
Channel Dimension	Mean Bankfull Depth (ft):	**0.19**	Bankfull Width (ft):	**1.55**	Cross-Sectional Area (ft^2):	**0.3**	Width of Flood-Prone Area (ft):	**8.16**	Entrenchment Ratio:	**1.1**
Channel Pattern	Mean: Range:	λ/W_{bkf}: **N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**10.45** **5.94-18.52**	Sinuosity:	**1.09**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☑ Step/Pool	☐ Plane Bed	☑ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed				
	Max Bankfull Depth (ft):	Riffle **0.27**	Pool **0.35**	Depth Ratio (max to mean):	Riffle **1.42**	Pool **1.3**	Pool-to-Pool Spacing:	Ratio **NA**	Slope Valley: **0.2504**	Water Surface: **0.22974**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Burnt trees & young aspen**		Potential Composition/Density: **Aspen, Doug-fir, Ponderosa pi**		Remarks: Condition, Vigor & Usage of Existing Reach: **Burnt tress dominate landscape, few young aspen re**				
	Flow Regime: **E1, E2, E8**	Stream Size & Order: **S-2(1)**		Meander Patterns: **N/A**		Depositional Patterns: **N/A**		Debris/Channel Blockages: **D2**		
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**		Modified Pfankuch Stability Rating (Numeric & Adjective Rating):		**133 (Poor)**		
	Width/depth Ratio (W/d):	**52**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**4.14**	W/d Ratio State Stability Rating:	**Highly Unstable**		
	Meander Width Ratio (MWR):	**10.45**	Reference MWR_{ref}:	**1.5**	Degree of confinement (MWR / MWR_{ref}):	**6.966667**	MWR / MWR_{ref} Stability Rating:	**Slight Departure from Reference**		
Bank Erosion Summary	Length of Reach Studied (ft):	**190**	Annual Streambank Erosion Rate: **11.73** (tons/yr)	**0.0617** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:	**Used Yellowstone curve for very low BEHI**			
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity			Remarks:				
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**95**	$\tau =$ **0.528**	$\tau^* =$ **N/A**	Existing Depth: **0.19**	Required Depth: **0.07**	Existing Slope: **0.123**	Required Slope: **0.04**		
Successional Stage Shift	→	→	→	→	→	Existing Stream State (Type): **A4a+**	Potential Stream State (Type): **A4a+**			
Lateral Stability	☐ *Stable*	☑ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*		Remarks/causes:				
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*		Remarks/causes:				
Vertical Stability (Degradation)	☐ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☑ *Degradation*		Remarks/causes:	**Noted obvious headcuts**			
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*		Remarks/causes:	**Noted channel widening & incision**			
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:	**significant contribution from road, also noted sediment supply from both bed and banks**				

Appendix C3

A4a+ Stream Type

Poor Stability South Reach

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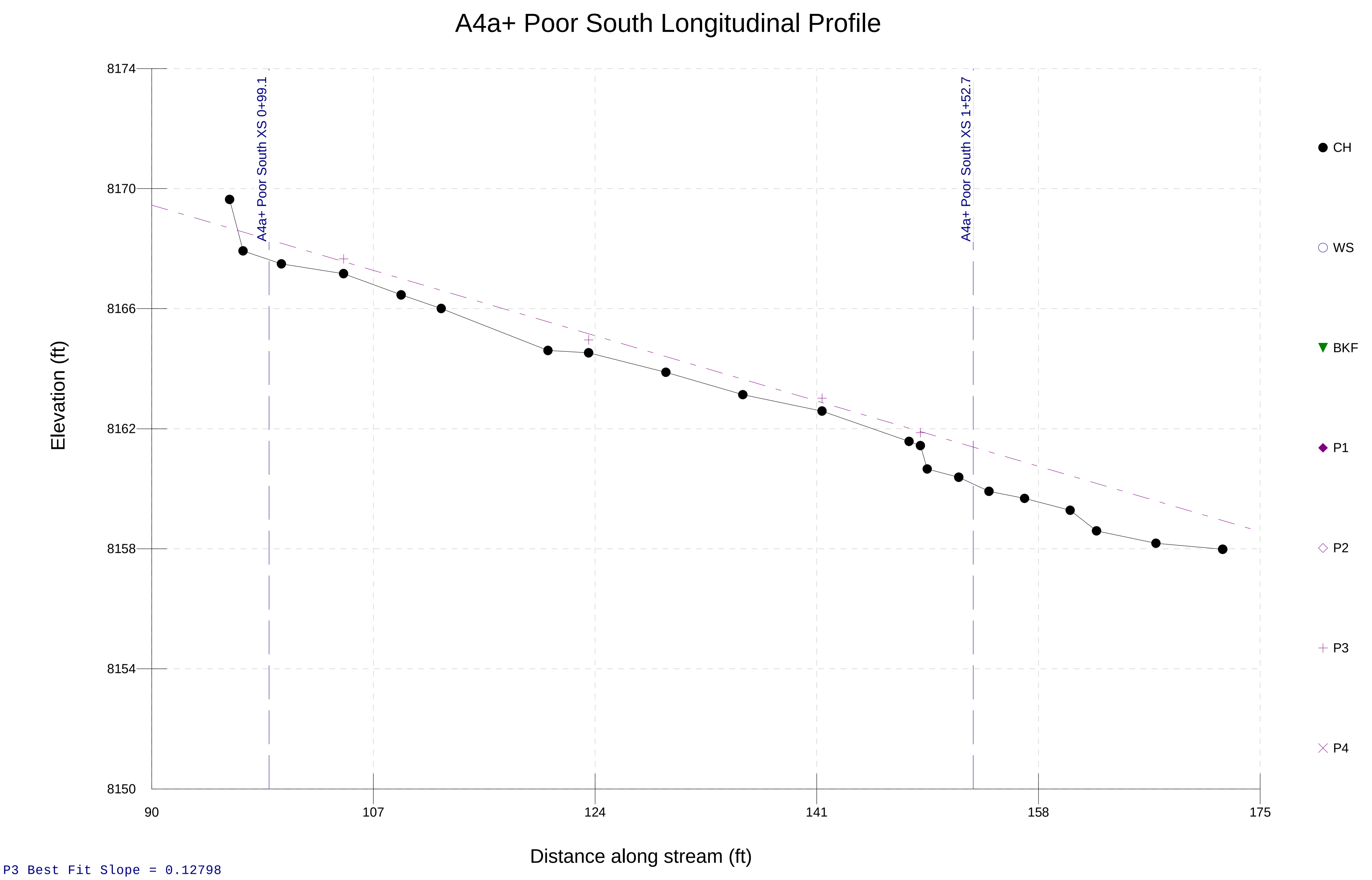
Appendix C3: A4a+ Poor South Reach

A4a+ Poor South Reach Location & Overview

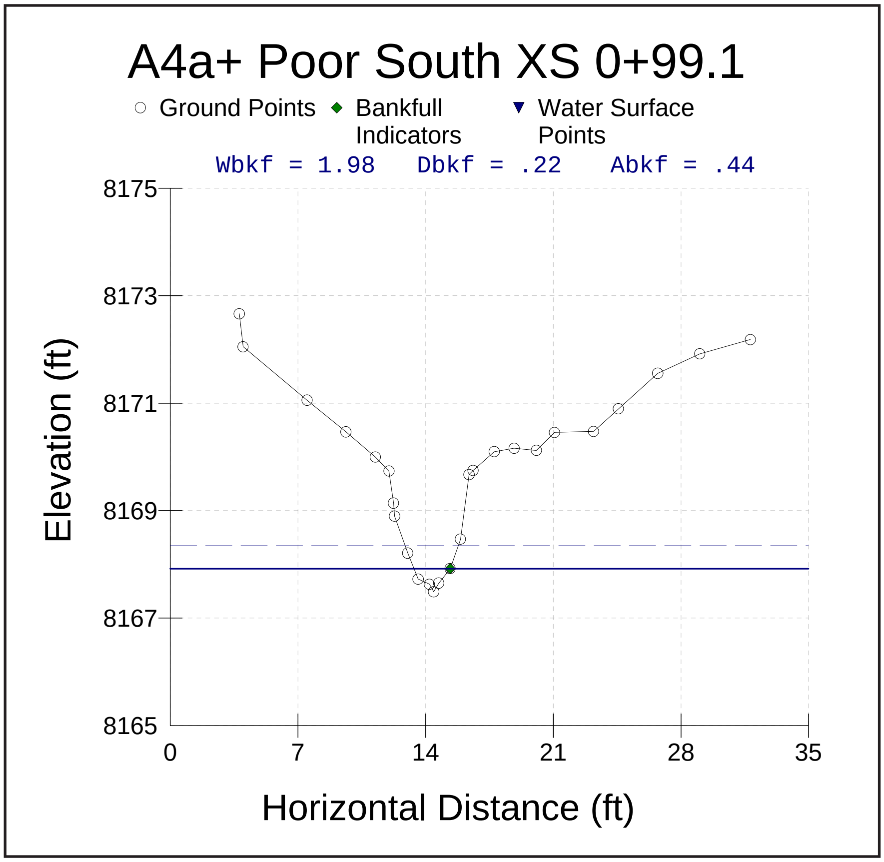
The A4a+ Poor south reach is a 1st order, ephemeral stream located in the Trail Creek Watershed (**Figure C-2**) with a high sediment supply due to channel processes. The photograph depicts the advancing headcut documenting both bed instability and accelerated streambank erosion. The stability rating is "Poor" due to degradation, active incision, and lateral instability. The streambank erosion rate is *0.0355 tons/yr/ft*, more than an order of magnitude higher than its reference condition. The sediment supply also rates as *High* due to the same processes, including a *Moderate Increase* in channel enlargement. The overall "Poor" condition rating indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows. The increase in water yield using the WRENSS model for this small, ephemeral channel of 0.32 cfs is *0.6 acre-ft*. This increase corresponds with an increase in bedload using the FLOWSED model of *1.7 tons/yr* and *3.1 tons/yr* of suspended sediment.

The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

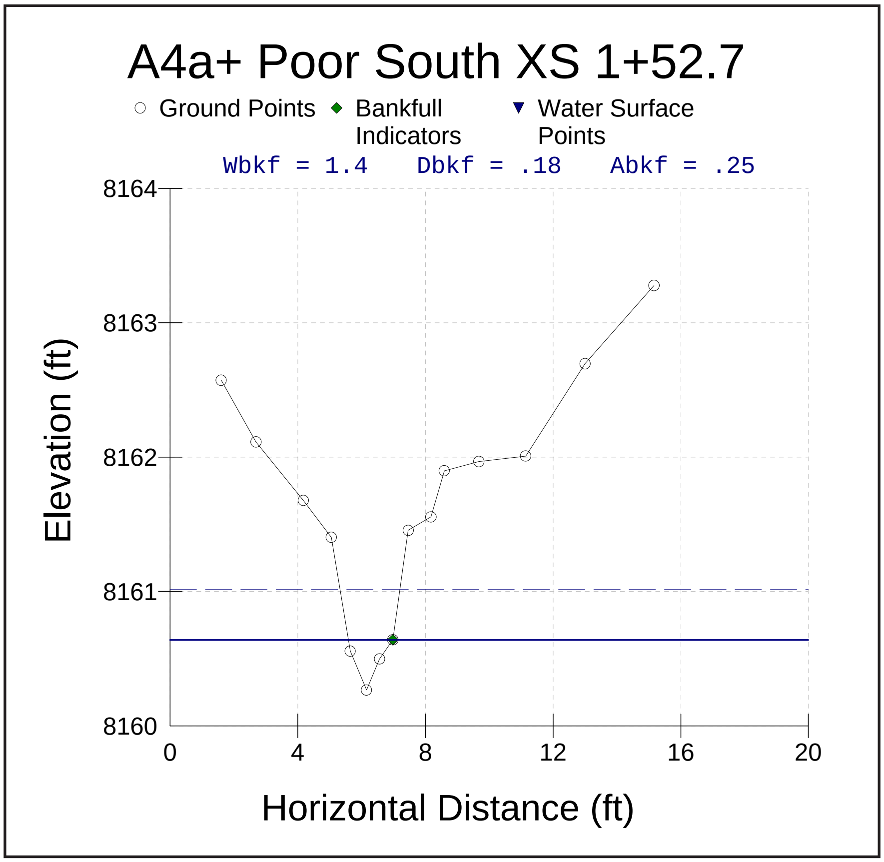
Survey Summary



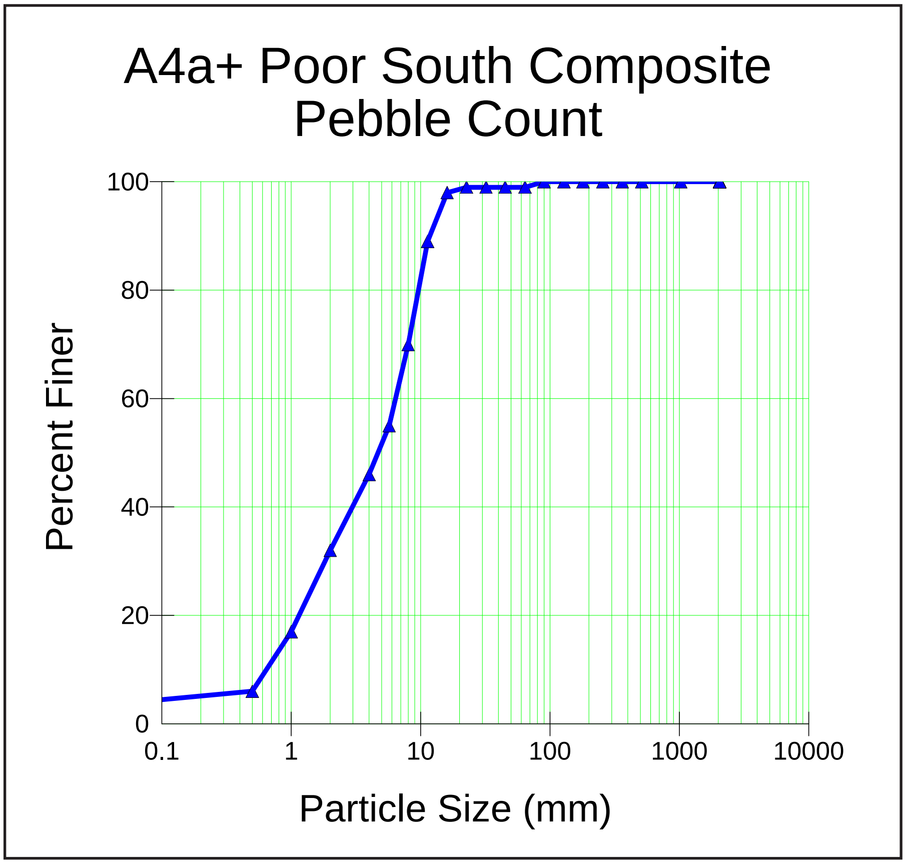
Longitudinal Profile (graph generated from RIVERMorph^{TM})



Representative Cross-section 0+99.1 (graph generated from RIVERMorph^{TM})



Cross-section 1+52.7 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, A4a+ Poor South**			Location:	**XS 0+99.1, Pike N.F., Colorado**
Date:	**9/2/2010**	Stream Type:	**A4a+**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**			HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**0.44**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.22**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**1.98**	**W_{bkf}** (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**2.42**	**W_p** (ft)
D_{84} at Riffle	**10.4**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.03**	**D_{84}** (ft)
Bankfull SLOPE	**0.1280**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.18**	**R** (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**5.30**	**R / D_{84}**
Drainage Area	**0.002**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.865**	**u*** (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\,2.83 + 5.66 * Log\,\{\,R / D_{84}\,\}\,]\,u^*$	**5.99**	ft / sec	**2.64**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2}/n$ **n =**		ft / sec		cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2}/n$ **n =**		ft / sec		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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 **n = 0.235**	**0.73**	ft / sec	**0.32**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach**	**7.17**	ft / sec	**3.15**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Hey**	**7.21**	ft / sec	**3.17**	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q = ____ year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, A4a+ Poor South Reach**

Basin: Drainage Area: acres **0.002** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+99.1** Date: **9/2/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**1.98**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.22**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**0.44**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.0**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.43**	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.	**2.91**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.47**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**4.76**	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.	**0.1280**	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 (S_{val} / S).	**1.01**	

Stream Type **A4a+** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4a+ Poor South Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010** Valley Type: **I** Stream Type: **A4a+**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Riffle Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Riffle Width (Wbkf)	**1.7**	**1.4**	**2.0**	ft	Riffle Cross-Sectional Area (Abkf) (ft2)	**0.3**	**0.3**	**0.4**
Mean Riffle Depth (dbkf)	**0.20**	**0.18**	**0.22**	ft	Riffle Width/Depth Ratio (Wbkf / dbkf)	**8.4**	**7.8**	**9.0**
Maximum Riffle Depth (dmax)	**0.40**	**0.37**	**0.43**	ft	Max Riffle Depth to Mean Riffle Depth (dmax/dbkf)	**2.005**	**1.955**	**2.056**
Width of Flood-Prone Area (Wfpa)	**2.40**	**1.88**	**2.91**	ft	Entrenchment Ratio (Wfpa / Wbkf)	**1.41**	**1.35**	**1.47**
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Trail Creek, A4a+ Poor South Reach**			Location:	**Pike National Forest, Colorado**		
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**	Valley Type:	**I**	Stream Type:	**A4a+**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**0.73**	ft/sec	Estimation Method	**Manning's n from Jarrett**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**0.32**	cfs	Drainage Area	**0.002**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**2.6**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.51**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.1293**	ft/ft	Average Water Surface Slope (S)	**0.1280**	ft/ft	Sinuosity (S_{val} / S)	**1.01**
Stream Length (SL)	**20.0**	ft	Valley Length (VL)	**19.8**	ft	Sinuosity (SL / VL)	**1.01**

Low Bank Height (LBH)	start	**2.00**	ft	Max Bankfull Depth (d_{max})	start	**0.43**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**4.7**
	end	**1.50**	ft		end	**0.43**	ft		end	**3.5**

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

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**0.48**	**0.37**	**0.61**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.400**	**1.850**	**3.050**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**			D_{16}	**1**				mm
% Sand	**32**			D_{35}	**2**				mm
% Gravel	**67**			D_{50}	**5**				mm
% Cobble	**1**			D_{84}	**10**				mm
% Boulder	**0**			D_{95}	**14**				mm
% Bedrock	**0**			D_{100}	**90**				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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, A4a+ Poor South Reach**

Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher**

Reference reach ☐ Disturbed (impacted reach) ☒

Date: **9/2/2010**

Existing species composition: **Aspen, Raspberry**

Potential species composition: **Aspen, Ponderosa Pine**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**0%**	**0%**		**0%**
					100%
2. Understory	Shrub layer	▨	**10%**	**Raspberry**	**80%**
				Aspen	**20%**
					100%
3. Ground level	Herbaceous	▨	**60%**	**Forbs(Kinnikinik, Senecio, Physelia, Scarlet Gilia)**	**50%**
				Grasses(Rush, Bunchgrass)	**50%**
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**25%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Rilling from side slopes noticable, esp. on south aspects. Vegetation showing signs of recovery.

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, A4a+ Poor South** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

List ALL COMBINATIONS that APPLY..............☞	**E1**	**E2**	**E8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, A4a+ Poor South Reach**
Location: **Pike National Forest, Colorado**
Observers: **Chavez, Kasun & Gallagher**
Date: **9/2/2010**

Stream Size Category and Order ☞ **S-2(1)**

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 5-9. Meander patterns.

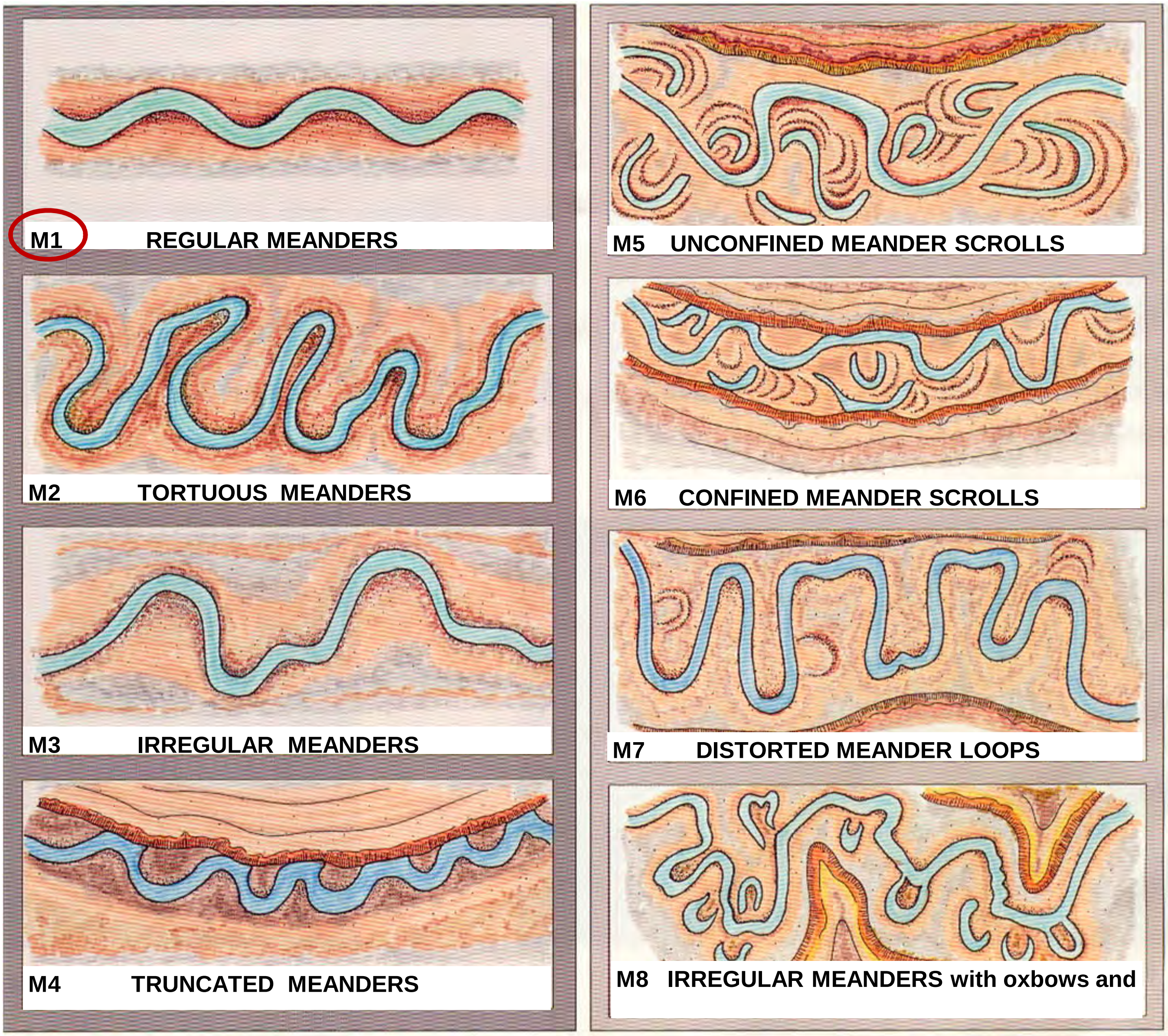
Meander Patterns

Stream: **Trail Creek, A4a+ Poor South Reach** Location: **Pike National Forest, CO**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

List ALL CATEGORIES that APPLY ☞	**M1**				

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



Worksheet 5-10. Depositional patterns.

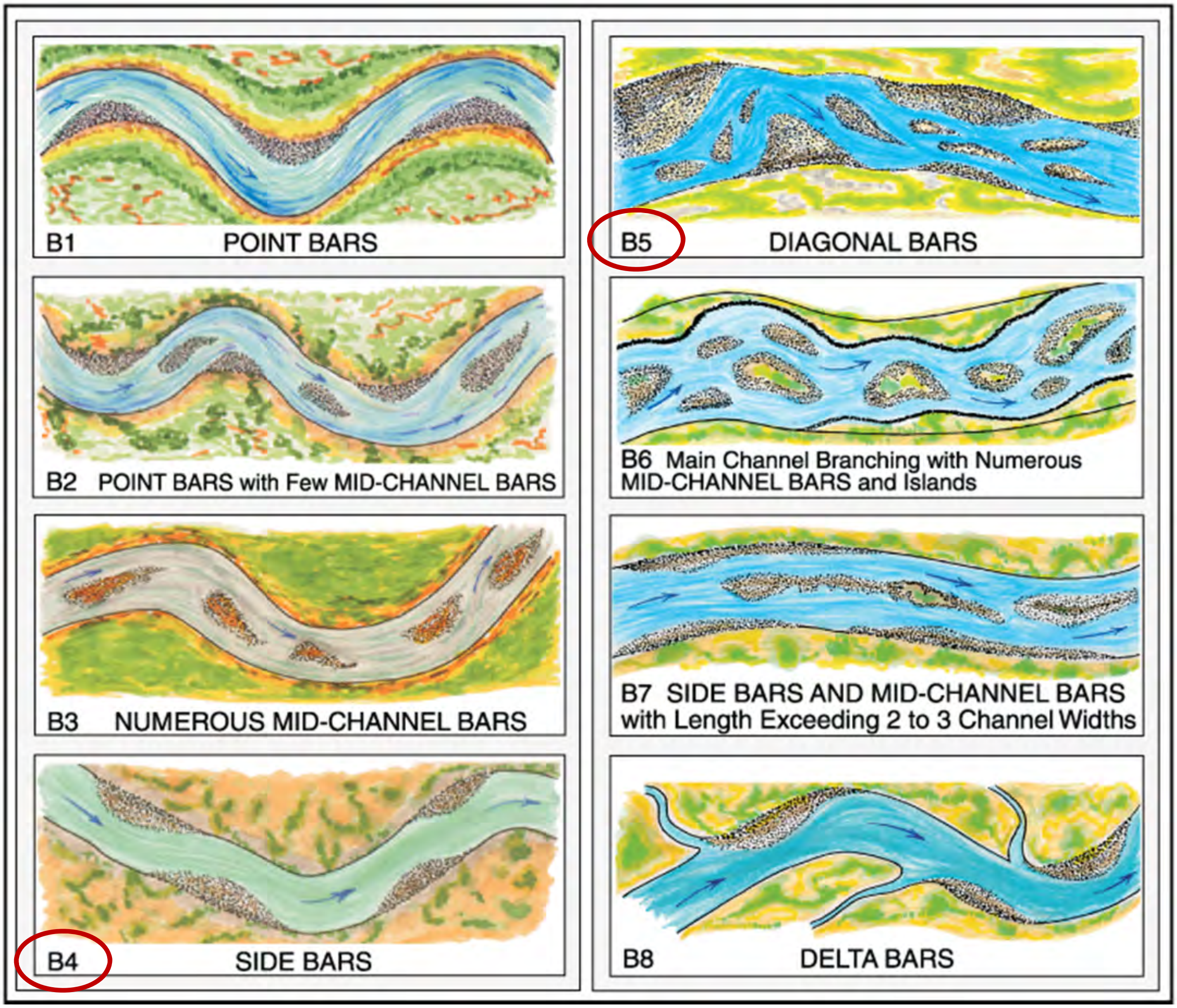
Depositional Patterns

Stream: **Trail Creek, A4a+ Poor South Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

List ALL CATEGORIES that APPLY ☞	**B4**	**B5**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages			
Stream:	**Trail Creek, A4a+ Poor South Reach**	Location: **Pike National Forest, Colorado**	
Observers:	**Chavez, Kasun & Gallagher**	Date: **9/2/2010**	
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 5-12. Degree of channel incision.

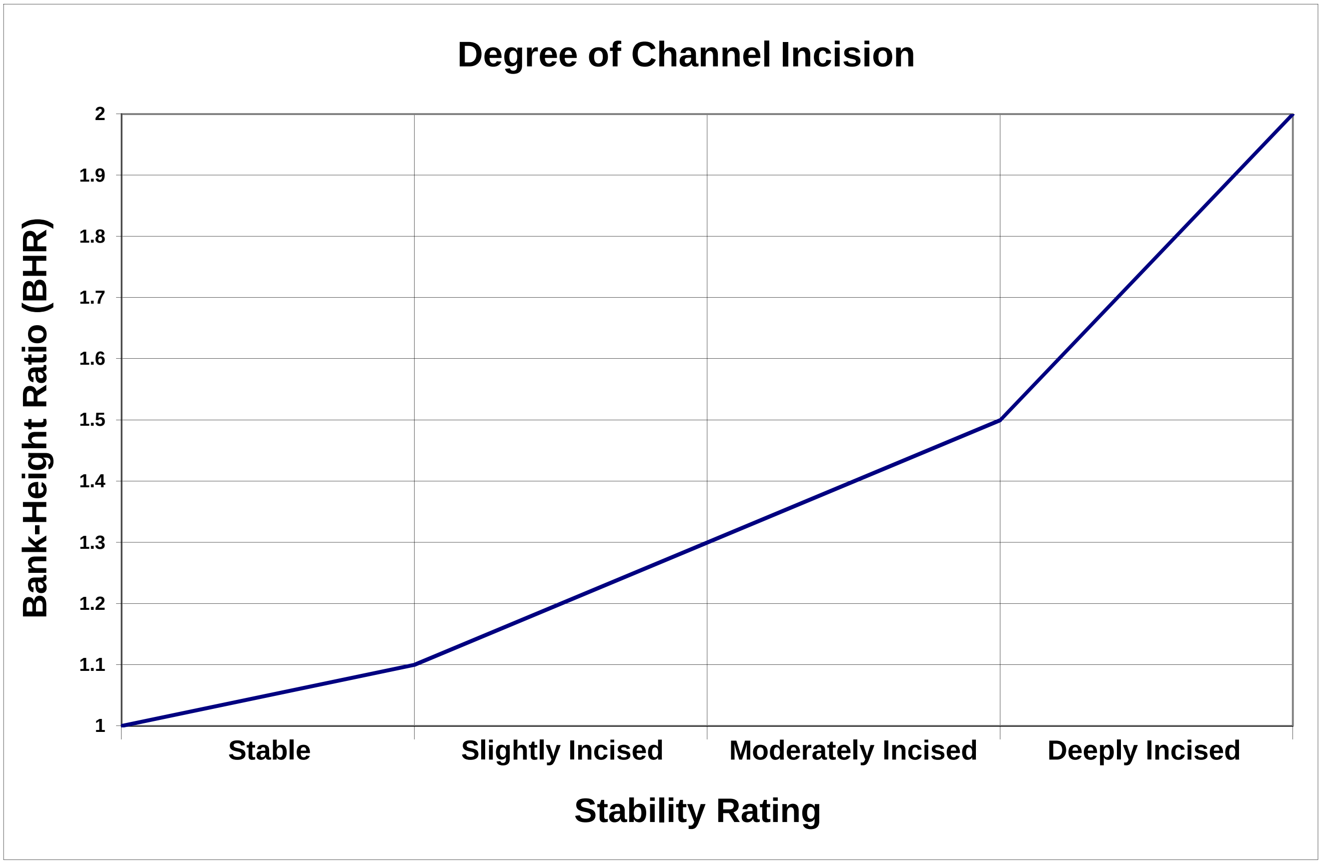
Degree of Channel Incision

Low Bank Height: **2**

Max Bankfull Depth: **0.43**

Bank-Height Ratio: **4.7**

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

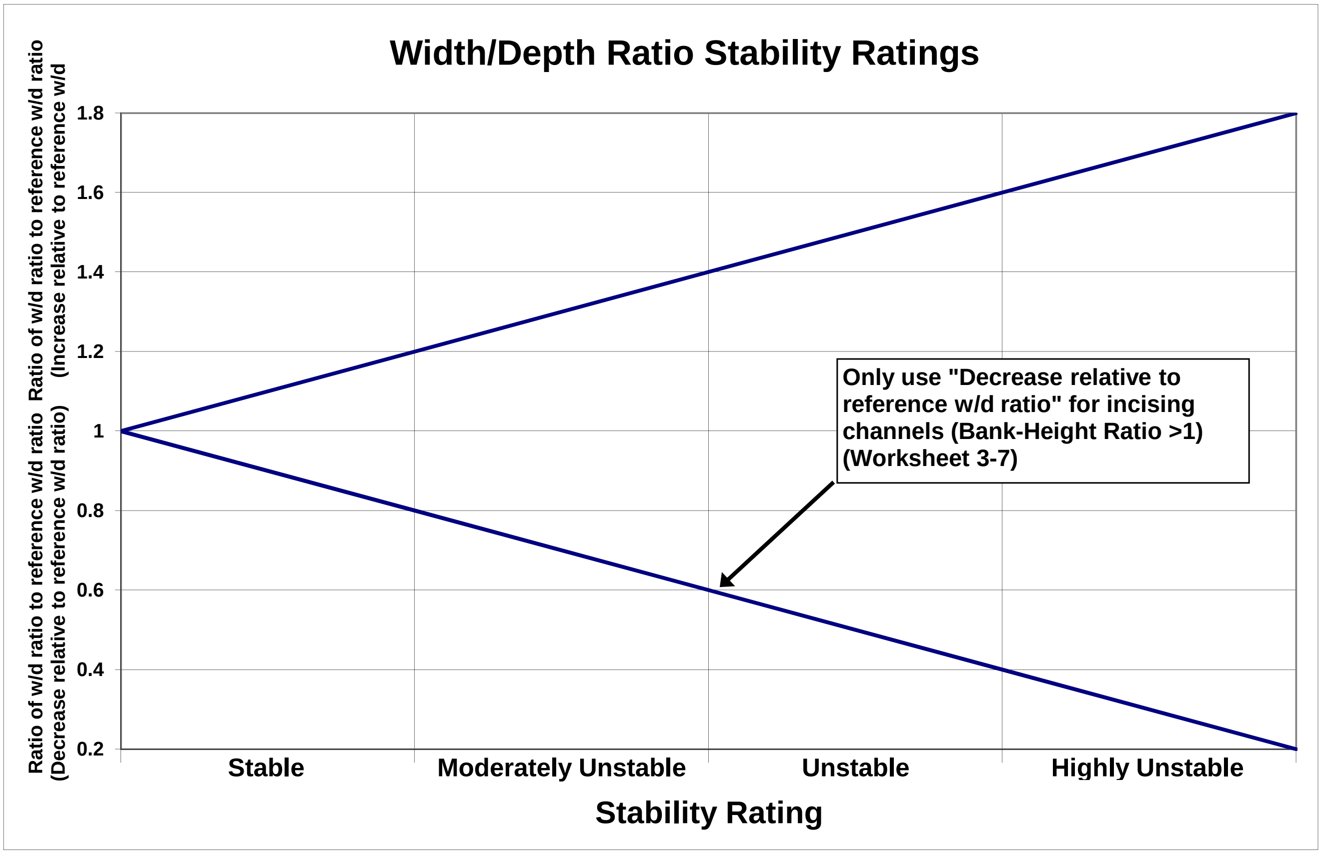


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	9	Ratio of existing W/d to reference W/d:	0.82
Reference Width/Depth Ratio:	10.95		

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

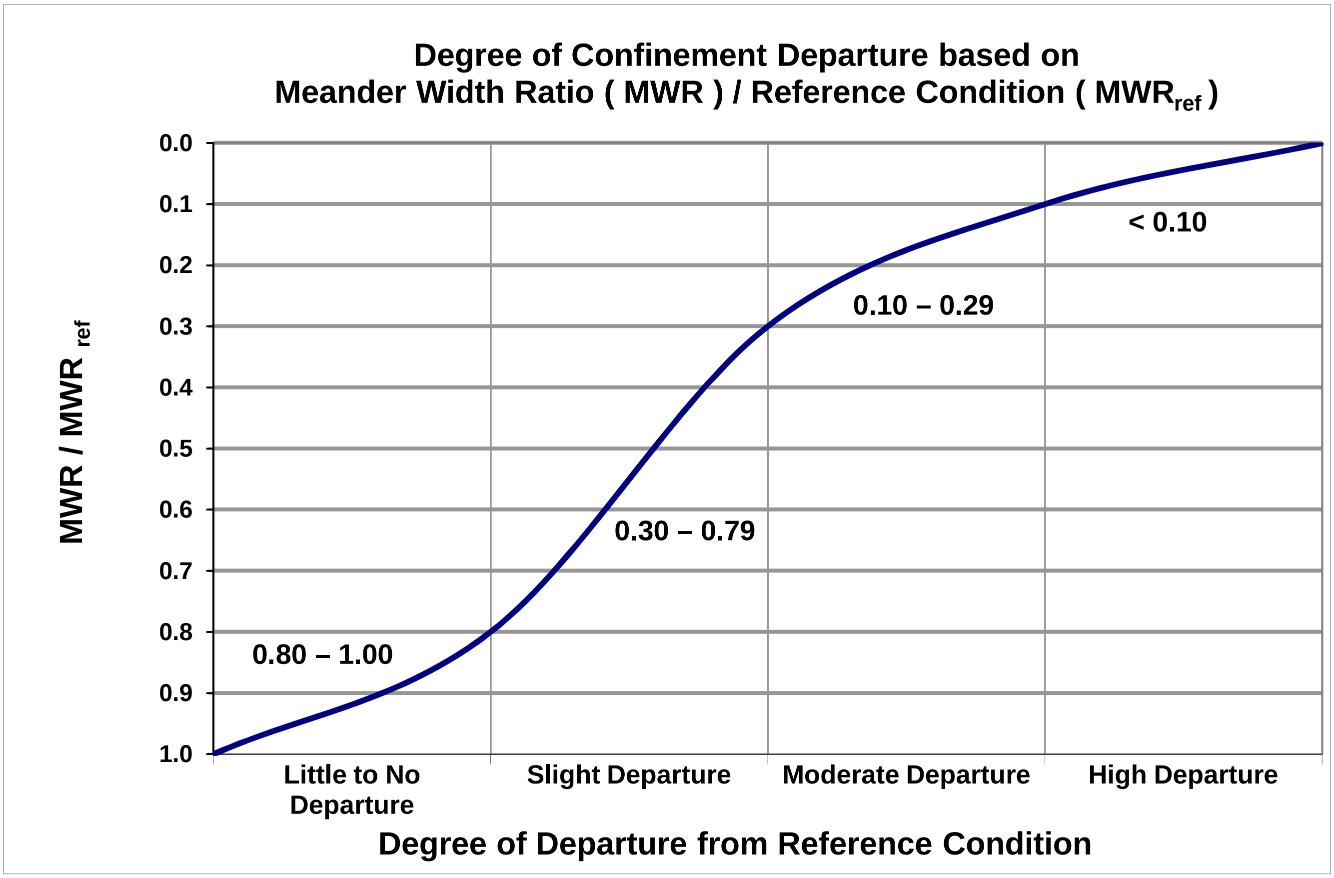


Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**1.5**	Ratio of MWR to MWR$_{ref}$:	**1.00**
Reference Meander Width Ratio (MWR$_{ref}$):	**1.5**		

Degree of Confinement Stability Rating ☞ **No Departure**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, A4a+ Poor South Reach **Location:** Pike National Forest, CO **Valley Type:** I **Observers:** Chavez, Kasun & Gallagher **Date:** 9/2/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	3	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	[✓ 6]	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ 12]
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 4]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	10	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ 12]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	[✓ 4]
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 3]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	[✓ 14]	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	[✓ 12]	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ 8]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ 16]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	[✓ 24]
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	3	Good total =	6	Fair total =	32	Poor total =	92

Stream type	A1	A2	A3	[✓ A4]	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	133
Existing stream type =	A4a+
*Potential stream type =	A4a+
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

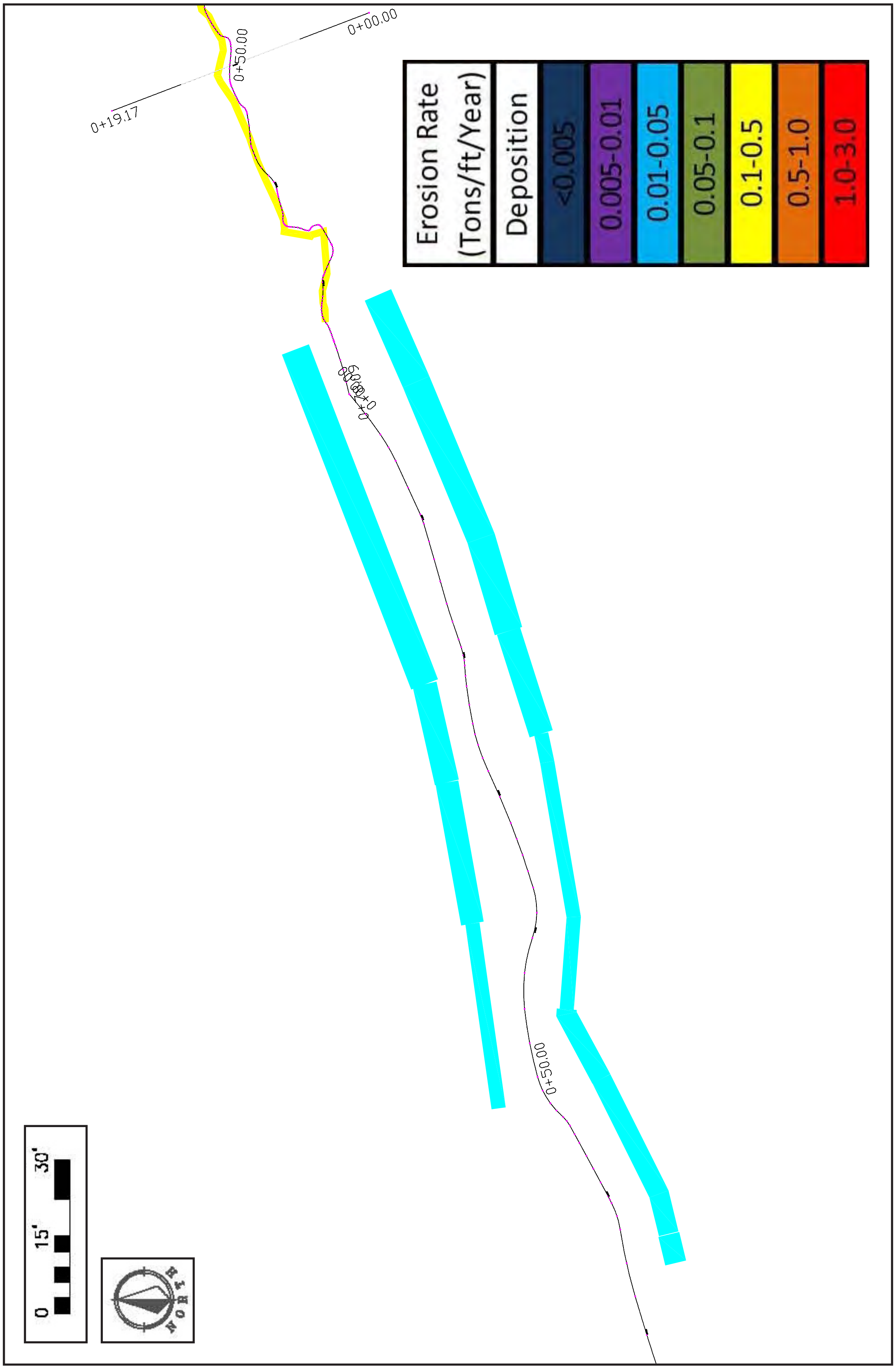
Stream: **Trail Creek, A4a+ Poor South Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **77** Date: **9/2/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I** Stream Type: **A4a+**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+0 - 0+25R**	**High**	**Low**	**0.25042**	**25.0**	**2.0**	**12.52**	**0.02411**
2. **0+0 - 0+25L**	**High**	**Low**	**0.25042**	**25.0**	**2.0**	**12.52**	**0.02411**
3. **0+25 - 0+32R**	**High**	**Low**	**0.25042**	**7.0**	**1.7**	**2.98**	**0.02050**
4. **0+25 - 0+32L**	**High**	**Low**	**0.25042**	**7.0**	**1.7**	**2.98**	**0.02050**
5. **0+32 - 0+42R**	**High**	**Low**	**0.25042**	**10.0**	**1.6**	**4.01**	**0.01929**
6. **0+25 - 0+55L**	**High**	**Low**	**0.25042**	**22.0**	**1.0**	**5.51**	**0.01206**
7. **0+42 - 0+55R**	**High**	**Low**	**0.25042**	**13.0**	**1.0**	**3.26**	**0.01206**
8 **0+55 - 0+60R**	**Moderate**	**Low**	**0.15287**	**5.0**	**1.4**	**1.07**	**0.01030**
9 **0+55 - 0+60L**	**High**	**Low**	**0.25042**	**5.0**	**1.4**	**1.75**	**0.01688**
10 **0+60 - 0+72R**	**Moderate**	**Low**	**0.15287**	**12.0**	**1.8**	**3.30**	**0.01325**
11 **0+63 - 0+75L**	**High**	**Low**	**0.25042**	**12.0**	**1.4**	**4.21**	**0.01688**
12 **0+72 - 0+77R**	**High**	**Low**	**0.25042**	**5.0**	**1.5**	**1.88**	**0.01809**
13 **0+75 - 0+77L**	**High**	**Low**	**0.25042**	**2.0**	**1.5**	**0.75**	**0.01809**
14							
15							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**56.74**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**2.10**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**2.73**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0355**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	0.32	0.0014	0.01406
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	0.8													
0.10%	0.7	0.05%	0.09%	0.34	0.8	2.363	7.461	0.00	6.670	0.87	0.3	0.00	0.30	0.30
0.25%	0.6	0.08%	0.15%	0.55	0.7	2.036	5.232	0.00	4.809	0.62	0.4	0.00	0.34	0.34
0.50%	0.5	0.13%	0.25%	0.91	0.6	1.761	3.706	0.00	3.494	0.45	0.5	0.00	0.41	0.41
0.75%	0.4	0.13%	0.25%	0.91	0.5	1.513	2.592	0.00	2.502	0.32	0.4	0.00	0.30	0.30
1%	0.4	0.13%	0.25%	0.91	0.4	1.300	1.817	0.00	1.790	0.23	0.4	0.00	0.21	0.21
1.5%	0.3	0.25%	0.50%	1.83	0.4	1.120	1.289	0.00	1.289	0.17	0.7	0.00	0.31	0.31
2%	0.3	0.25%	0.50%	1.83	0.3	0.949	0.886	0.00	0.893	0.12	0.6	0.00	0.21	0.21
3%	0.2	0.50%	1.00%	3.65	0.3	0.795	0.600	0.00	0.602	0.08	0.9	0.00	0.28	0.28
4%	0.2	0.50%	1.00%	3.65	0.2	0.674	0.424	0.00	0.415	0.05	0.8	0.00	0.20	0.20
5%	0.2	0.50%	1.00%	3.65	0.2	0.587	0.322	0.00	0.304	0.04	0.7	0.00	0.14	0.14
10%	0.1	2.50%	5.00%	18.25	0.1	0.450	0.200	0.00	0.165	0.02	2.6	0.00	0.39	0.39
20%	0.1	5.00%	10.00%	36.50	0.1	0.269	0.103	0.00	0.045	0.01	3.1	0.00	0.22	0.22
30%	0.0	5.00%	10.00%	36.50	0.1	0.158	0.075	0.00	0.006	0.00	1.8	0.00	0.03	0.03
40%	0.0	5.00%	10.00%	36.50	0.0	0.108	0.068	0.00	0.000	0.00	1.3	0.00	0.00	0.00
50%	0.0	5.00%	10.00%	36.50	0.0	0.079	0.066	0.00	0.000	0.00	0.9	0.00	0.00	0.00
60%	0.0	5.00%	10.00%	36.50	0.0	0.061	0.065	0.00	0.000	0.00	0.7	0.00	0.00	0.00
70%	0.0	5.00%	10.00%	36.50	0.0	0.047	0.064	0.00	0.000	0.00	0.6	0.00	0.00	0.00
80%	0.0	5.00%	10.00%	36.50	0.0	0.039	0.064	0.00	0.000	0.00	0.5	0.00	0.00	0.00
90%	0.0	5.00%	10.00%	36.50	0.0	0.032	0.064	0.00	0.000	0.00	0.4	0.00	0.00	0.00
100%	0.0	5.00%	10.00%	36.50	0.0	0.016	0.064	0.00	0.000	0.00	0.2	0.00	0.00	0.00
								Annual Totals:			17.6 (cfs) 35.0 (acre-ft)	0.0 (tons/yr)	3.3 (tons/yr)	3.3 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Poor" Pagosa	$y = 0.07176+1.02176x^{2.3772}$	0.32	0.00096	53.83
2. Suspended Sediment	"Poor" Pagosa	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	0.8													
0.10%	0.7	0.05%	0.09%	0.34	0.8	2.385	22.277	2.47	8.142	0.75	0.3	0.85	0.26	1.10
0.25%	0.6	0.08%	0.15%	0.55	0.7	2.059	13.032	1.25	5.757	0.53	0.4	0.68	0.29	0.97
0.50%	0.5	0.13%	0.25%	0.91	0.6	1.783	7.748	0.64	4.113	0.38	0.5	0.59	0.34	0.93
0.75%	0.5	0.13%	0.25%	0.91	0.5	1.536	4.525	0.32	2.904	0.27	0.4	0.29	0.24	0.54
1%	0.4	0.13%	0.25%	0.91	0.4	1.322	2.660	0.16	2.057	0.19	0.4	0.15	0.17	0.32
1.5%	0.3	0.25%	0.50%	1.83	0.4	1.143	1.599	0.08	1.475	0.14	0.7	0.16	0.25	0.40
2%	0.3	0.25%	0.50%	1.83	0.3	0.971	0.927	0.04	1.025	0.09	0.6	0.08	0.17	0.25
3%	0.2	0.50%	1.00%	3.65	0.3	0.817	0.539	0.02	0.704	0.06	1.0	0.07	0.24	0.31
4%	0.2	0.50%	1.00%	3.65	0.2	0.695	0.342	0.01	0.502	0.05	0.8	0.04	0.17	0.21
5%	0.2	0.50%	1.00%	3.65	0.2	0.606	0.246	0.01	0.382	0.04	0.7	0.03	0.13	0.15
10%	0.1	2.50%	5.00%	18.25	0.1	0.465	0.155	0.00	0.237	0.02	2.7	0.06	0.40	0.46
20%	0.1	5.00%	10.00%	36.50	0.1	0.275	0.107	0.00	0.119	0.01	3.2	0.05	0.40	0.45
30%	0.0	5.00%	10.00%	36.50	0.1	0.159	0.100	0.00	0.085	0.01	1.9	0.03	0.28	0.31
40%	0.0	5.00%	10.00%	36.50	0.0	0.108	0.099	0.00	0.077	0.01	1.3	0.02	0.26	0.28
50%	0.0	5.00%	10.00%	36.50	0.0	0.079	0.099	0.00	0.074	0.01	0.9	0.01	0.25	0.26
60%	0.0	5.00%	10.00%	36.50	0.0	0.061	0.099	0.00	0.073	0.01	0.7	0.01	0.24	0.25
70%	0.0	5.00%	10.00%	36.50	0.0	0.047	0.099	0.00	0.072	0.01	0.6	0.01	0.24	0.25
80%	0.0	5.00%	10.00%	36.50	0.0	0.039	0.099	0.00	0.072	0.01	0.5	0.01	0.24	0.25
90%	0.0	5.00%	10.00%	36.50	0.0	0.032	0.099	0.00	0.072	0.01	0.4	0.01	0.24	0.25
100%	0.0	5.00%	10.00%	36.50	0.0	0.016	0.099	0.00	0.072	0.01	0.2	0.00	0.24	0.24
								Annual Totals:			17.9 (cfs) 35.6 (acre-ft)	3.1 (tons/yr)	5.0 (tons/yr)	8.2 (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, A4a+ Poor South Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

Enter Required Information for Existing Condition

4.8	D_{50}	Riffle bed material D_{50} (mm)			
	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.30	D_{max}	Largest particle from **Bed Material** (ft)	**90**	**(mm)**	304.8 mm/ft
0.1280	S	Existing bankfull water surface slope (ft/ft)			
0.22	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

1.757		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 **140**	CO **230**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **1.2**	CO **0.48**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.15**	CO **0.06**	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 **0.0874**	CO **0.0350**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, A4a+ Poor South** Stream Type: **A4a+**

Location: **Pike National Forest, CO** Valley Type: **I**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, A4a+ Poor South Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

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 5-13)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**2**
	0.82 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 Depositional Patterns (Worksheet 5-10)	B1, B2	B4, B8	B3	**B5**, B6, B7	**4**
	(1)	**(2)**	**(3)**	**B4, B5** [✓ **(4)**]	
3 Meander Patterns (Worksheet 5-9)	M1, M3, M4		M2, M5, M6, M7, M8		**1**
	M1 [✓ **(1)**]		**(3)**		
4 Dominant BEHI / NBS (Worksheet 5-18)	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, **H/L**, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**6**
	(2)	**(4)**	**H/L** [✓ **(6)**]	**(8)**	
5 Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	1.0 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**14**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐	

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, A4a+ Poor South Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	Excess [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
	Excess [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	0.82 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, **B4**	B3, **B5**	B6, B7, B8	**3**
	(1)	**(2)**	**B4, B5** [✓ **(3)**]	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	**D1**, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D1 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**12**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream: **Trail Creek, A4a+ Poor South Reach** Stream Type: **A4a+**
Location: **Pike National Forest, Colorado** Valley Type: **I**
Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

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 5-22)**	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	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	**4.70** [✓ **(8)**]	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**4**
	(2)	**BHR 4.7, W/D 9** [✓ **(4)**]	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.00 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**29**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☑

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, A4a+ Poor South Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

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 5-24)**	**Stream Type at Potential**, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **at potential [✓ (2)]**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **[✓ (6)]**	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **[✓ (2)]**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **[✓ (8)]**	**8**
				Total Points	**18**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream: **Trail Creek, A4a+ Poor South Reach** Stream Type: **A4a+**

Location: **Pike National Forest, Colorado** Valley Type: **I**

Observers: **Chavez, Kasun & Gallagher** Date: **9/2/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	1	3
	Mod. Unstable	2	
	Unstable	[✓ 3]	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	1	4
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	[✓ 4]	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	3
	Slight Increase	2	
	Mod. Increase	[✓ 3]	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	1	4
	Fair: Mod. Unstable	2	
	Poor: Unstable	[✓ 4]	
		Total Points	**15**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, A4a+ Poor South Reach**				Location:	**Pike National Forest, Colorado**				
Observers:	**Chavez, Kasun & Gallagher**		Date:	**9/2/2010**		Stream Type:	**A4a+**		Valley Type:	**I**
Channel Dimension (XS 0+99.1)	Mean Bankfull Depth (ft):	**0.22**	Bankfull Width (ft):	**1.98**	Cross-Sectional Area (ft^2):	**0.44**	Width of Flood-Prone Area (ft):	**2.91**	Entrenchment Ratio:	**1.47**
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**N/A**	Sinuosity: **1.01**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope	
		0.48			**2.4**				Valley: **0.129**	Water Surface: **0.128**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:		Remarks: Condition, Vigor & Usage of Existing Reach:				
		Aspen, Raspberry		**Aspen, Ponderosa Pine**		**Sideslope rill on south aspects, veg. recovering.**				
	Flow Regime:	**E1, E2, E8**	Stream Size & Order:	**S-2(1)**	Meander Patterns:	**M1**	Depositional Patterns:	**B4, B5**	Debris/Channel Blockages:	**D1 (None)**
	Degree of Incision (Bank-Height Ratio):	**4.7**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**133 (Poor)**				
	Width/depth Ratio (W/d):	**9**	Reference W/d Ratio (W/d_{ref}):	**11**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**0.82**	W/d Ratio State Stability Rating:	**Stable**		
	Meander Width Ratio (MWR):	**1.5**	Reference MWR_{ref}:	**1.5**	Degree of confinement (MWR / MWR_{ref}):	**1**	MWR / MWR_{ref} Stability Rating:	**No Departure from Reference**		
Bank Erosion Summary	Length of Reach Studied (ft):	**77**	Annual Streambank Erosion Rate:	**2.73** (tons/yr)	**0.0355** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity	Remarks:						
Entrainment/ Competence	Largest Particle from **Bed Material** (mm):	**90**	$\tau =$	**1.757**	$\tau^* =$	**N/A**	Existing Depth: **0.22**	Required Depth: **0.15**	Existing Slope: **0.128**	Required Slope: **0.087**
Successional Stage Shift	**A4a+** →	**A4a+** →	→	→	→	Existing Stream State (Type):	**A4a+**	Potential Stream State (Type):	**A4a+**	
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:					
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:					
Vertical Stability (Degradation)	☐ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☑ *Degradation*	Remarks/causes:					
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:					
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:					

Appendix C4

A4a+ Stream Type

Poor Stability Downstream Reach

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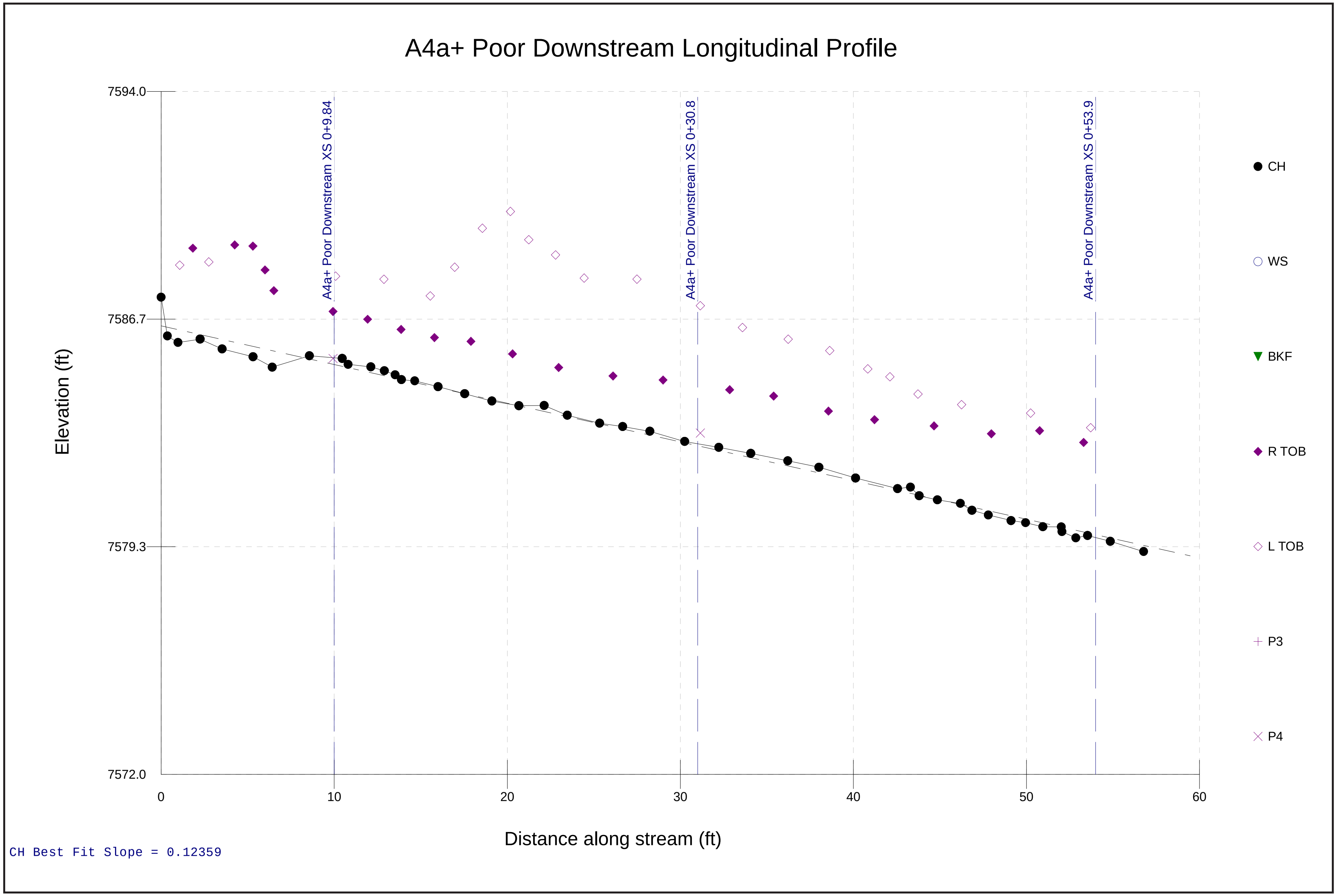
Appendix C4: A4a+ Poor Downstream Reach

A4a+ Poor Downstream Reach Location & Overview

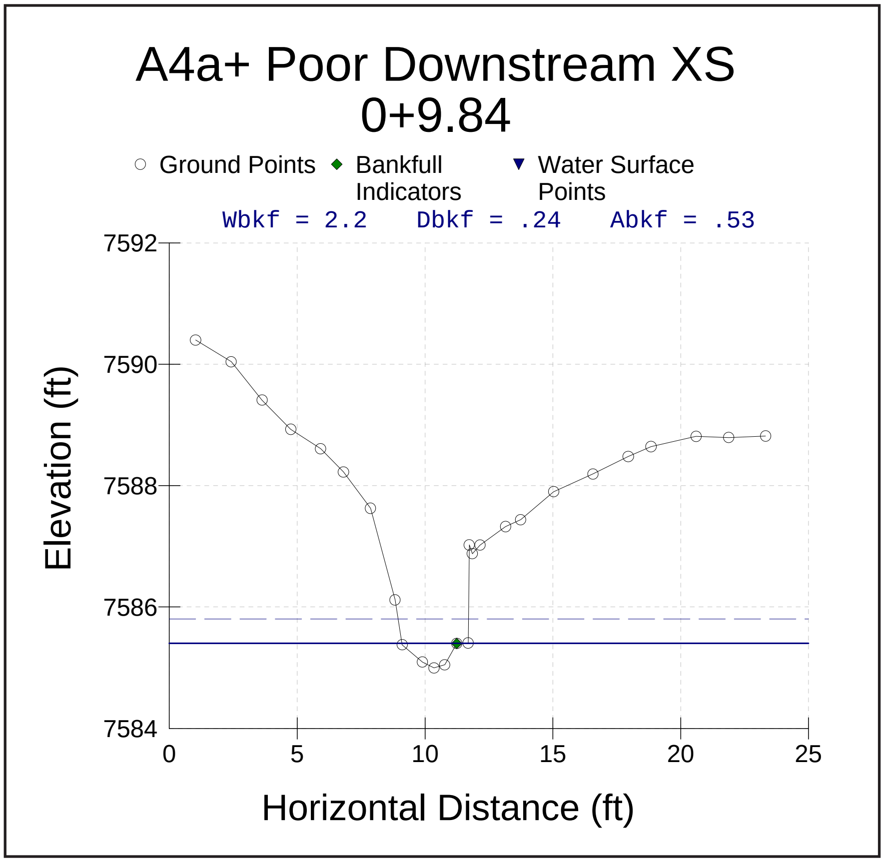
The A4a+ Poor downstream reach is a 2nd order, ephemeral stream in the Trail Creek Watershed (**Figure C-2**) with a high sediment supply due to channel processes. The stability rating is "Poor" due to degradation, active incision, and lateral instability. The streambank erosion rate is *0.0785 tons/yr/ft*, more than an order of magnitude higher than its reference condition (*0.0017 tons/yr/ft*). The sediment supply rating is also *High* due to the same processes including a *Moderate Increase* in channel enlargement. The overall rating of "Poor" indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows. The bankfull discharge for this small ephemeral stream is 0.41 cfs. The increase in flow using the WRENSS model is *1.0 acre-ft*. The corresponding increase in bedload using the FLOWSED model is *2.6 tons/yr* and *4.2 tons/yr* of suspended sediment, with a total sediment increase of *6.8 tons/yr*. The pre-fire sediment yields were one-third of this value.

The photograph depicts the typical character of this representative A4a+ Poor stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

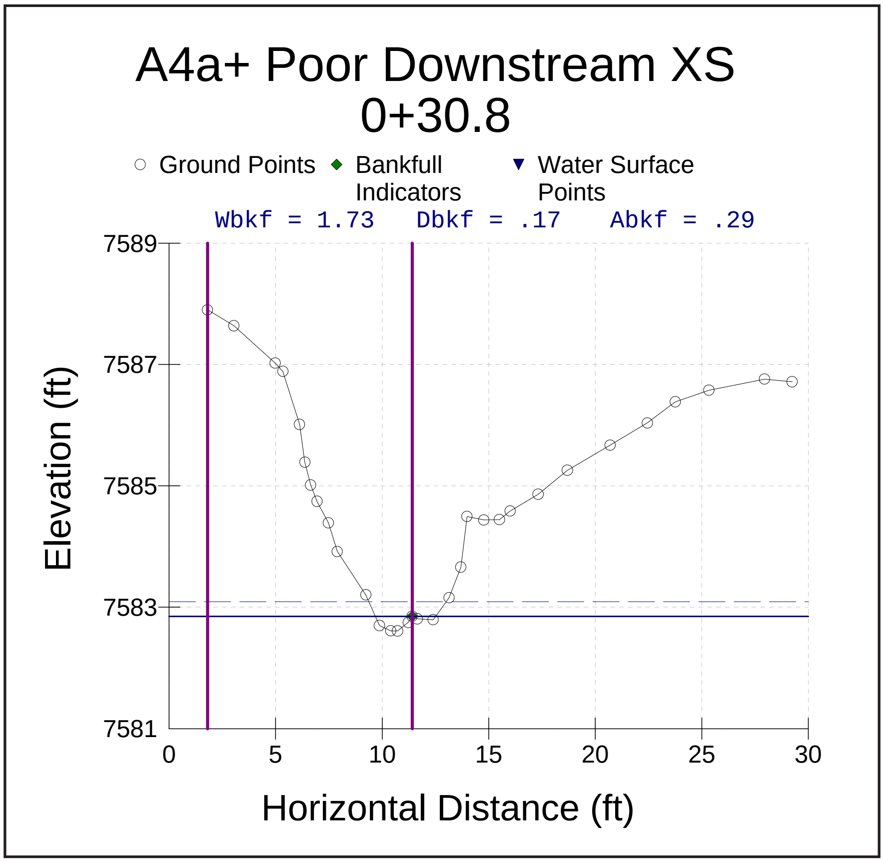
Survey Summary



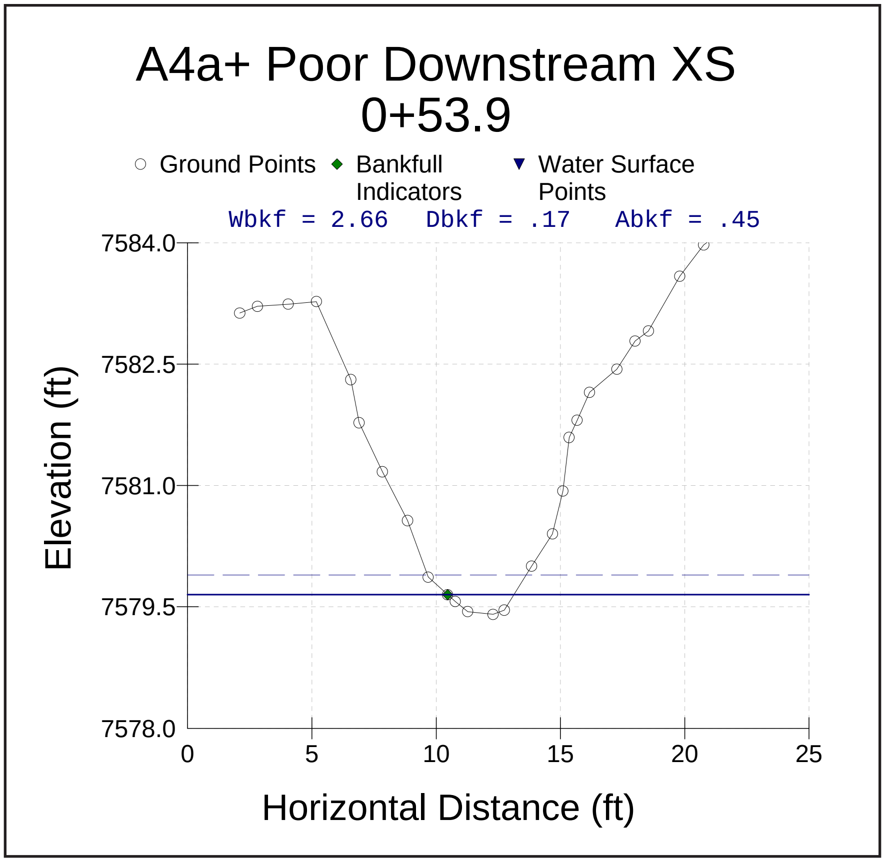
Longitudinal Profile (graph generated from RIVERMorph^{TM})



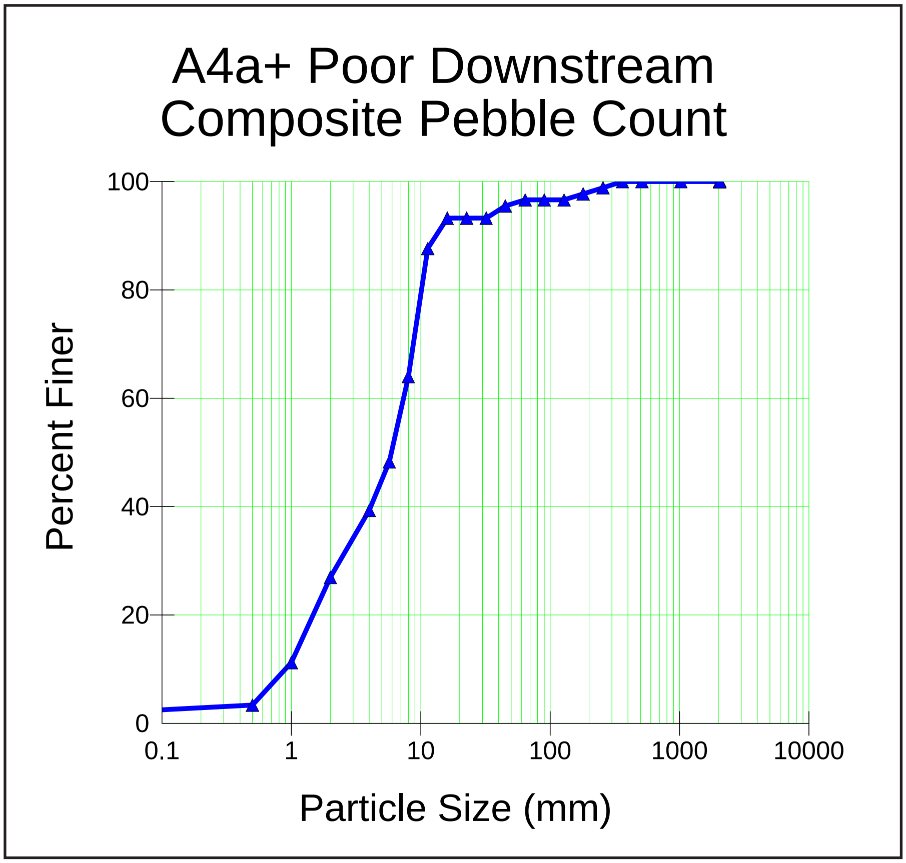
Representative Cross-section 0+9.84 (graph generated from RIVERMorph^{TM})



Cross-section 0+30.8 (graph generated from RIVERMorph^{TM})



Cross-section 0+53.9 (graph generated from RIVERMorph™)



Composite Pebble Count (graph generated from RIVERMorph™)

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, A4a+ Poor Downstream**			Location:	**XS 0+9.84, Pike N.F., Colorado**
Date:	**9/3/2010**	Stream Type:	**A4a+**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**			HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	**0.53**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.24**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**2.20**	W_{bkf} (ft)	Wetted PERMIMETER ~ (2 * d_{bkf}) + W_{bkf}	**2.68**	W_p (ft)
D_{84} at Riffle	**10.8**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.04**	D_{84} (ft)
Bankfull SLOPE	**0.1236**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.20**	**R** (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**5.58**	**R / D_{84}**
Drainage Area	**0.0027**	**DA** (mi^2)	Shear Velocity u* = (gRS)^{½}	**0.887**	**u*** (ft/sec)

ESTIMATION METHODS	**Bankfull VELOCITY**		**Bankfull DISCHARGE**	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log \{ R / D_{84} \}] u*$	**6.26**	ft / sec	**3.32**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ ***n* =** **0.0094**	**18.91**	ft / sec	**10.02**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ ***n* =**		ft / sec		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* =** **0.228**	**0.78**	ft / sec	**0.41**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, A4a+ Poor Downstream Reach**

Basin: Drainage Area: acres **0.0027** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+9.84** Date: **9/3/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **III**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**2.20**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.24**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**0.53**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.17**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.40**	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.	**2.75**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.25**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**6**	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.	**0.1236**	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 (S_{val} / S).	**1.09**	

Stream Type → **A4a+** ← **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4a+ Poor Downstream Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010** Valley Type: **III** Stream Type: **A4a+**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**2.2**	**1.7**	**2.7**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**0.42**	**0.29**	**0.53**
Mean Riffle Depth (d_{bkf})	**0.19**	**0.17**	**0.24**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**11.7**	**9.2**	**15.7**
Maximum Riffle Depth (d_{max})	**0.29**	**0.24**	**0.40**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	**1.497**	**1.411**	**1.667**
Width of Flood-Prone Area (W_{fpa})	**2.91**	**2.01**	**3.97**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.30**	**1.16**	**1.49**
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4a+ Poor Downstream Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010** Valley Type: **III** Stream Type: **A4a+**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**0.78**	ft/sec	Estimation Method	**Manning's n from Jarrett**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**0.41**	cfs	Drainage Area	**0.0027**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**13.8**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**6.30**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.1347**	ft/ft	Average Water Surface Slope (S)	**0.1236**	ft/ft	Sinuosity (S_{val} / S)	**1.09**
Stream Length (SL)	**72.1**	ft	Valley Length (VL)	**66.0**	ft	Sinuosity (SL / VL)	**1.09**

Low Bank Height (LBH)	start	**2.05**	ft	Max Bankfull Depth (d_{max})	start	**0.40**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**5.1**	
	end		ft		end		ft		end		

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

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

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**			D_{16}	**1.30**				mm
% Sand	**27**			D_{35}	**3.30**				mm
% Gravel	**70**			D_{50}	**5.95**				mm
% Cobble	**2**			D_{84}	**10.79**				mm
% Boulder	**1**			D_{95}	**42.05**				mm
% Bedrock	**0**			D_{100}	**361.99**				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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, A4a+ Poor Downstream Reach**

Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **9/3/2010**

Existing species composition: **Ponderosa Pine Seedlings, Forbs/Grass**

Potential species composition: **Mature Ponderosa Pine, Shrubs, Forb/Grass**

	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**	**100%**
					100%
2. Understory	Shrub layer	▨	**1%**	**Raspberry**	**100%**
					100%
3. Ground level	Herbaceous	▨	**48%**	**Geranium**	**50%**
				Grass (little bluestem, grama, cheat)	**50%**
					100%
	Leaf or needle litter	▨	**20%**		
	Bare ground	▨	**30%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or
usage of existing reach:
Ponderosa Pine beginning to regenerate

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, A4a+ Poor Dwnstm** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL COMBINATIONS that APPLY..............☞	**E1**	**E2**	**E8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, A4a+ Poor Downstream**
Location: **Pike National Forest, Colorado**
Observers: **Chavez, Kasun & Gallagher**
Date: **9/3/2010**

Stream Size Category and Order ☞ **S-2(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 5-9. Meander patterns.

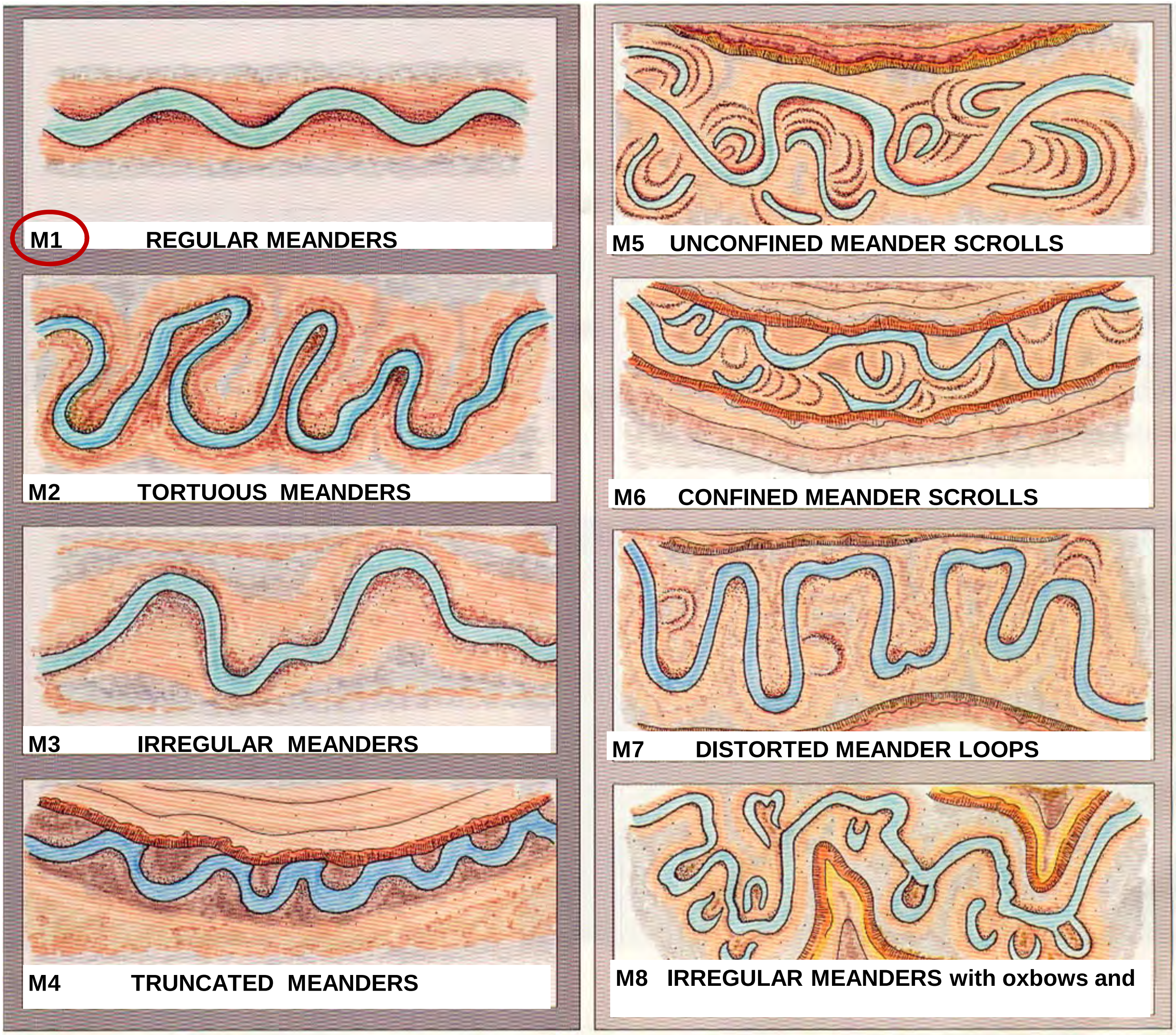
Meander Patterns

Stream: **Trail Creek, A4a+ Poor Downstream** Location: **Pike National Forest, CO**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL CATEGORIES that APPLY ☞	**M1**				

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



Worksheet 5-10. Depositional patterns.

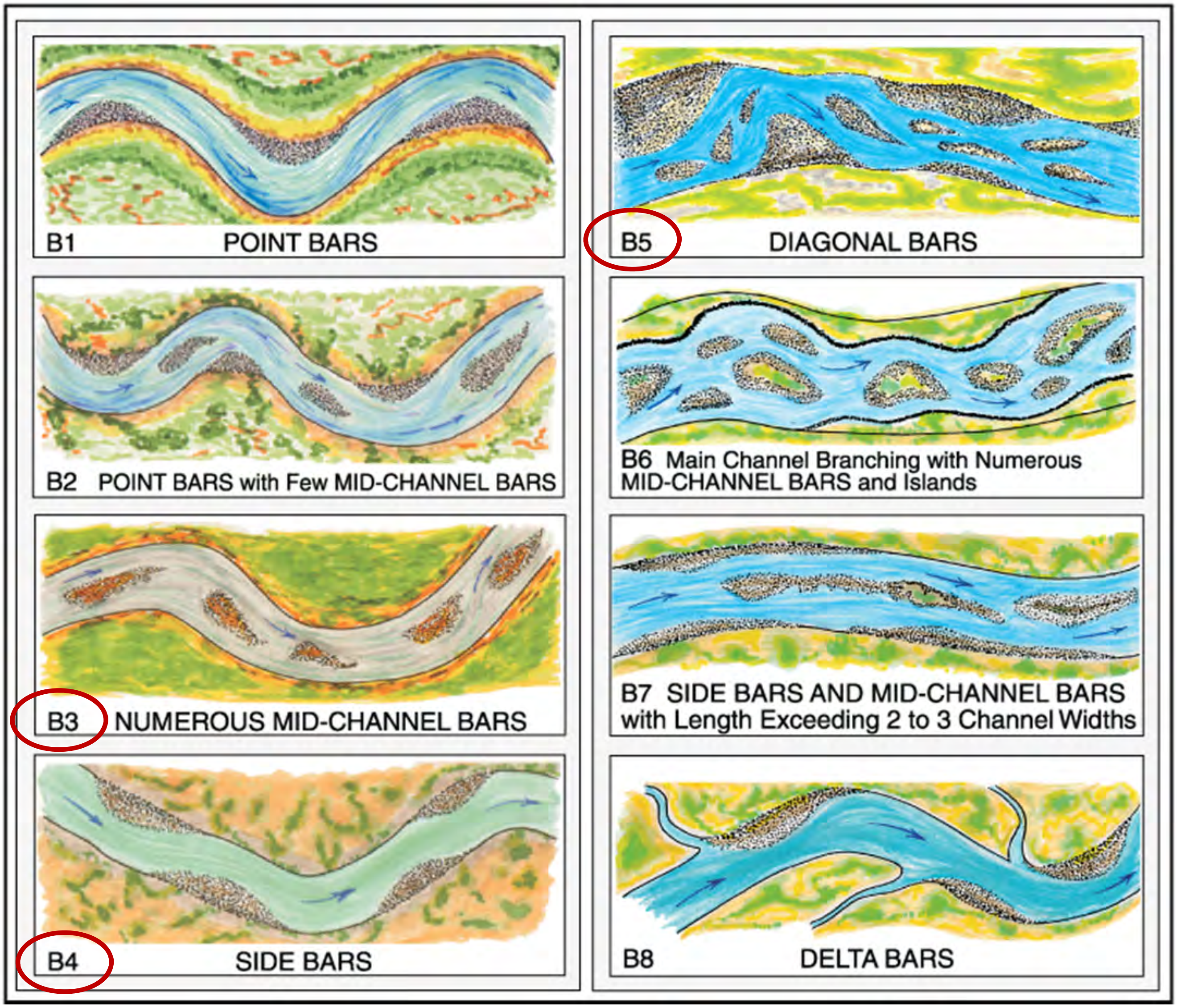
Depositional Patterns

Stream: **Trail Creek, A4a+ Poor Downstream** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL CATEGORIES that APPLY ☞	**B3**	**B4**	**B5**		

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, A4a+ Poor Downstream Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

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.	☐

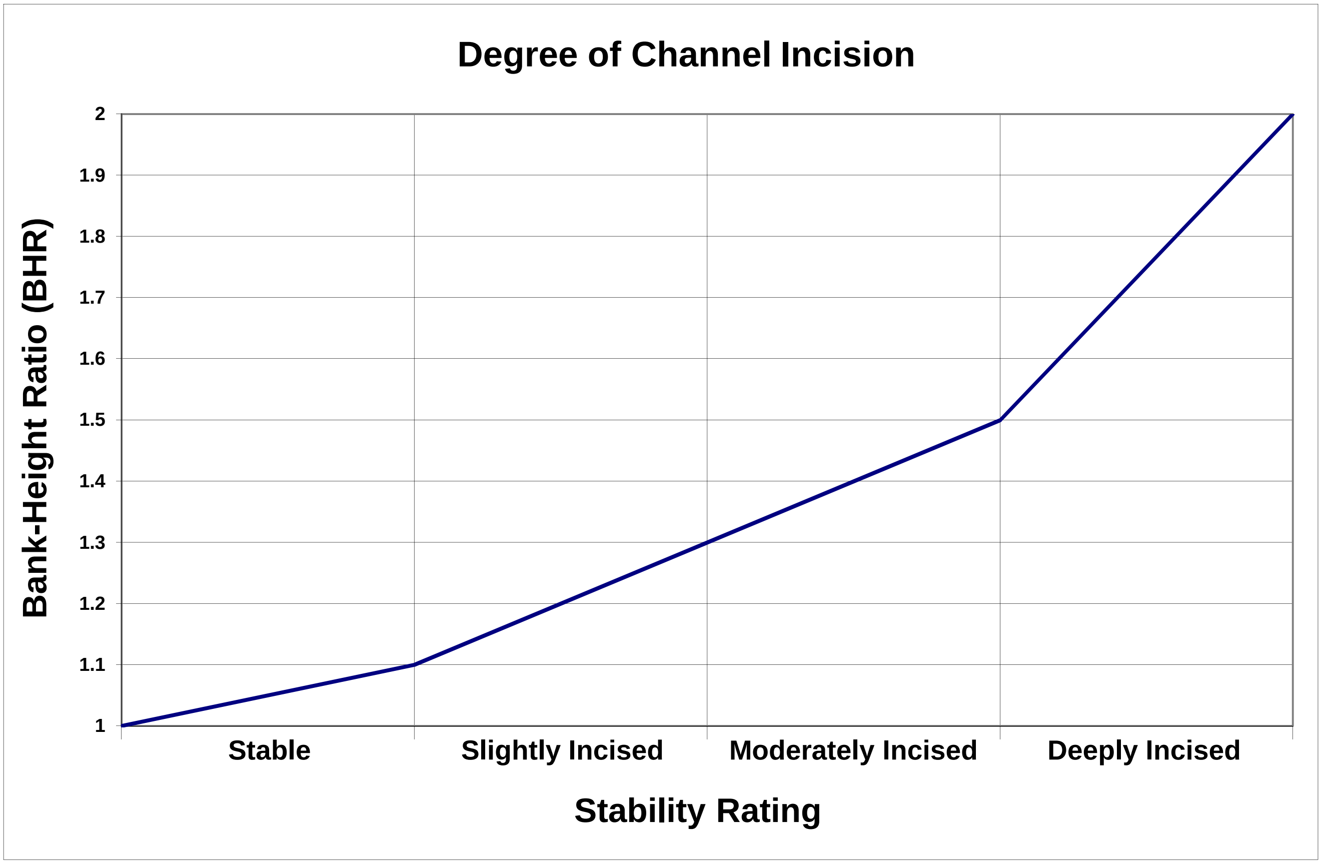
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**2.05**
Max Bankfull Depth:	**0.4**

Bank-Height Ratio:	**5.1**

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



Worksheet 5-13. Width/depth ratio state.

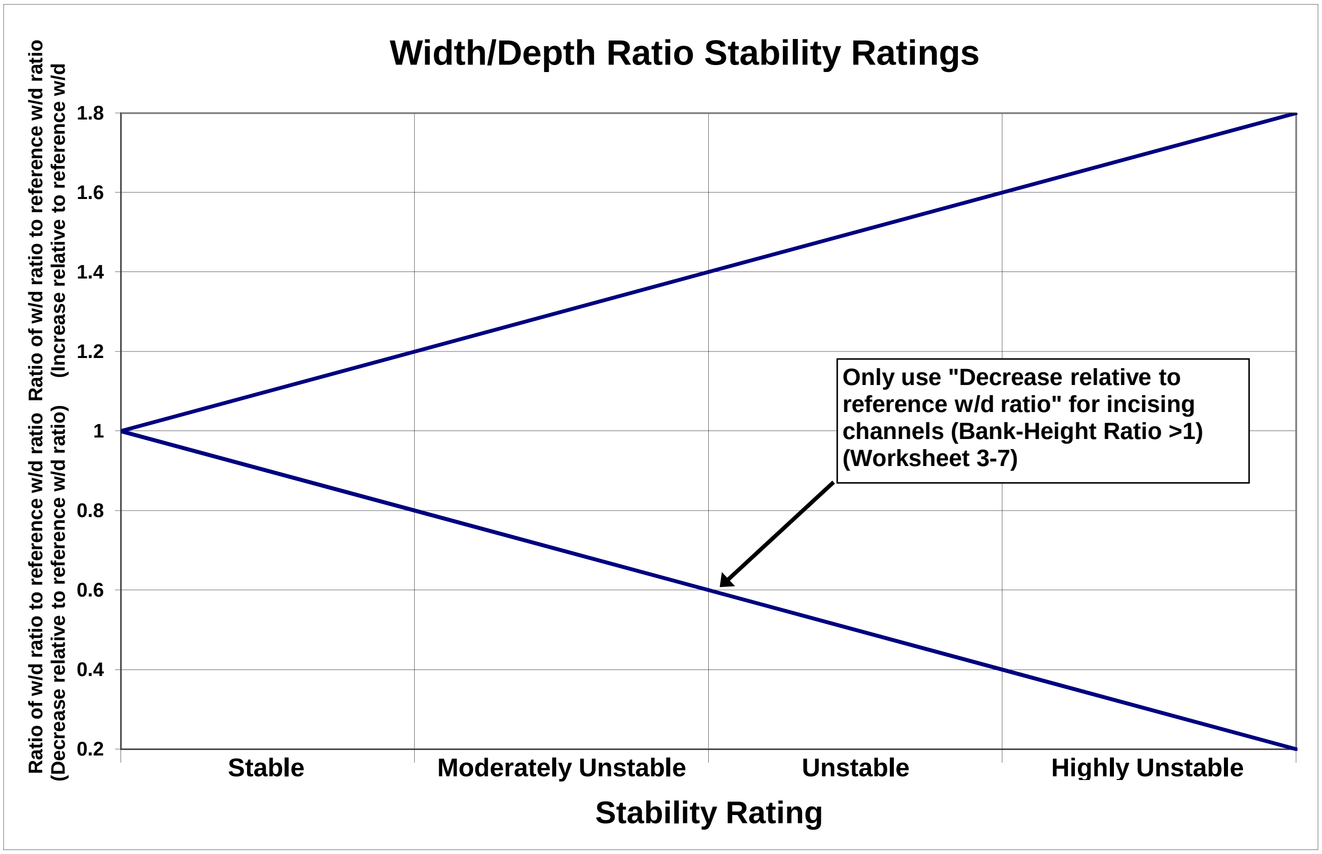
Width/Depth Ratio State

Existing Width/Depth Ratio: **9.17**

Reference Width/Depth Ratio: **10.95**

Ratio of existing W/d to reference W/d: **0.84**

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



Worksheet 5-14. Degree of channel confinement (lateral containment).

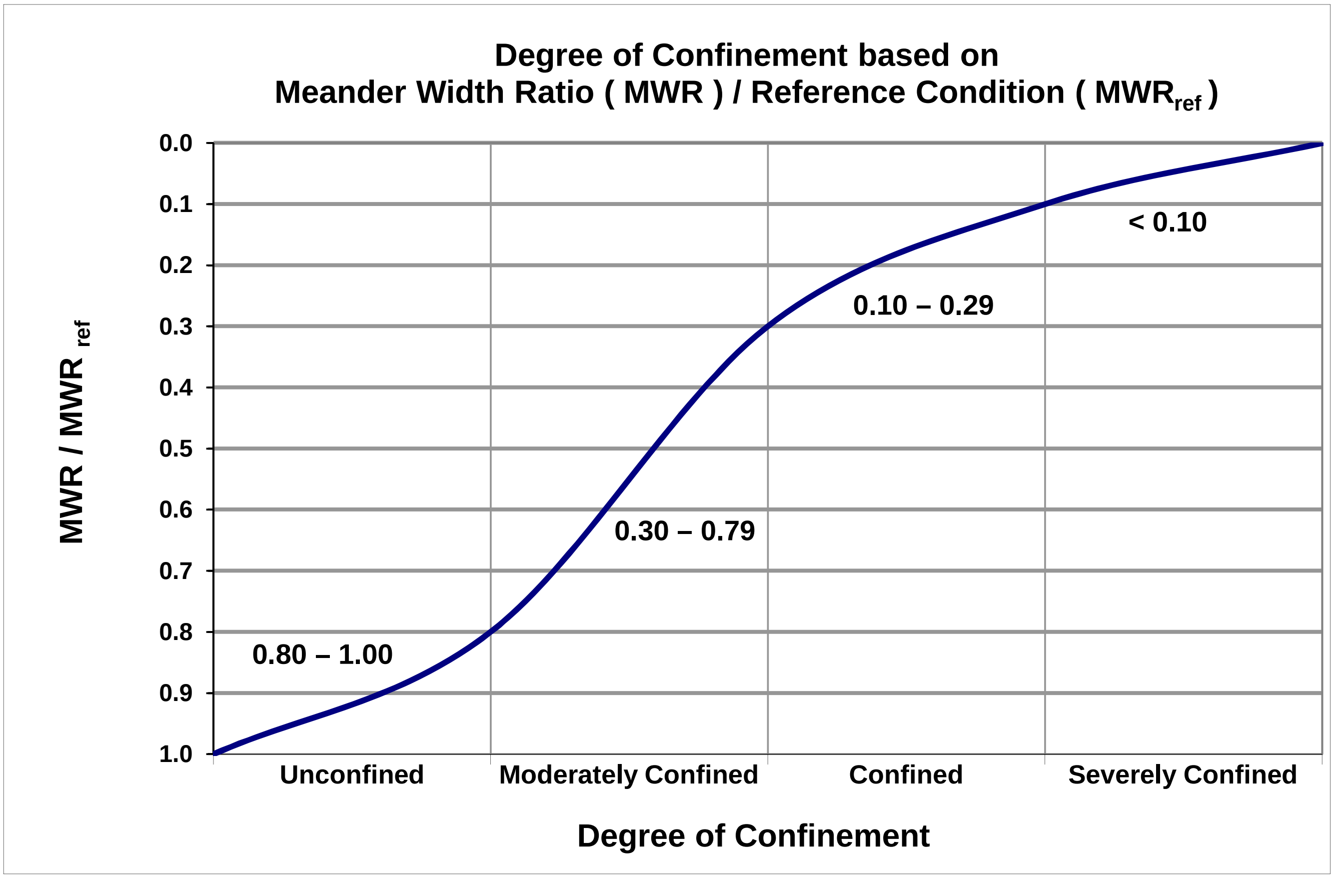
Degree of Confinement

Existing Meander Width Ratio (MWR): **5.4**

Reference Meander Width Ratio (MWR_{ref}): **1.5**

Ratio of MWR to MWR_{ref}: **3.60**

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, A4a+ Poor Downstream **Location: Pike National Forest, CO** **Valley Type: III** **Observers: Chavez, Kasun & Gallagher** **Date: 9/3/2010**

Loca-tion	Key	Category	Excellent Description	Rating	Good Description	Rating	Fair Description	Rating	Poor Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	3	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	**0**	**Good total =**	**12**	**Fair total =**	**0**	**Poor total =**	**128**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**140**
Existing stream type =	**A4a+**
***Potential stream type =**	**A4a+**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, A4a+ Poor Downstream** Location: **Pike National Forest, Colorado**

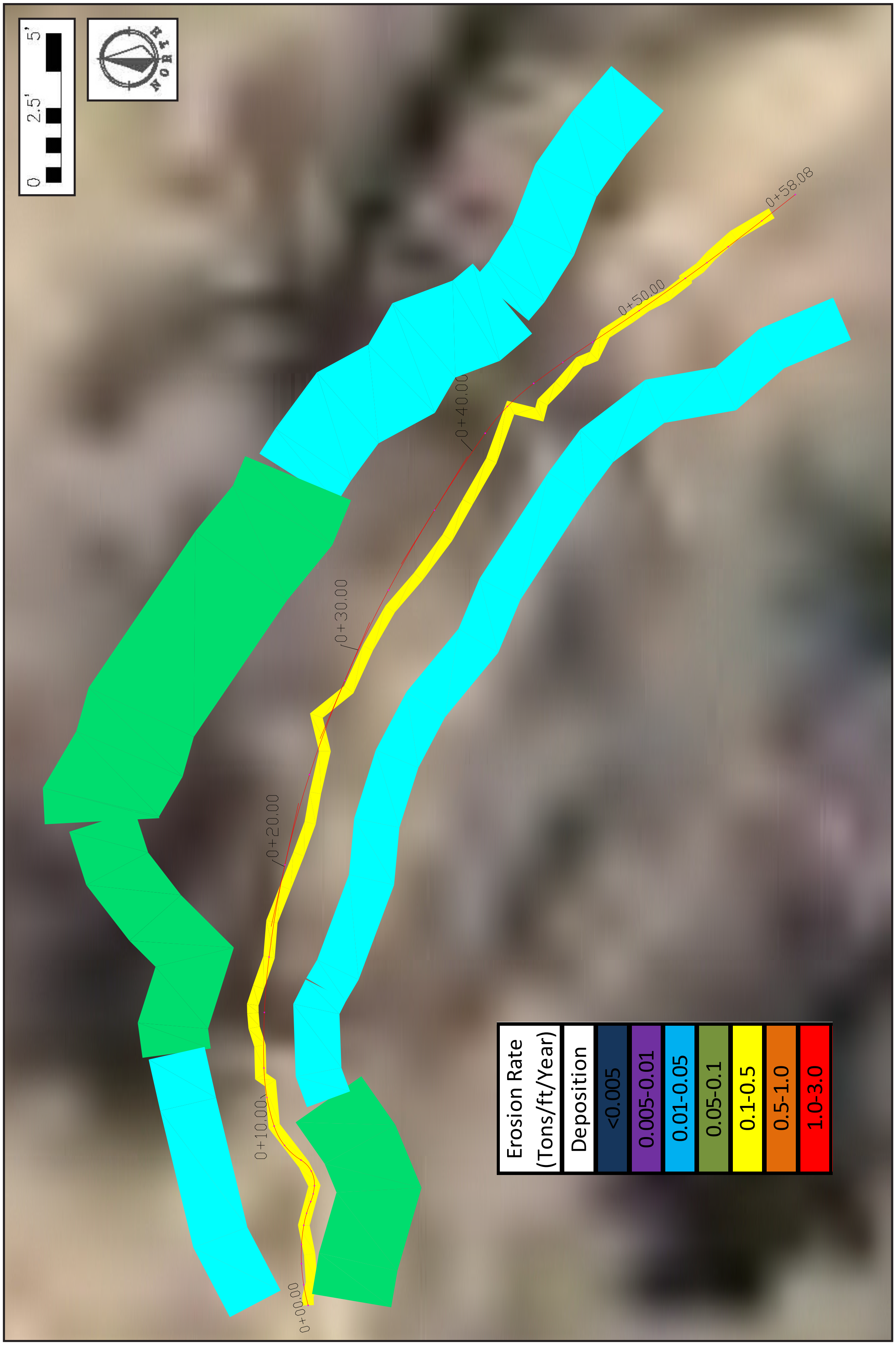
Graph Used: **Colorado** Total Stream Length (ft): **58** Date: **9/3/2010**

Observers: **Chavez, Kasun, Gallagher** Valley Type: **III** Stream Type: **A4a+**

(1) Station (ft)	(2) BEHI rating (Worksheet 5-16) (adjective)	(3) NBS rating (Worksheet 5-17) (adjective)	(4) Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. R_0+00 - 0+09	Extreme	Low	0.41998	9.0	3.5	13.23	0.07077
2. L_0+00 - 0+11	Very High	Low	0.25042	11.0	2.5	6.89	0.03014
3. R_0+09 - 0+15	Very High	Low	0.25042	6.0	2.0	3.01	0.02411
4. L_0+11 - 0+19	Extreme	Low	0.41998	8.0	3.0	10.08	0.06066
5. R_0+15 - 0+58	Very High	Low	0.25042	43.0	2.0	21.54	0.02411
6. L_0+19 - 0+35	Very High	Low	0.25042	16.0	5.0	20.03	0.06029
7. L_0+35 - 0+45	Very High	Low	0.25042	10.0	4.0	10.02	0.04823
8 L_0+45 - 0+58	Very High	Low	0.25042	13.0	3.0	9.77	0.03617
9							
10							
11							
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total Erosion (ft^3/yr)	94.55
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	Total Erosion (yds^3/yr)	3.50
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	Total Erosion (tons/yr)	4.55
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	Total Erosion (tons/yr/ft)	0.0785

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**0.41**	**0.0015**	**0.0182**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**1.0**													
0.10%	**0.9**	**0.05%**	**0.09%**	**0.34**	**1.0**	**2.363**	**7.461**	**0.00**	**6.670**	**0.94**	**0.3**	**0.00**	**0.32**	**0.32**
0.25%	**0.8**	**0.08%**	**0.15%**	**0.55**	**0.8**	**2.036**	**5.232**	**0.00**	**4.809**	**0.68**	**0.5**	**0.00**	**0.37**	**0.37**
0.50%	**0.7**	**0.13%**	**0.25%**	**0.91**	**0.7**	**1.761**	**3.706**	**0.00**	**3.494**	**0.49**	**0.7**	**0.00**	**0.45**	**0.45**
0.75%	**0.6**	**0.13%**	**0.25%**	**0.91**	**0.6**	**1.513**	**2.592**	**0.00**	**2.502**	**0.35**	**0.6**	**0.00**	**0.32**	**0.32**
1%	**0.5**	**0.13%**	**0.25%**	**0.91**	**0.5**	**1.300**	**1.817**	**0.00**	**1.790**	**0.25**	**0.5**	**0.00**	**0.23**	**0.23**
1.5%	**0.4**	**0.25%**	**0.50%**	**1.83**	**0.5**	**1.120**	**1.289**	**0.00**	**1.289**	**0.18**	**0.8**	**0.00**	**0.33**	**0.33**
2%	**0.4**	**0.25%**	**0.50%**	**1.83**	**0.4**	**0.949**	**0.886**	**0.00**	**0.893**	**0.13**	**0.7**	**0.00**	**0.23**	**0.23**
3%	**0.3**	**0.50%**	**1.00%**	**3.65**	**0.3**	**0.795**	**0.600**	**0.00**	**0.602**	**0.09**	**1.2**	**0.00**	**0.31**	**0.31**
4%	**0.3**	**0.50%**	**1.00%**	**3.65**	**0.3**	**0.674**	**0.424**	**0.00**	**0.415**	**0.06**	**1.0**	**0.00**	**0.21**	**0.21**
5%	**0.2**	**0.50%**	**1.00%**	**3.65**	**0.2**	**0.587**	**0.322**	**0.00**	**0.304**	**0.04**	**0.9**	**0.00**	**0.16**	**0.16**
10%	**0.1**	**2.50%**	**5.00%**	**18.25**	**0.2**	**0.450**	**0.200**	**0.00**	**0.165**	**0.02**	**3.4**	**0.00**	**0.43**	**0.43**
20%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.269**	**0.103**	**0.00**	**0.045**	**0.01**	**4.0**	**0.00**	**0.23**	**0.23**
30%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.158**	**0.075**	**0.00**	**0.006**	**0.00**	**2.4**	**0.00**	**0.03**	**0.03**
40%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.108**	**0.068**	**0.00**	**0.000**	**0.00**	**1.6**	**0.00**	**0.00**	**0.00**
50%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.079**	**0.066**	**0.00**	**0.000**	**0.00**	**1.2**	**0.00**	**0.00**	**0.00**
60%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.061**	**0.065**	**0.00**	**0.000**	**0.00**	**0.9**	**0.00**	**0.00**	**0.00**
70%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**0.7**	**0.00**	**0.00**	**0.00**
80%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**0.6**	**0.00**	**0.00**	**0.00**
90%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**0.5**	**0.00**	**0.00**	**0.00**
100%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**0.2**	**0.00**	**0.00**	**0.00**
									Annual Totals:		**22.6** (cfs) **44.8** (acre-ft)	**0.0** (tons/yr)	**3.6** (tons/yr)	**3.6** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Poor" Pagosa**	$y = 0.07176+1.02176x^{2.3772}$	**0.41**	**0.0012**	**56.45**
2. Suspended Sediment	**"Poor" Pagosa**	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**1.1**													
0.10%	**0.9**	**0.05%**	**0.09%**	**0.34**	**1.0**	**2.387**	**22.319**	**3.33**	**8.152**	**0.92**	**0.3**	**1.14**	**0.32**	**1.46**
0.25%	**0.8**	**0.08%**	**0.15%**	**0.55**	**0.8**	**2.060**	**13.060**	**1.68**	**5.765**	**0.65**	**0.5**	**0.92**	**0.36**	**1.28**
0.50%	**0.7**	**0.13%**	**0.25%**	**0.91**	**0.7**	**1.785**	**7.767**	**0.87**	**4.120**	**0.46**	**0.7**	**0.79**	**0.42**	**1.21**
0.75%	**0.6**	**0.13%**	**0.25%**	**0.91**	**0.6**	**1.537**	**4.537**	**0.44**	**2.910**	**0.33**	**0.6**	**0.40**	**0.30**	**0.70**
1%	**0.5**	**0.13%**	**0.25%**	**0.91**	**0.5**	**1.324**	**2.669**	**0.22**	**2.061**	**0.23**	**0.5**	**0.20**	**0.21**	**0.41**
1.5%	**0.4**	**0.25%**	**0.50%**	**1.83**	**0.5**	**1.144**	**1.605**	**0.11**	**1.478**	**0.17**	**0.9**	**0.21**	**0.30**	**0.51**
2%	**0.4**	**0.25%**	**0.50%**	**1.83**	**0.4**	**0.972**	**0.930**	**0.06**	**1.028**	**0.12**	**0.7**	**0.10**	**0.21**	**0.31**
3%	**0.3**	**0.50%**	**1.00%**	**3.65**	**0.3**	**0.818**	**0.541**	**0.03**	**0.706**	**0.08**	**1.2**	**0.10**	**0.29**	**0.39**
4%	**0.3**	**0.50%**	**1.00%**	**3.65**	**0.3**	**0.696**	**0.344**	**0.01**	**0.504**	**0.06**	**1.0**	**0.05**	**0.21**	**0.26**
5%	**0.2**	**0.50%**	**1.00%**	**3.65**	**0.2**	**0.607**	**0.247**	**0.01**	**0.384**	**0.04**	**0.9**	**0.03**	**0.16**	**0.19**
10%	**0.1**	**2.50%**	**5.00%**	**18.25**	**0.2**	**0.465**	**0.155**	**0.00**	**0.238**	**0.03**	**3.5**	**0.08**	**0.49**	**0.57**
20%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.275**	**0.107**	**0.00**	**0.119**	**0.01**	**4.1**	**0.07**	**0.49**	**0.56**
30%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.159**	**0.100**	**0.00**	**0.085**	**0.01**	**2.4**	**0.04**	**0.35**	**0.38**
40%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.108**	**0.099**	**0.00**	**0.077**	**0.01**	**1.6**	**0.02**	**0.32**	**0.34**
50%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.079**	**0.099**	**0.00**	**0.074**	**0.01**	**1.2**	**0.02**	**0.31**	**0.32**
60%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.061**	**0.099**	**0.00**	**0.073**	**0.01**	**0.9**	**0.01**	**0.30**	**0.31**
70%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.047**	**0.099**	**0.00**	**0.072**	**0.01**	**0.7**	**0.01**	**0.30**	**0.31**
80%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.039**	**0.099**	**0.00**	**0.072**	**0.01**	**0.6**	**0.01**	**0.30**	**0.31**
90%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.032**	**0.099**	**0.00**	**0.072**	**0.01**	**0.5**	**0.01**	**0.30**	**0.30**
100%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.016**	**0.099**	**0.00**	**0.072**	**0.01**	**0.2**	**0.00**	**0.30**	**0.30**
									Annual Totals:		**23.0** (cfs) **45.6** (acre-ft)	**4.2** (tons/yr)	**6.2** (tons/yr)	**10.4** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, A4a+ Poor Downstream**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/2/2010**

Enter Required Information for Existing Condition

6.0	D_{50}	Riffle bed material D_{50} (mm)			
	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.04	D_{max}	**D84** particle from **Bed Material** (ft)	**10.79**	**(mm)**	304.8 mm/ft
0.12360	S	Existing bankfull water surface slope (ft/ft)			
0.24	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

1.851		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 **140**	CO **240**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **0.18**	CO **0.028**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.02**	CO **0.004**	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 **0.0120**	CO **0.0019**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, A4a+ Poor Dwnstrm**	Stream Type: **A4a+**
Location: **Pike National Forest, CO**	Valley Type: **III**
Observers: **Chavez, Kasun & Gallagher**	Date: **9/3/2010**
Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

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 5-13)**	< 1.2 **0.84** [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	**B4**, B8 **(2)**	**B3** **(3)**	**B5**, B6, B7 **B3, B4, B5** [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4 **M1** [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **VH/L** [✓ **(6)**]	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**6**
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**14**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	Excess [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
	Excess [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	0.84 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, **B4**	**B3, B5**	B6, B7, B8	**3**
	(1)	**(2)**	**B3, B4, B5** [✓ **(3)**]	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**12**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

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 5-22)**	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	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	**5.10** [✓ **(8)**]	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**4**
	(2)	**BHR 5.1, W/d 9.17** [✓ **(4)**]	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	[✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**29**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☑

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

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 5-24)**	**Stream Type at Potential**, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* [✓ **(6)**]	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* [✓ **(8)**]	**8**
				Total Points	**18**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	1	**3**
	Mod. Unstable	2	
	Unstable	[✓ 3]	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	[✓ 1]	**1**
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	1	**4**
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	[✓ 4]	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	1	**3**
	Slight Increase	2	
	Mod. Increase	[✓ 3]	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet5-15)**	***Good: Stable***	1	**4**
	Fair: Mod. Unstable	2	
	Poor: Unstable	[✓ 4]	
		Total Points	**15**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, A4a+ Poor Downstream Reach**						Location:	**Pike National Forest, Colorado**			
Observers:	**Chavez, Kasun & Gallagher**		Date:	**9/3/2010**			Stream Type:	**A4a+**	Valley Type:	**III**	
Channel Dimension (XS 0+9.84)	Mean Bankfull Depth (ft):	**0.24**	Bankfull Width (ft):	**2.2**	Cross-Sectional Area (ft^2):	**0.53**	Width of Flood-Prone Area (ft):	**2.75**	Entrenchment Ratio:	**1.25**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**5.4**	Sinuosity:	**1.09**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence			☐ Dunes/Antidunes/Smooth Bed				
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope		
									Valley:	**0.1347**	Water Surface: **0.1236**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:		Remarks: Condition, Vigor & Usage of Existing Reach:					
		P.Pine Seedlings/Grass/Forb		**Mature P.Pine/Shrub/Grs/Fb**		**Ponderosa Pine beginning to regenerate**					
	Flow Regime:	**E1, E2, E8**	Stream Size & Order:	**S-2(2)**	Meander Patterns:	**M1**	Depositional Patterns:	**B3, B4, B5**	Debris/Channel Blockages:	**D2 (Infrequent)**	
	Degree of Incision (Bank-Height Ratio):	**5.1**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**140 (Poor)**					
	Width/depth Ratio (W/d):	**9.17**	Reference W/d Ratio (W/d_{ref}):	**11**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**0.84**	W/d Ratio State Stability Rating:	**Stable**			
	Meander Width Ratio (MWR):	**5.4**	Reference MWR_{ref}:	**1.5**	Degree of confinement (MWR / MWR_{ref}):	**3.6**	MWR / MWR_{ref} Stability Rating:	**Unconfined**			
Bank Erosion Summary	Length of Reach Studied (ft):	**58**	Annual Streambank Erosion Rate:	**4.55** (tons/yr)	**0.0785** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:				
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity			Remarks:					
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**10.79**	$\tau =$	**1.851**	$\tau^* =$	**N/A**	Existing Depth: **0.24**	Required Depth: **0.02**	Existing Slope: **0.124**	Required Slope: **0.012**	
Successional Stage Shift	**A4a+** →	**A4a+** →	→	→	→	Existing Stream State (Type):	**A4a+**	Potential Stream State (Type):	**A4a+**		
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:						
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:						
Vertical Stability (Degradation)	☐ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☑ *Degradation*	Remarks/causes:						
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:						
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:						

Appendix C5

B4 Stream Type

Fair Stability Reach

Table of Contents

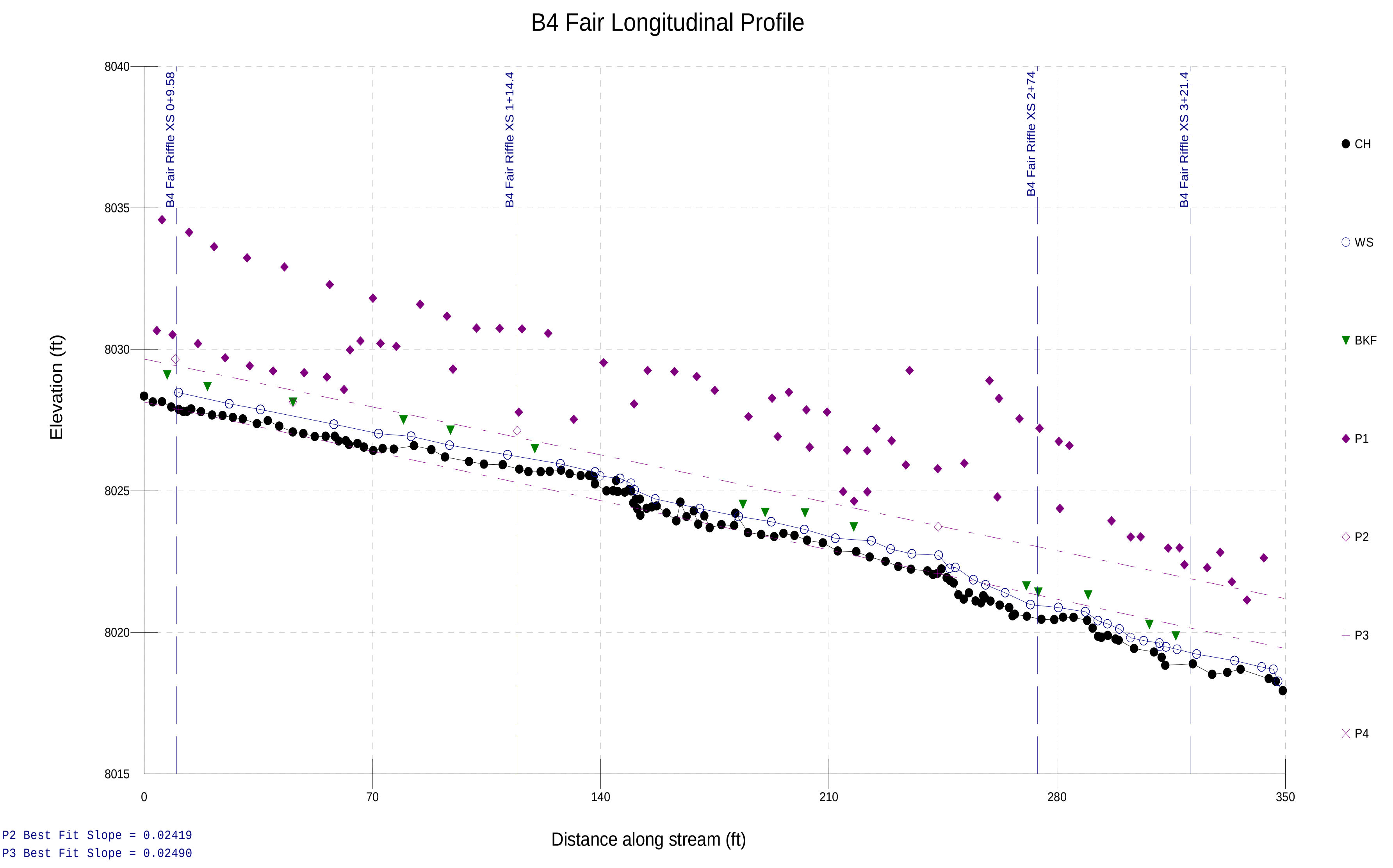
Appendix C5: B4 Fair Reach

B4 Fair Reach Location & Overview

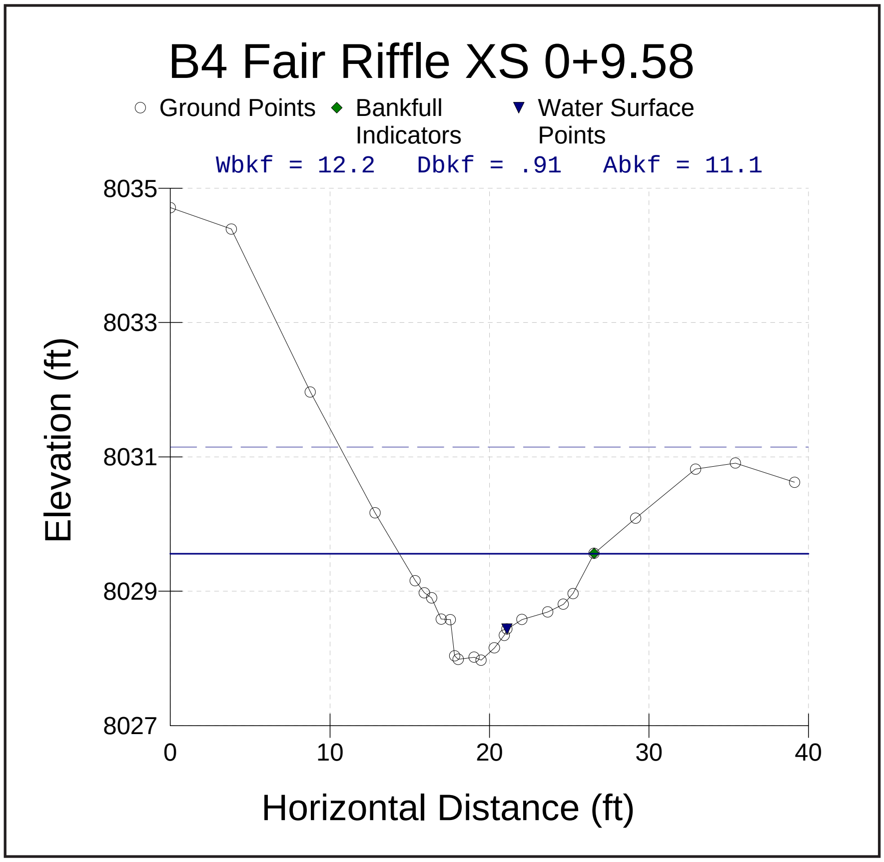
The B4 Fair representative reach is a 3rd order, perennial stream located in main Trail Creek (**Figure C-2**). The photograph depicts high eroding banks, although the riparian vegetation is slowly reoccupying this reach as the stream has gradually evolved from an F4b to a B4 stream type. However, the higher width/depth ratio than the reference condition has led to excess sediment deposition in the channel. The stability rating is "Fair" due to a "Fair" Pfankuch stability rating and the relatively high streambank erosion rate of *0.0973 tons/yr/ft* compared to the B4 reference rate of *0.0048 tons/yr/ft*. The sediment transport capacity model (POWERSED) indicates aggradation. The sediment supply rating is *High* due primarily to the streambank erosion source and increase in stored sediment in the channel bed. This rating indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows compared to the reference B4 condition. The WRENSS model suggests a water yield increase due to the fire of *1,736 acre-ft*. Bedload was subsequently increased from *39 tons/yr* to *222 tons/yr*, and the suspended sediment was increased from *62 tons/yr* to *438 tons/yr*, representing a total increase in sediment of *560 tons/yr*. These are high sediment values for a B4 stream type of this size (30 cfs bankfull) and reflect the accelerated sediment yield due to flow-related sediment.

The photograph depicts the typical character of this representative B4 stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Fair" rating.

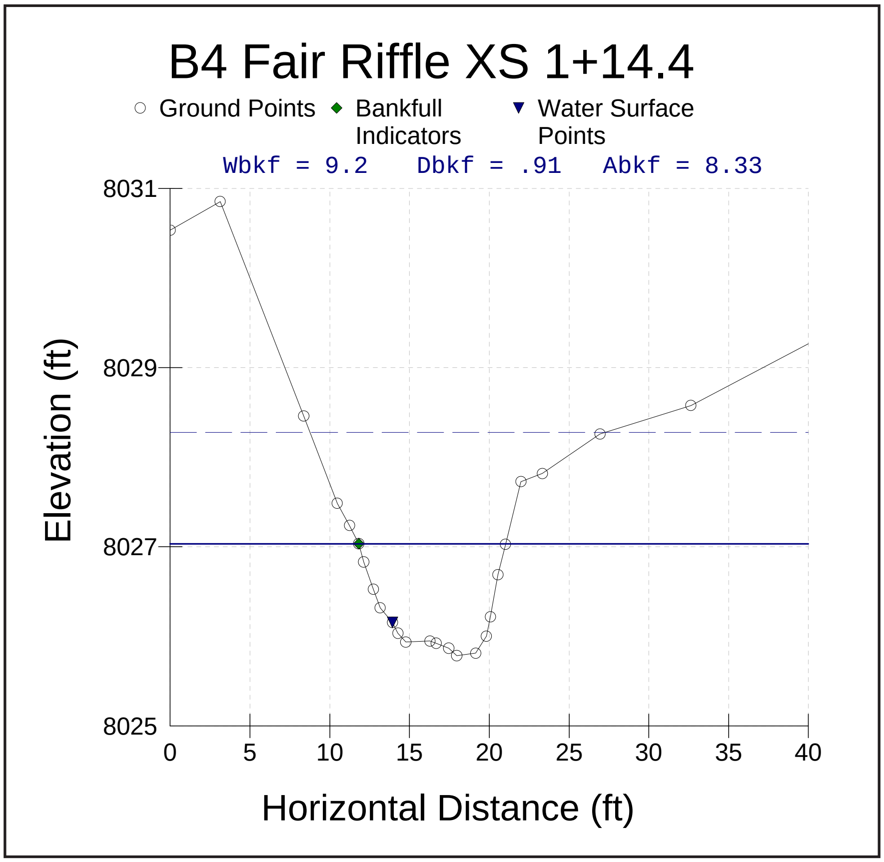
Survey Summary



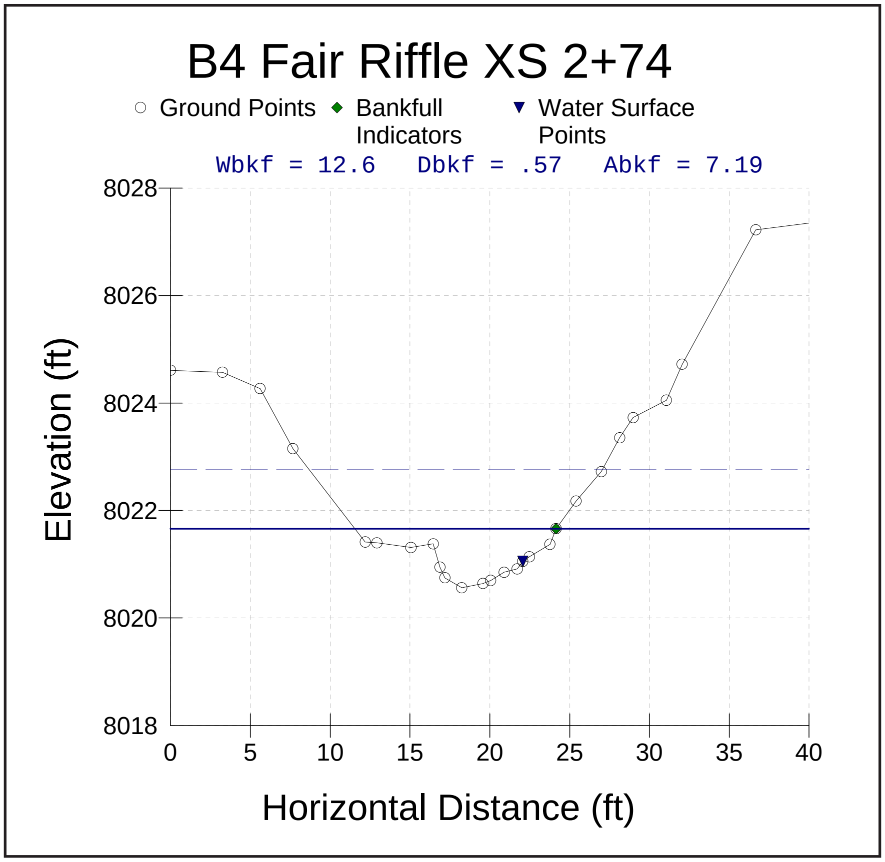
Longitudinal Profile (graph generated from RIVERMorph^{TM})



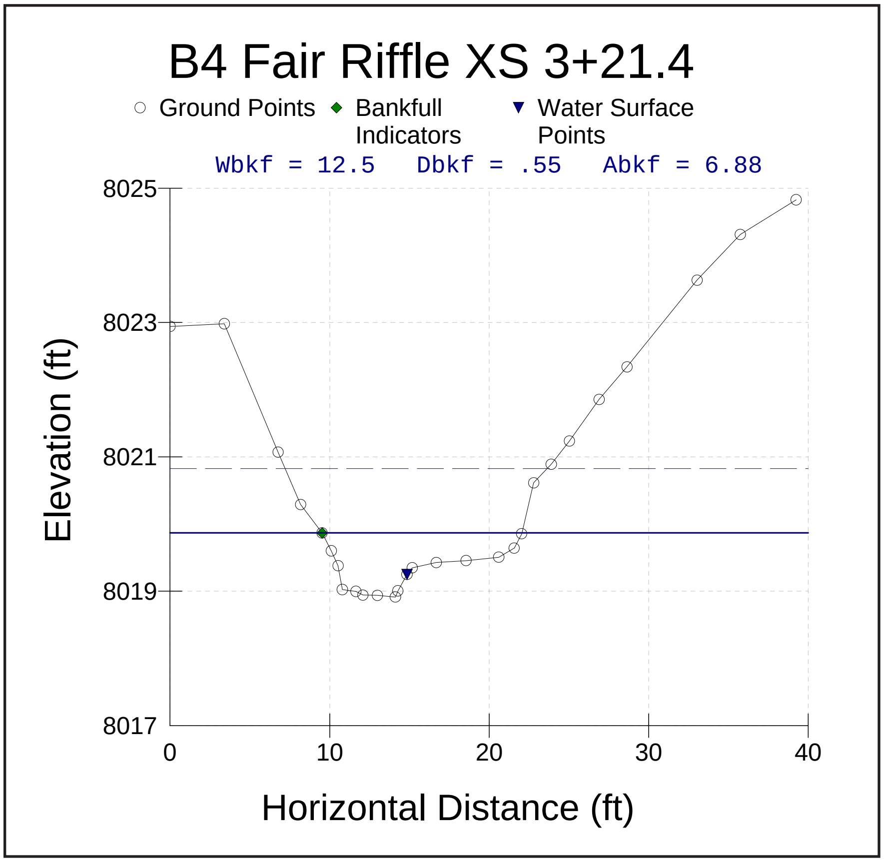
Riffle Cross-section 0+9.58 (graph generated from RIVERMorph^{TM})



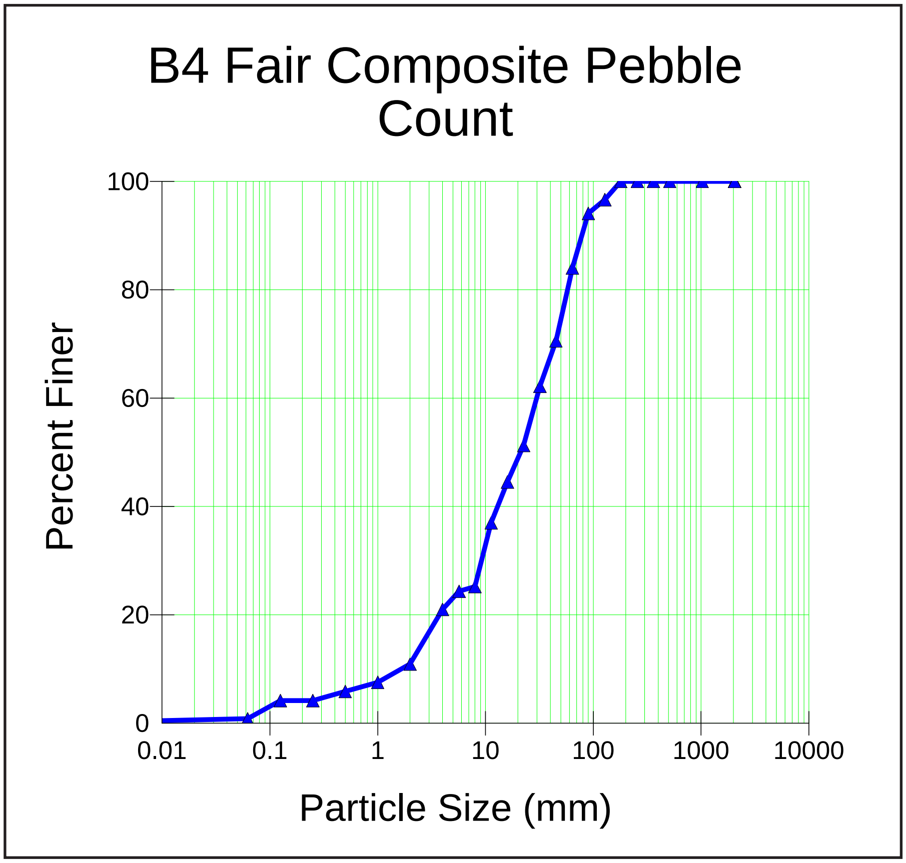
Riffle Cross-section 1+14.4 (graph generated from RIVERMorph^{TM})



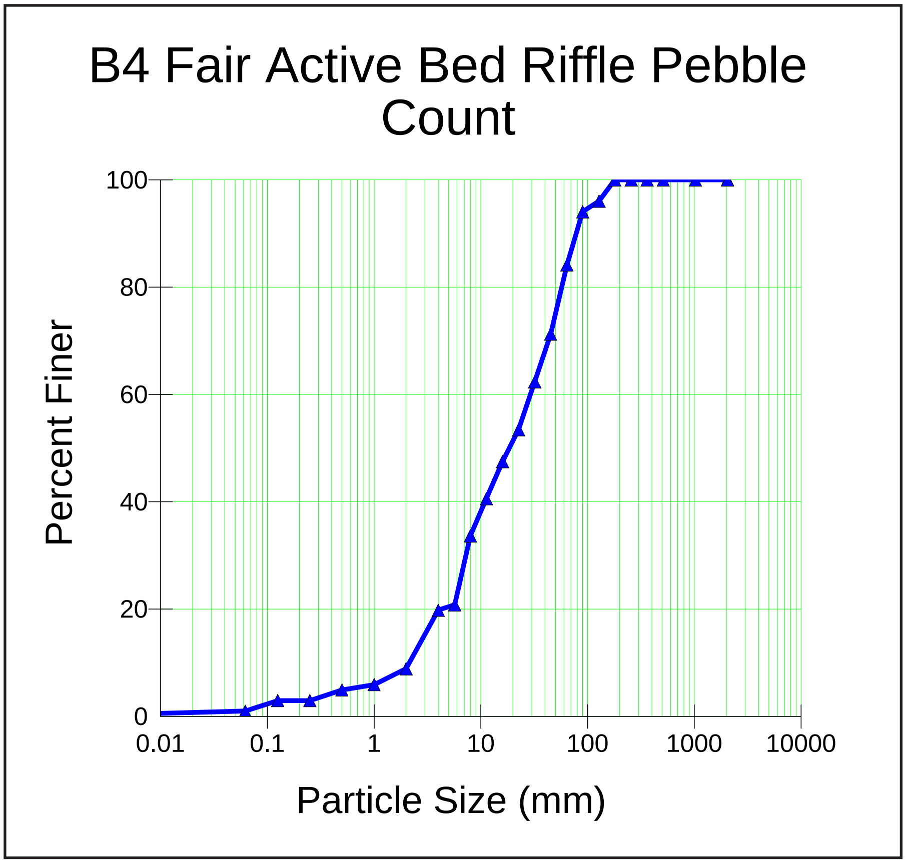
Representative Riffle Cross-section 2+74 (graph generated from RIVERMorph^{TM})



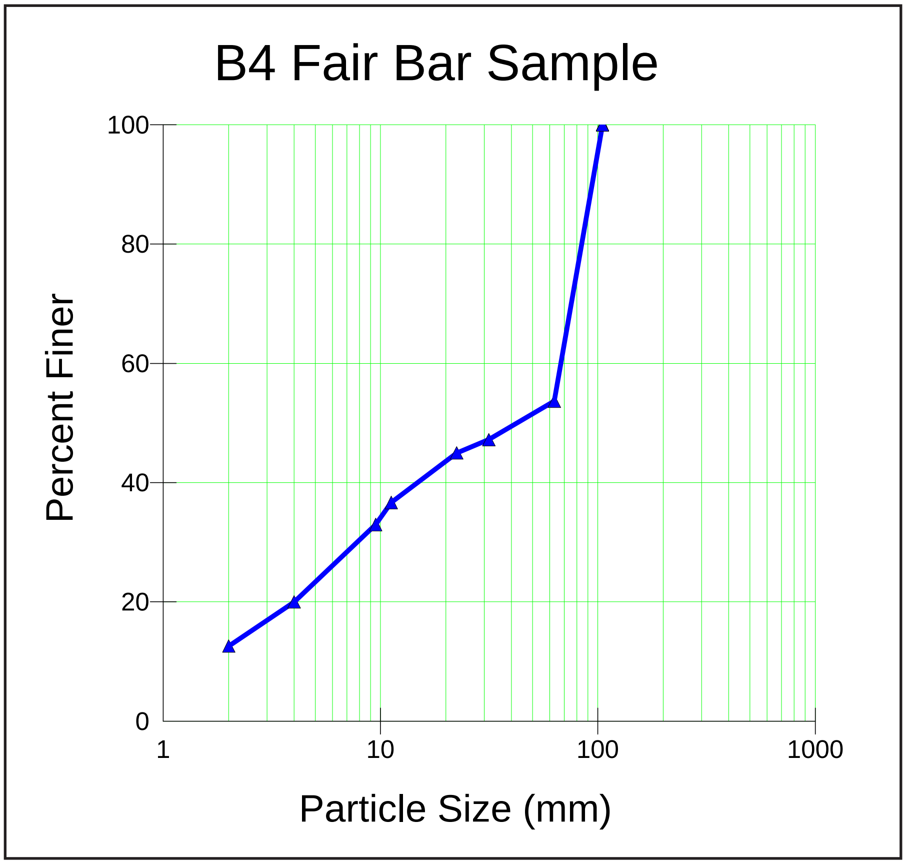
Riffle Cross-section 3+21.4 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream: **Trail Creek, B4 Fair Reach**

Location: **XS 2+74, Pike N.F., Colorado**

Date: **8/20/2010**

Stream Type: **B4**

Valley Type: **VIII**

Observers: **K. Wright & B. Kasun**

HUC:

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**7.19**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.57**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**12.60**	W_{bkf} (ft)	Wetted PERMIMETER ~ (2 * d_{bkf}) + W_{bkf}	**13.07**	W_p (ft)
D_{84} at Riffle	**63.8**	Dia. (mm)	D_{84} (mm) / 304.8	**0.21**	D_{84} (ft)
Bankfull SLOPE	**0.024**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.55**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**2.63**	R / D_{84}
Drainage Area	**10.1**	DA (mi^2)	Shear Velocity $u* = (gRS)^{½}$	**0.652**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log \{ R / D_{84} \}] u*$	**3.39**	ft / sec	**24.41**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ n = **0.048**	**3.23**	ft / sec	**23.21**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ n = **0.057**	**2.72**	ft / sec	**19.55**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 n = **0.057**	**2.72**	ft / sec	**19.55**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ______ **year**		ft / sec		cfs
4. Continuity Equations: b) u = Q / A (based on riffle 1+14.2- good bkf)	**4.20**	ft / sec	**30.2**	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. Level II stream classification.

Stream: **Trail Creek, B4 Fair Reach**

Basin: Drainage Area: **6464** acres **10.1** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 2+74** Date: **08/20/10**

Observers: **K. Wright & B. Kasun** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**12.59**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.57**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**7.19**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**22.09**	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.	**1.1**	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.	**18.36**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.46**	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.	**21.36**	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.	**0.024**	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).	**1.21**	

Stream Type **B4** (See **Figure 2-14**)

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, B4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/20/2010** Valley Type: **VIII** Stream Type: **B4**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**14.0**	**12.2**	**18.5**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**8.4**	**6.9**	**11.1**
Mean Riffle Depth (d_{bkf})	**0.74**	**0.55**	**0.91**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**17.1**	**10.1**	**22.8**
Maximum Riffle Depth (d_{max})	**1.23**	**0.96**	**1.59**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.699**	**1.370**	**1.930**
Width of Flood-Prone Area (W_{fpa})	**18.7**	**16.4**	**21.7**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.64**	**1.31**	**2.01**
Riffle Inner Berm Width (W_{ib})	**6.2**	**5.5**	**6.9**	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	**0.443**	**0.392**	**0.495**
Riffle Inner Berm Depth (d_{ib})	**0.38**	**0.32**	**0.47**	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	**0.517**	**0.435**	**0.639**
Riffle Inner Berm Area (A_{ib})	**2.4**	**1.8**	**3.2**	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	**0.285**	**0.209**	**0.386**
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	**16.5**	**14.7**	**17.7**					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Trail Creek, B4 Fair Reach**			Location:	**Pike National Forest, Colorado**		
Observers:	**K. Wright & B. Kasun**	Date:	**8/20/2010**	Valley Type:	**VIII**	Stream Type:	**B4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.20**	ft/sec	Estimation Method	**Continuity**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**30.2**	cfs	Drainage Area	**10.1**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**N/A**			ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**N/A**		
Stream Meander Length (L_m)	**100.0**			ft	Stream Meander Length Ratio (L_m / W_{bkf})	**7.16**		
Radius of Curvature (R_c)	**N/A**			ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**N/A**		
Belt Width (W_{blt})	**41.4**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**2.97**		
Arc Length (L_a)	**N/A**			ft	Arc Length to Riffle Width (L_a / W_{bkf})	**N/A**		
Riffle Length (L_r)	**39.4**	**23.1**	**54.9**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**2.82**	**1.65**	**3.93**
Individual Pool Length (L_p)	**11.5**	**6.6**	**20.9**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.82**	**0.47**	**1.50**
Pool to Pool Spacing (P_s)	**50.6**	**11.4**	**83.9**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**3.62**	**0.82**	**6.01**

Channel Profile

Valley Slope (S_{val})	**0.0290**	ft/ft	Average Water Surface Slope (S)	**0.0240**	ft/ft	Sinuosity (S_{val} / S)	**1.21**
Stream Length (SL)	**349.2**	ft	Valley Length (VL)	**290.0**	ft	Sinuosity (SL / VL)	**1.20**

Low Bank Height (LBH)	start	**1.25**	ft	Max Bankfull Depth (d_{max})	start	**1.25**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.0**
	end	**1.38**	ft		end	**1.38**	ft		end	**1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0350**	**0.0210**	**0.0550**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.4583**	**0.8750**	**2.2917**
Run Slope (S_{run})	**0.1710**	**0.0750**	**0.2510**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**7.1250**	**3.1250**	**10.4583**
Pool Slope (S_p)	**0.0150**	**0.0060**	**0.0270**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.6250**	**0.2500**	**1.1250**
Glide Slope (S_g)	**0.0160**	**0.0140**	**0.0170**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.6667**	**0.5833**	**0.7083**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.46**	**1.25**	**1.62**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.986**	**1.701**	**2.204**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})	**1.68**	**1.54**	**1.79**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.286**	**2.095**	**2.435**
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**1**	**1**	**0**	D_{16}	**3.0**	**3.3**	**2.9**		mm
% Sand	**10**	**8**	**13**	D_{35}	**10.8**	**8.6**	**10.4**		mm
% Gravel	**73**	**75**	**43**	D_{50}	**21.4**	**18.8**	**45.1**		mm
% Cobble	**16**	**16**	**45**	D_{84}	**64.0**	**63.8**	**90.5**		mm
% Boulder	**0**	**0**	**0**	D_{95}	**103.3**	**108.0**	**100.5**		mm
% Bedrock	**0**	**0**	**0**	D_{100}	**180.0**	**180.0**	**105.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, B4 Fair Reach**		Location: **Pike National Forest, Colorado**	
Observers: **K. Wright & B. Kasun**	Reference reach ☐	Disturbed (impacted reach) ☒	Date: **8/20/10**
Existing species composition: **Willow/Aspen/Grass**		Potential species composition: **Willow/Aspen/Grass**	

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	70%	22%	Willows	90%
				Aspen	10%
					100%
2. Understory	Shrub layer	▨	33%	Willow	100%
					100%
3. Ground level	Herbaceous	▨	24%	Mullen	10%
				Red Top	25%
				Poa	25%
				Thistle	5%
				Annual Forbs	35%
					100%
	Leaf or needle litter	▨	less than 3%		
	Bare ground	▨	18%		
			Column total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Remarks:

Condition, vigor and/or usage of existing reach:

Adjacent to road fill, invasive species control needed

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, B4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

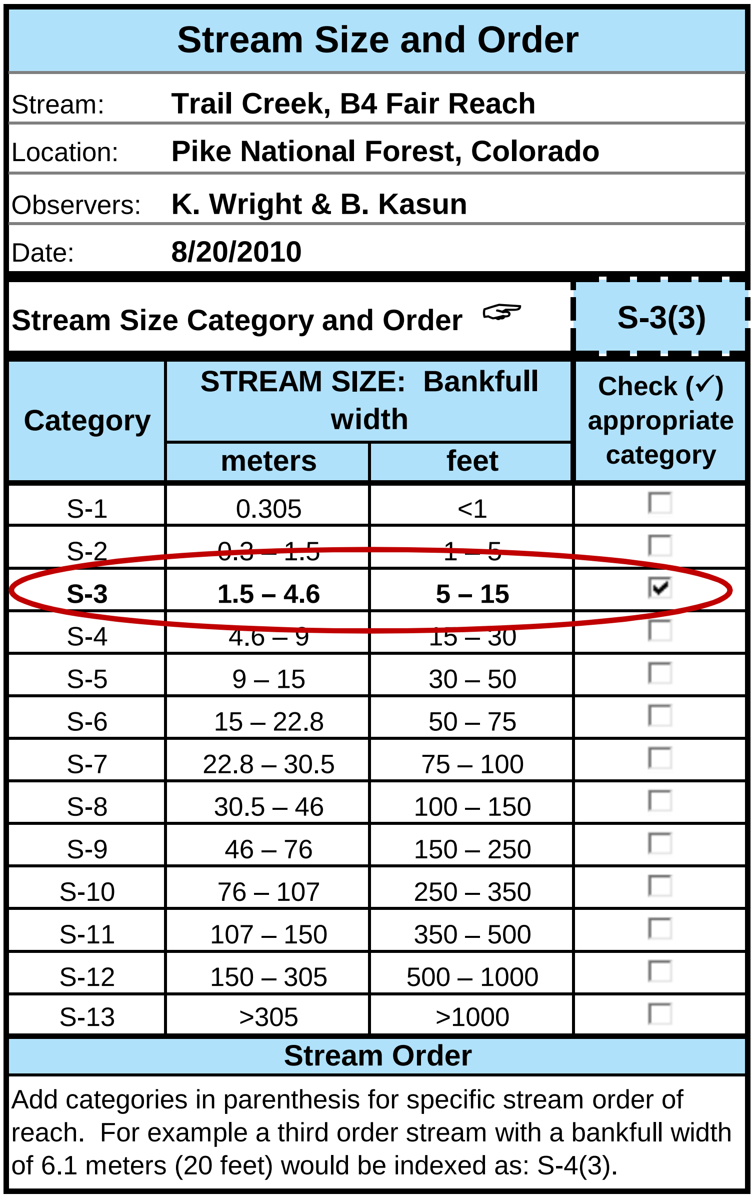
General Category

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 5-8. Stream order & stream size.



Stream Size and Order

Stream:	**Trail Creek, B4 Fair Reach**
Location:	**Pike National Forest, Colorado**
Observers:	**K. Wright & B. Kasun**
Date:	**8/20/2010**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

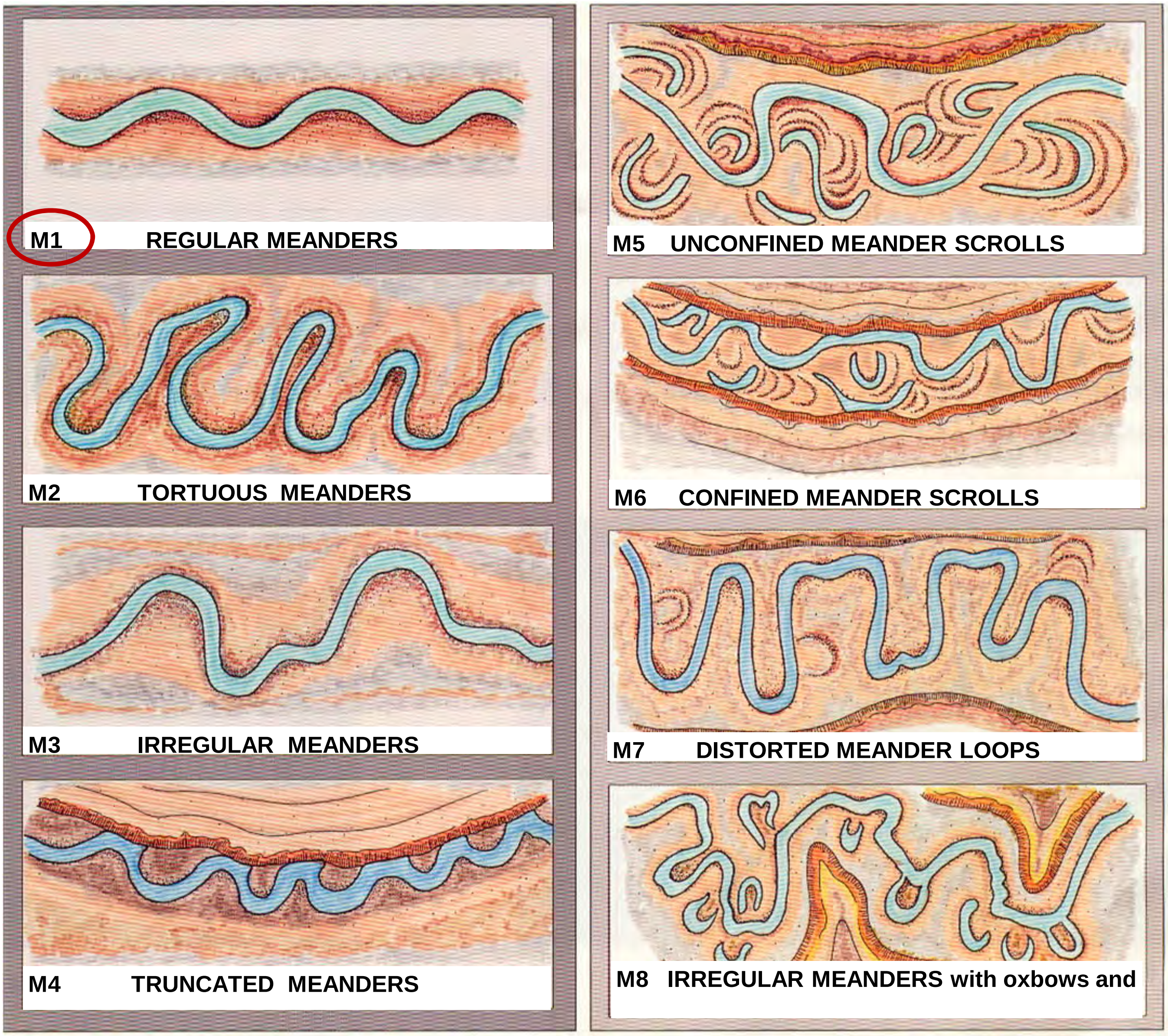
Meander Patterns

Stream: **Trail Creek, B4 Fair Reach** Location: **Pike National Forest, CO**

Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

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

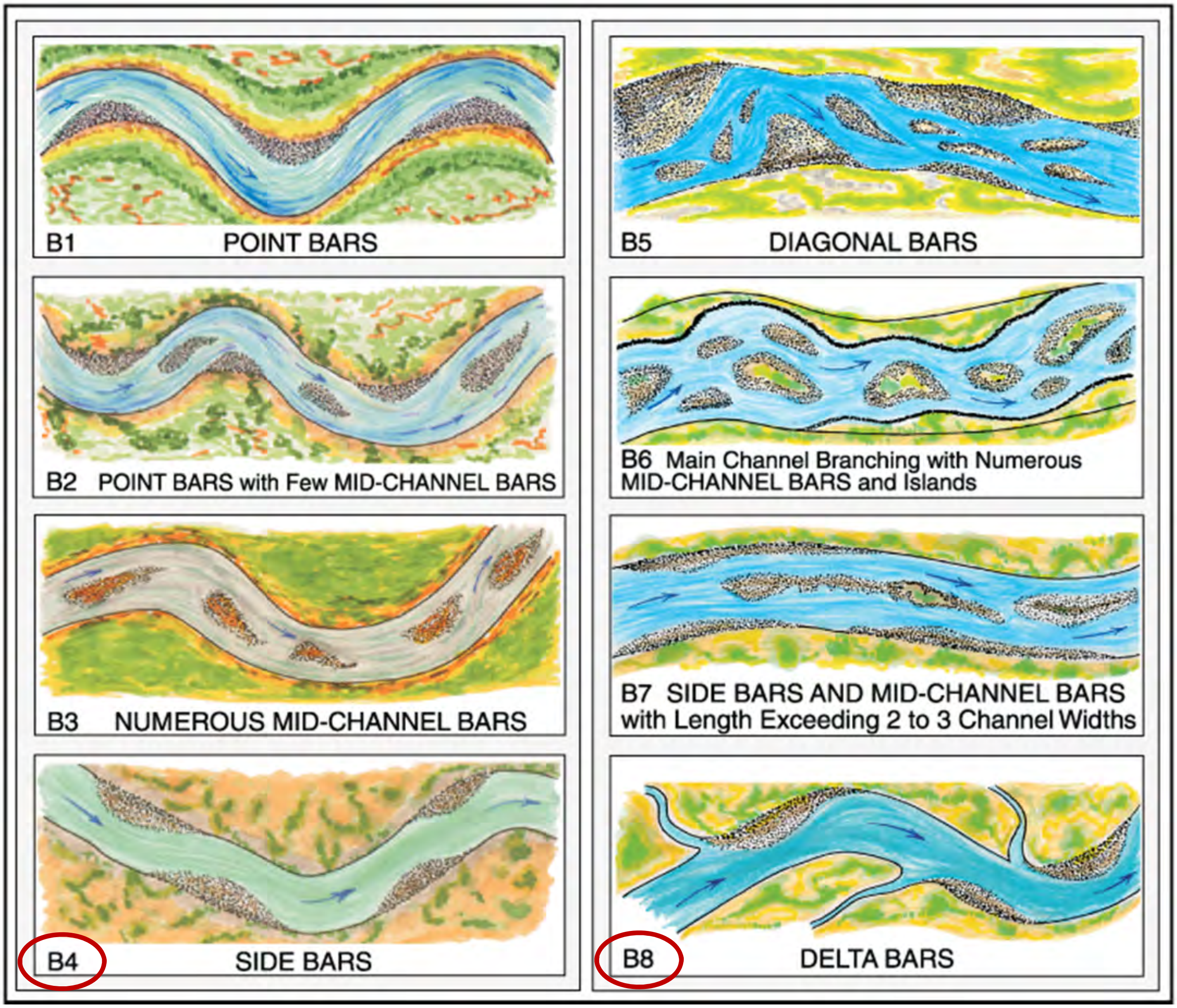
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**Trail Creek, B4 Fair Reach**	Location:	**Pike National Forest, CO**
Observers:	**K. Wright & B. Kasun**	Date:	**8/20/2010**

List ALL CATEGORIES that APPLY ☞	**B4**	**B8**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages			
Stream:	**Trail Creek, B4 Fair Reach**	Location: **Pike National Forest, Colorado**	
Observers:	**K. Wright & B. Kasun**	Date: **8/20/2010**	
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.	☐

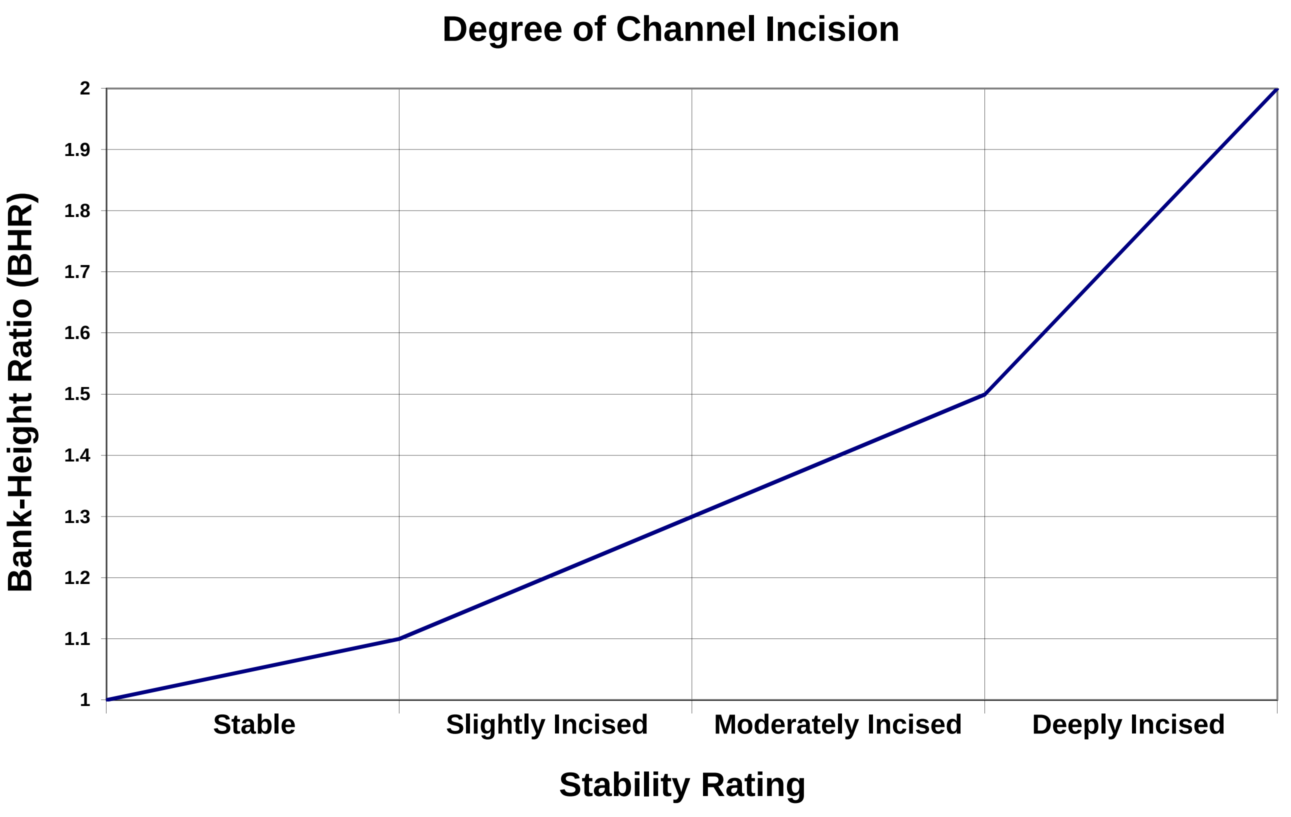
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	1.25
Max Bankfull Depth:	1.25

Bank-Height Ratio:	1.0

Degree of Channel Incision Stability Rating ☞	**Stable**

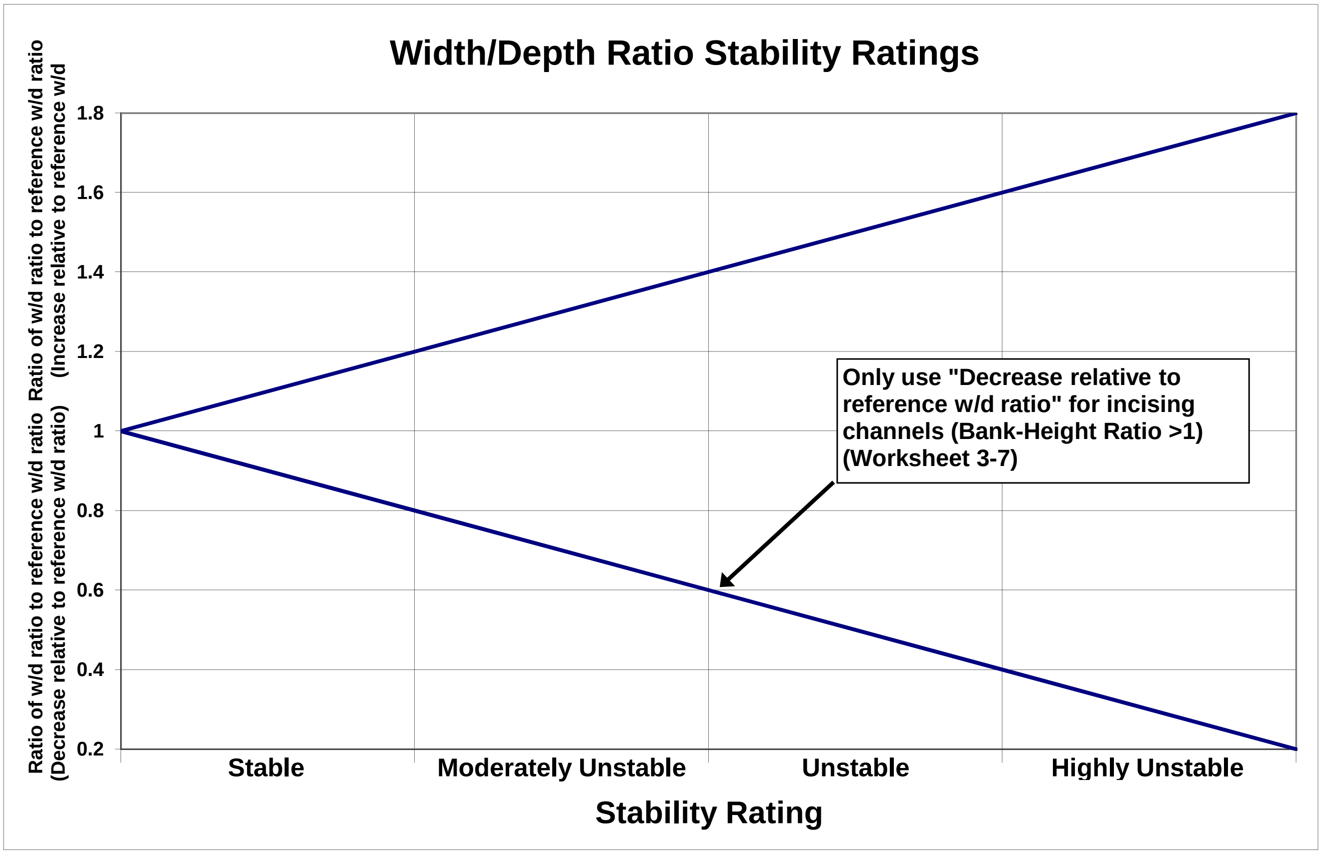


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**22.09**	Ratio of existing W/d to reference W/d:	**1.75**
Reference Width/Depth Ratio:	**12.6**		

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



Worksheet 5-14. Degree of channel confinement (lateral containment).

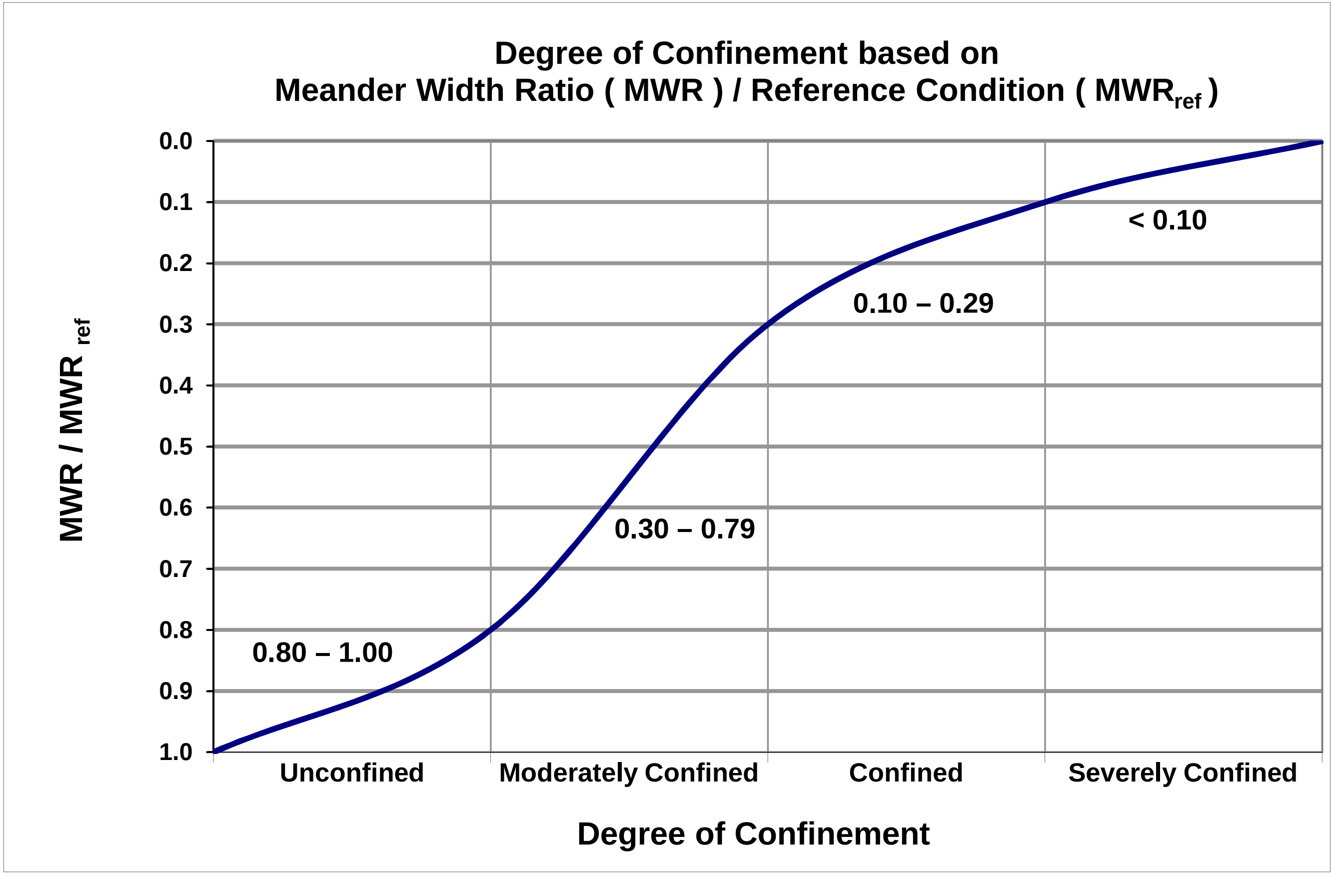
Degree of Confinement

Existing Meander Width Ratio (MWR): **2.97**

Reference Meander Width Ratio (MWR_{ref}): **2.7**

Ratio of MWR to MWR_{ref}: **1.10**

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: **Trail Creek, B4 Fair Reach** Location: **Pike NF, CO** Valley Type: **VIII** Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

Loca-tion	Key	Category	Excellent Description	Rating	Good Description	Rating	Fair Description	Rating	Poor Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	[✓ 2]	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	[✓ 4]	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	4	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ 12]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	[✓ 5]	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 2]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	7	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	[✓ 12]	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	[✓ 4]	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	[✓ 3]	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	[✓ 4]	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	[✓ 9]	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	18	Good total =	15	Fair total =	17	Poor total =	20

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	[✓ B4]	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	70
Existing stream type =	B4
*Potential stream type =	B4
Modified channel stability rating =	Fair

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

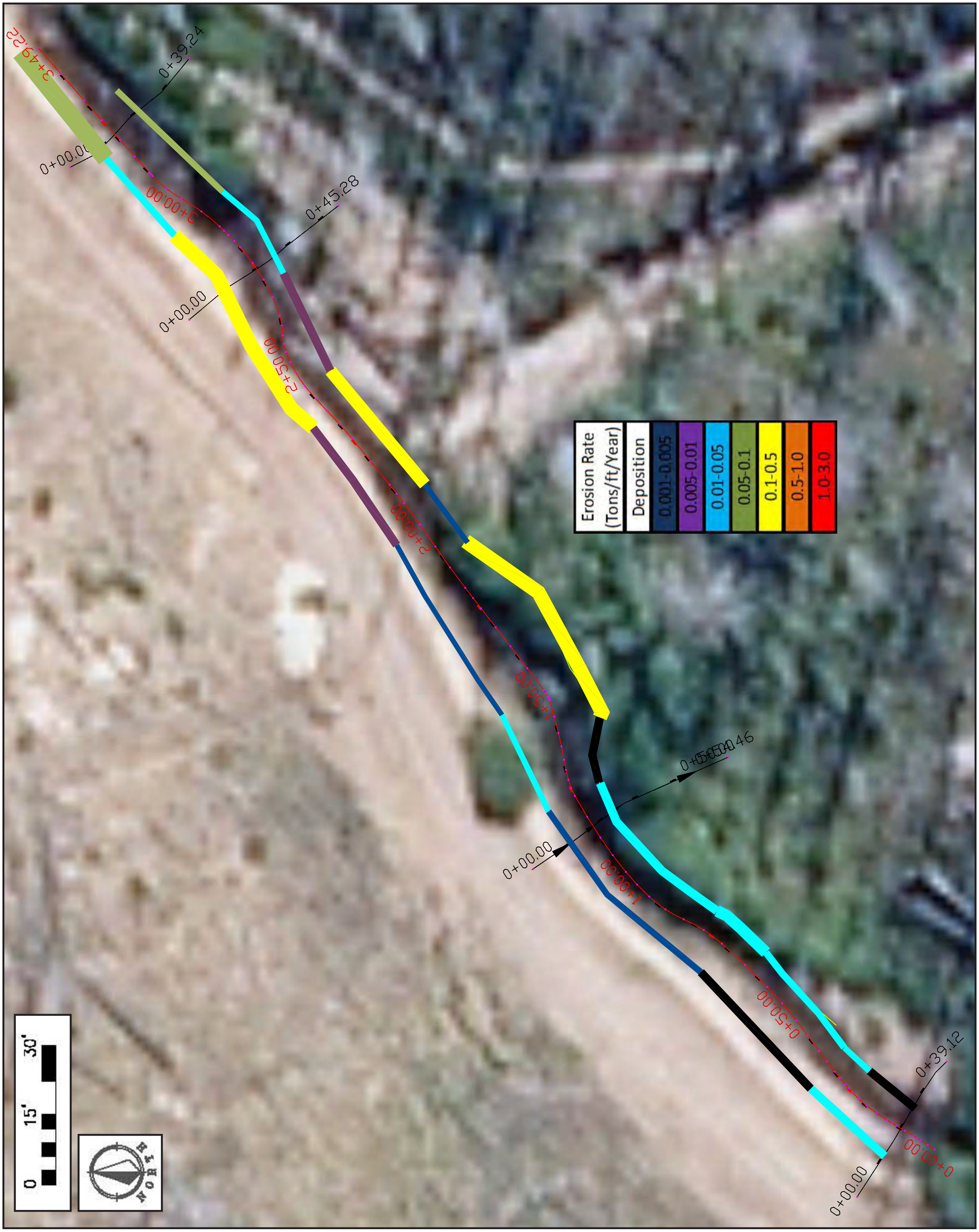
Stream: **Trail Creek, B4 Fair Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **340** Date: **8/20/2010**

Observers: **Wright, J.J. & Kasun** Valley Type: **VIII** Stream Type: **B4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+00 to 0+37 Left**	**High**	**Moderate**	**0.37957**	**37.0**	**2.0**	**28.09**	**0.03655**
2. **0+23 to 0+36 Right**	**Moderate**	**High**	**0.42031**	**12.0**	**1.5**	**7.57**	**0.03036**
3. **0+35 to 0+60 Right**	**Moderate**	**Moderate**	**0.25348**	**25.0**	**1.7**	**10.77**	**0.02075**
4. **0+65 to 0+89 Right**	**Very High**	**Moderate**	**0.37957**	**23.0**	**2.8**	**24.44**	**0.05117**
5. **0+89 to 1+23 Left**	**Low**	**Low**	**0.03566**	**34.0**	**1.5**	**1.82**	**0.00258**
6. **0+89 to 1+23 Right**	**Moderate**	**Moderate**	**0.25348**	**34.0**	**2.1**	**18.10**	**0.02563**
7. **1+23 to 1+36 Left**	**Low**	**Moderate**	**0.07435**	**13.0**	**1.4**	**1.35**	**0.00501**
8 **1+36 to 1+85 Left**	**Low**	**Low**	**0.03566**	**49.0**	**1.2**	**2.10**	**0.00206**
9 **1+36 to 1+87 Right**	**Very High**	**Very High**	**0.87205**	**1.0**	**3.5**	**3.05**	**0.14696**
10 **1+85 to 2+20 Left**	**Moderate**	**Low**	**0.15287**	**35.0**	**2.0**	**10.70**	**0.01472**
11 **1+87 to 2+05 Right**	**Low**	**Low**	**0.03566**	**18.0**	**1.3**	**0.83**	**0.00223**
12 **2+20 to 2+56 Left**	**Very High**	**Very High**	**0.87205**	**36.0**	**3.5**	**109.88**	**0.14696**
13 **2+05 to 2+33 Right**	**Extreme**	**Extreme**	**2.76027**	**28.0**	**3.0**	**231.86**	**0.39871**
14 **2+33 to 2+56 Right**	**High**	**Very High**	**0.87205**	**23.0**	**2.0**	**40.11**	**0.08398**
15 **2+56 to 2+71 Right**	**Moderate**	**Low**	**0.15287**	**15.0**	**1.4**	**3.21**	**0.01030**
16 **2+56 to 2+84 Left**	**Low**	**Low**	**0.03566**	**28.0**	**1.6**	**1.60**	**0.00275**
17 **2+71 to 3+40 Right**	**High**	**Very High**	**0.87205**	**69.0**	**1.5**	**90.26**	**0.06298**
18 **2+84 to 3+40 Left**	**Moderate**	**High**	**0.42031**	**56.0**	**4.3**	**101.21**	**0.08702**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**686.96**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**25.44**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**33.08**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0973**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	30.17	0.0160	21.46
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**76.7**													
0.10%	**65.9**	**0.05%**	**0.09%**	**0.34**	**71.3**	**2.363**	**7.461**	**30.82**	**6.670**	**10.16**	**24.5**	**10.58**	**3.49**	**14.06**
0.25%	**57.0**	**0.08%**	**0.15%**	**0.55**	**61.4**	**2.036**	**5.232**	**18.62**	**4.809**	**7.33**	**33.6**	**10.20**	**4.01**	**14.21**
0.50%	**49.2**	**0.13%**	**0.25%**	**0.91**	**53.1**	**1.761**	**3.706**	**11.41**	**3.494**	**5.32**	**48.5**	**10.41**	**4.86**	**15.27**
0.75%	**42.0**	**0.13%**	**0.25%**	**0.91**	**45.6**	**1.513**	**2.592**	**6.86**	**2.502**	**3.81**	**41.7**	**6.26**	**3.48**	**9.73**
1%	**36.4**	**0.13%**	**0.25%**	**0.91**	**39.2**	**1.300**	**1.817**	**4.13**	**1.790**	**2.73**	**35.8**	**3.77**	**2.49**	**6.26**
1.5%	**31.2**	**0.25%**	**0.50%**	**1.83**	**33.8**	**1.120**	**1.289**	**2.52**	**1.289**	**1.96**	**61.7**	**4.61**	**3.58**	**8.19**
2%	**26.1**	**0.25%**	**0.50%**	**1.83**	**28.6**	**0.949**	**0.886**	**1.47**	**0.893**	**1.36**	**52.3**	**2.68**	**2.48**	**5.16**
3%	**21.9**	**0.50%**	**1.00%**	**3.65**	**24.0**	**0.795**	**0.600**	**0.83**	**0.602**	**0.92**	**87.5**	**3.05**	**3.35**	**6.39**
4%	**18.7**	**0.50%**	**1.00%**	**3.65**	**20.3**	**0.674**	**0.424**	**0.50**	**0.415**	**0.63**	**74.2**	**1.82**	**2.31**	**4.13**
5%	**16.7**	**0.50%**	**1.00%**	**3.65**	**17.7**	**0.587**	**0.322**	**0.33**	**0.304**	**0.46**	**64.6**	**1.21**	**1.69**	**2.90**
10%	**10.5**	**2.50%**	**5.00%**	**18.25**	**13.6**	**0.450**	**0.200**	**0.16**	**0.165**	**0.25**	**247.9**	**2.87**	**4.58**	**7.46**
20%	**5.7**	**5.00%**	**10.00%**	**36.50**	**8.1**	**0.269**	**0.103**	**0.05**	**0.045**	**0.07**	**295.7**	**1.76**	**2.53**	**4.29**
30%	**3.8**	**5.00%**	**10.00%**	**36.50**	**4.8**	**0.158**	**0.075**	**0.02**	**0.006**	**0.01**	**173.9**	**0.75**	**0.36**	**1.11**
40%	**2.7**	**5.00%**	**10.00%**	**36.50**	**3.3**	**0.108**	**0.068**	**0.01**	**0.000**	**0.00**	**118.9**	**0.47**	**0.00**	**0.47**
50%	**2.1**	**5.00%**	**10.00%**	**36.50**	**2.4**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**87.0**	**0.33**	**0.00**	**0.33**
60%	**1.6**	**5.00%**	**10.00%**	**36.50**	**1.8**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**66.7**	**0.25**	**0.00**	**0.25**
70%	**1.3**	**5.00%**	**10.00%**	**36.50**	**1.4**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**52.2**	**0.19**	**0.00**	**0.19**
80%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.2**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**43.5**	**0.16**	**0.00**	**0.16**
90%	**0.8**	**5.00%**	**10.00%**	**36.50**	**1.0**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**34.8**	**0.13**	**0.00**	**0.13**
100%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**17.4**	**0.06**	**0.00**	**0.06**
									Annual Totals:		**1,662.1** (cfs) **3,296.8** (acre-ft)	**61.6** (tons/yr)	**39.2** (tons/yr)	**100.8** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	30.17	0.0290	38.00
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	98.1													
0.10%	87.2	0.05%	0.09%	0.34	92.6	3.070	13.965	132.73	11.856	32.75	31.8	45.54	11.24	56.78
0.25%	78.3	0.08%	0.15%	0.55	82.8	2.743	10.664	90.56	9.260	25.58	45.3	49.58	14.01	63.59
0.50%	70.6	0.13%	0.25%	0.91	74.5	2.468	8.281	63.26	7.341	20.28	67.9	57.73	18.51	76.24
0.75%	63.4	0.13%	0.25%	0.91	67.0	2.220	6.433	44.22	5.819	16.08	61.1	40.35	14.67	55.02
1%	57.7	0.13%	0.25%	0.91	60.6	2.007	5.058	31.43	4.661	12.88	55.3	28.68	11.75	40.43
1.5%	52.3	0.25%	0.50%	1.83	55.0	1.823	4.023	22.69	3.770	10.42	100.4	41.42	19.01	60.43
2%	46.8	0.25%	0.50%	1.83	49.5	1.642	3.141	15.96	2.995	8.27	90.4	29.12	15.10	44.22
3%	42.7	0.50%	1.00%	3.65	44.7	1.483	2.471	11.34	2.393	6.61	163.3	41.39	24.13	65.52
4%	37.8	0.50%	1.00%	3.65	40.2	1.333	1.929	7.96	1.894	5.23	146.8	29.06	19.10	48.16
5%	33.4	0.50%	1.00%	3.65	35.6	1.181	1.455	5.32	1.448	4.00	130.0	19.41	14.60	34.01
10%	20.9	2.50%	5.00%	18.25	27.1	0.900	0.787	2.19	0.793	2.19	495.5	40.00	39.99	79.99
20%	7.5	5.00%	10.00%	36.50	14.2	0.470	0.215	0.31	0.183	0.50	518.0	11.44	18.42	29.86
30%	3.9	5.00%	10.00%	36.50	5.7	0.190	0.081	0.05	0.015	0.04	209.1	1.73	1.54	3.27
40%	2.7	5.00%	10.00%	36.50	3.3	0.110	0.068	0.02	0.000	0.00	121.1	0.85	0.00	0.85
50%	2.1	5.00%	10.00%	36.50	2.4	0.079	0.066	0.02	0.000	0.00	87.0	0.59	0.00	0.59
60%	1.6	5.00%	10.00%	36.50	1.8	0.061	0.065	0.01	0.000	0.00	66.7	0.44	0.00	0.44
70%	1.3	5.00%	10.00%	36.50	1.4	0.047	0.064	0.01	0.000	0.00	52.2	0.34	0.00	0.34
80%	1.1	5.00%	10.00%	36.50	1.2	0.039	0.064	0.01	0.000	0.00	43.5	0.29	0.00	0.29
90%	0.8	5.00%	10.00%	36.50	1.0	0.032	0.064	0.01	0.000	0.00	34.8	0.23	0.00	0.23
100%	0.2	5.00%	10.00%	36.50	0.5	0.016	0.064	0.00	0.000	0.00	17.4	0.11	0.00	0.11
									Annual Totals:		2,537.4 (cfs) 5,032.9 (acre-ft)	438.28 (tons/yr)	222.07 (tons/yr)	660.35 (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "GOOD-FAIR" Curves)** Date: **08/14/10**

Observers: **S=.024, Q=30, 24, Bed.=.0638 lb/s, S.Sand=19 mg/l** Stream Type: **B4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.16**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.79**	**0.48**	**0.42**	**4.50**	**0.09**	**0.99**	**0.0240**	**0.14**	**0.72**	**0.16**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**1.11**	**0.95**	**0.71**	**5.30**	**0.13**	**1.34**	**0.0240**	**0.20**	**1.42**	**0.27**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.27**	**1.19**	**0.81**	**5.46**	**0.15**	**1.42**	**0.0240**	**0.22**	**1.78**	**0.33**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.59**	**1.43**	**0.92**	**5.62**	**0.16**	**1.50**	**0.0240**	**0.24**	**2.14**	**0.38**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.00%	**2.07**	**1.83**	**1.09**	**5.88**	**0.19**	**1.63**	**0.0240**	**0.28**	**2.74**	**0.47**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.70**	**2.39**	**1.32**	**6.21**	**0.21**	**1.81**	**0.0240**	**0.32**	**3.58**	**0.58**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.94**	**3.32**	**1.62**	**6.45**	**0.25**	**2.01**	**0.0240**	**0.37**	**4.97**	**0.77**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**7.53**	**5.74**	**2.34**	**6.98**	**0.34**	**2.43**	**0.0240**	**0.49**	**8.60**	**1.23**	**10%**	**36.50**	**0.04**	**0.02**	**1.46**	**0.73**	**2.19**
10.00%	**20.87**	**14.20**	**4.32**	**8.22**	**0.53**	**3.27**	**0.0240**	**0.77**	**21.27**	**2.59**	**10%**	**36.50**	**0.52**	**0.16**	**18.98**	**5.84**	**24.82**
5.00%	**33.46**	**27.17**	**6.75**	**9.33**	**0.72**	**4.03**	**0.0240**	**1.05**	**40.69**	**4.36**	**5%**	**18.25**	**2.20**	**1.11**	**40.15**	**20.26**	**60.41**
4.00%	**37.82**	**35.64**															
3.00%	**42.69**	**40.26**															
2.00%	**46.82**	**44.76**															
1.50%	**52.29**	**49.56**															
1.00%	**57.76**	**55.03**															
0.75%	**63.43**	**60.60**															
0.50%	**70.63**	**67.03**															
0.25%	**78.39**	**74.51**															
0.10%	**87.25**	**82.82**															
0.0060%	**98.13**	**92.69**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**60.6**	**27.9**	**88.5**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, B4 Fair Riffle XS 2+74** Location: **Pike National Forest, Colorado (Used "GOOD-FAIR" Curves)** Date: **08/14/10**

Observers: **S=.024, Q=30, 24, Bed.=.0638 lb/s, S.Sand=19 mg/l** Stream Type: **B4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.16**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.79**	**0.48**	**0.33**	**3.03**	**0.11**	**1.37**	**0.0240**	**0.16**	**0.72**	**0.24**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**1.11**	**0.95**	**0.53**	**3.58**	**0.15**	**1.70**	**0.0240**	**0.22**	**1.42**	**0.40**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.27**	**1.19**	**0.63**	**3.79**	**0.17**	**1.83**	**0.0240**	**0.25**	**1.78**	**0.47**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.59**	**1.43**	**0.72**	**4.00**	**0.18**	**1.96**	**0.0240**	**0.27**	**2.14**	**0.54**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.00%	**2.07**	**1.83**	**0.86**	**4.28**	**0.20**	**2.09**	**0.0240**	**0.30**	**2.74**	**0.64**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.70**	**2.39**	**1.05**	**4.65**	**0.23**	**2.25**	**0.0240**	**0.33**	**3.58**	**0.77**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.94**	**3.32**	**1.32**	**5.06**	**0.26**	**2.49**	**0.0240**	**0.38**	**4.97**	**0.98**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**7.53**	**5.74**	**1.91**	**5.54**	**0.34**	**2.98**	**0.0240**	**0.50**	**8.60**	**1.55**	**10%**	**36.50**	**0.17**	**0.03**	**6.21**	**1.09**	**7.30**
10.00%	**20.87**	**14.20**	**4.31**	**10.87**	**0.40**	**3.28**	**0.0240**	**0.57**	**21.27**	**1.96**	**10%**	**36.50**	**0.30**	**0.11**	**10.95**	**4.01**	**14.96**
5.00%	**33.46**	**27.17**	**6.72**	**12.44**	**0.54**	**4.02**	**0.0240**	**0.78**	**40.69**	**3.27**	**5%**	**18.25**	**1.17**	**0.61**	**21.35**	**11.13**	**32.48**
4.00%	**37.82**	**35.64**															
3.00%	**42.69**	**40.26**															
2.00%	**46.82**	**44.76**															
1.50%	**52.29**	**49.56**															
1.00%	**57.76**	**55.03**															
0.75%	**63.43**	**60.60**															
0.50%	**70.63**	**67.03**															
0.25%	**78.39**	**74.51**															
0.10%	**87.25**	**82.82**															
0.0060%	**98.13**	**92.69**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**38.5**	**17.3**	**55.8**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**60.6**	**27.9**	**88.5**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-22.1**	**-10.6**	**-32.7**
Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, ≈ 37% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, B4 Fair, XS 2+74**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Chavez, Kasun, Wright *et al*.**	Date:	**9/1/2010**

Enter Required Information for Existing Condition

18.8	D_{50}	Riffle bed material D_{50} (mm)			
45.1	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.34	D_{max}	Largest particle from bar sample (ft)	**105**	**(mm)**	304.8 mm/ft
0.0240	S	Existing bankfull water surface slope (ft/ft)			
0.57	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.42	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.60	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

0.854		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 **60**	CO **140**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.4**	CO **0.6**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.93**	CO **0.40**	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 **0.0394**	CO **0.0169**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, B4 Fair Reach** Stream Type: **B4**

Location: **Pike National Forest, CO** Valley Type: **VIII**

Observers: **Rosgen, *et al*.** Date: **8/20/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, B4 Fair Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/20/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**8**
	(2)	**(4)**	**(6)**	**1.75** [✓ **(8)**]	
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2	**B4, B8**	B3	B5, B6, B7	**2**
	(1)	**B4, B8** [✓ **(2)**]	**(3)**	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4		M2, M5, M6, M7, M8		**1**
	M1 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**4**
	(2)	**M/M** [✓ **(4)**]	**(6)**	**(8)**	
5 **Degree of Confinement ($\text{MWR} / \text{MWR}_{\text{ref}}$) (Worksheet 5-14)**	> 0.8	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	1.2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**16**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trail Creek, B4 Fair Reach** Stream Type: **B4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

	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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
		[✓ (2)]	(4)	(6)	(8)	
2	**Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**8**
		(2)	(4)	(6)	[✓ (8)]	
3	**W/d Ratio State (Worksheet 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
		(2)	(4)	(6)	**1.75** [✓ (8)]	
4	**Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
		[✓ (2)]	(4)	(6)	(8)	
5	**Depositional Patterns (Worksheet 5-10)**	B1	B2, **B4**	B3, B5	B6, B7, **B8**	**4**
		(1)	(2)	(3)	**B4, B8** [✓ (4)]	
6	**Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
		D2 [✓ (1)]	(2)	(3)	(4)	
					Total Points	**25**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream: **Trail Creek, B4 Fair Reach** Stream Type: **B4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

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 5-22)**	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**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 **[✓ (2)]**	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	> 0.80	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.10 **[✓ (1)]**	**(2)**	**(3)**	**(4)**	
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, B4 Fair Reach** Stream Type: **B4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright & B. Kasun** Date: **8/20/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* [✓ **(6)**]	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**16**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, B4 Fair Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/20/2010**

	Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1	**Lateral Stability (Worksheet 5-25)**	***Stable***	1	3
		Mod. Unstable	2	
		Unstable	[✓ 3]	
		Highly Unstable	4	
2	**Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	1	3
		Mod. Deposition	2	
		Excess Deposition	[✓ 3]	
		Aggradation	4	
3	**Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	[✓ 1]	1
		Slightly Incised	2	
		Mod. Incised	3	
		Degradation	4	
4	**Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	1	2
		Slight Increase	[✓ 2]	
		Mod. Increase	3	
		Extensive	4	
5	**Pfankuch Channel Stability (Worksheet 5-15)**	***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*** 5 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☑	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, B4 Fair Reach**					Location: **Pike National Forest, Colorado**				
Observers:	**K. Wright & B. Kasun**			Date: **8/20/2010**		Stream Type: **B4**			Valley Type: **VIII**	
Channel Dimension (XS 2+74)	Mean Bankfull Depth (ft):	**0.57**	Bankfull Width (ft):	**12.59**	Cross-Sectional Area (ft^2):	**7.19**	Width of Flood-Prone Area (ft):	**18.36**	Entrenchment Ratio:	**1.46**
Channel Pattern	Mean: Range: λ/W_{bkf}:	**7.16**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**2.97**	Sinuosity:	**1.2**
River Profile & Bed Features	Check: ☐ Riffle/Pool		☑ Step/Pool		☐ Plane Bed		☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed	
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope	
		1.23	**1.68**		**1.67**	**1.85**		**3.62**	Valley: **0.029**	Water Surface: **0.024**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:		Remarks: Condition, Vigor & Usage of Existing Reach:				
		Willow, Aspen, Grass		**Same w/o invasives**		**Invasive species control needed**				
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(3)**	Meander Patterns:	**M1**	Depositional Patterns:	**B4, B8**	Debris/Channel Blockages:	**D2**
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):			**70 (Fair)**		
	Width/depth Ratio (W/d):	**22.1**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**1.75**	W/d Ratio State Stability Rating:	**Highly Unstable**		
	Meander Width Ratio (MWR):	**2.97**	Reference MWR_{ref}:	**2.7**	Degree of confinement (MWR / MWR_{ref}):	**1.10**	MWR / MWR_{ref} Stability Rating:	**Unconfined**		
Bank Erosion Summary	Length of Reach Studied (ft):	**340**	Annual Streambank Erosion Rate: **33.08** (tons/yr)	**0.0973** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:				
Sediment Capacity (POWERSED)	☐ Sufficient Capacity		☑ Insufficient Capacity		☐ Excess Capacity	Remarks: ≈ **37% Reduction in Transport Capacity**				
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**105**	$\tau =$ **1.363**	$\tau^* =$ **N/A**	Existing Depth:	**0.57**	Required Depth:	**.4-.93**	Existing Slope: **0.024**	Required Slope: **0.017-.039**
Successional Stage Shift	B → G → Fb → [✓ B] → →					Existing Stream State (Type):	**B4**	Potential Stream State (Type):	**B4**	
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Bank Erosion, W/d, & Depositional Patterns**				
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:	**POWERSED, W/d, Depositional Patterns**				
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Trend toward Aggradation**				
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:					
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:					

Appendix C6

C4 Stream Type

Fair Stability Reach

Table of Contents

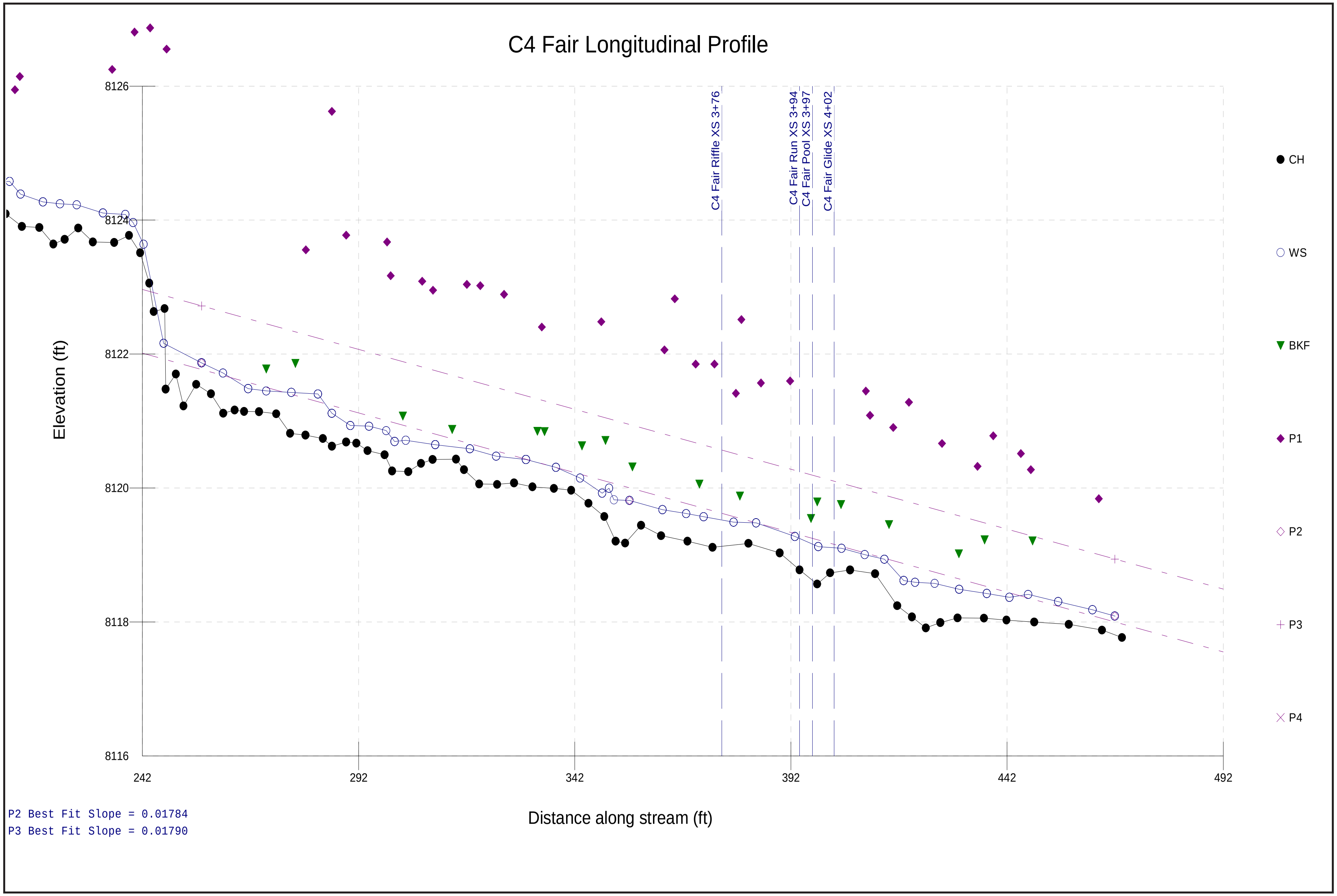
Appendix C6: C4 Fair Reach

C4 Fair Reach Location & Overview

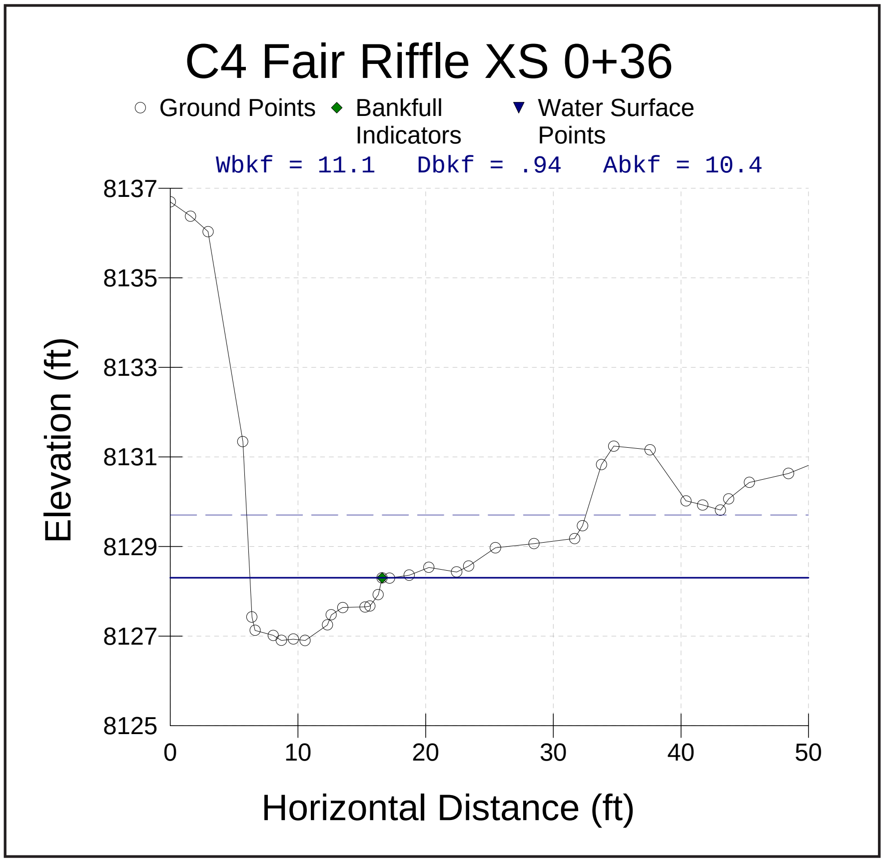
The C4 Fair representative reach is a 4th order, perennial stream located in main Trail Creek (**Figure C-2**). The photograph depicts high eroding banks, although the riparian vegetation is slowly reoccupying this reach that has gradually evolved from an F4 to a C4 stream type. However, the higher width/depth ratio than the reference condition has led to excess sediment deposition in the channel as the sediment transport capacity model (POWERSED) indicates aggradation. The stability rating is "Fair" due to a "Fair" Pfankuch stability rating and the relatively high streambank erosion rate of *0.0217 tons/yr/ft* compared to the C4 reference rate of *0.0063 tons/yr/ft*. The sediment supply rating is *Moderate* due primarily to the streambank erosion source and increase in stored sediment in the channel bed. This rating indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows compared to the reference C4 condition. The WRENSS model indicated a water yield increase due to the fire of *1,745 acre-ft*. The bedload was consequently increased from *39 tons/yr* to *249 tons/yr*, and the suspended sediment increased from *55 tons/yr* to *455 tons/yr*, representing a total increase in sediment of *610 tons/yr*. These are high values for a C4 stream type of this size, which reflect the accelerated sediment yield due to flow related sediment.

The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Fair" rating.

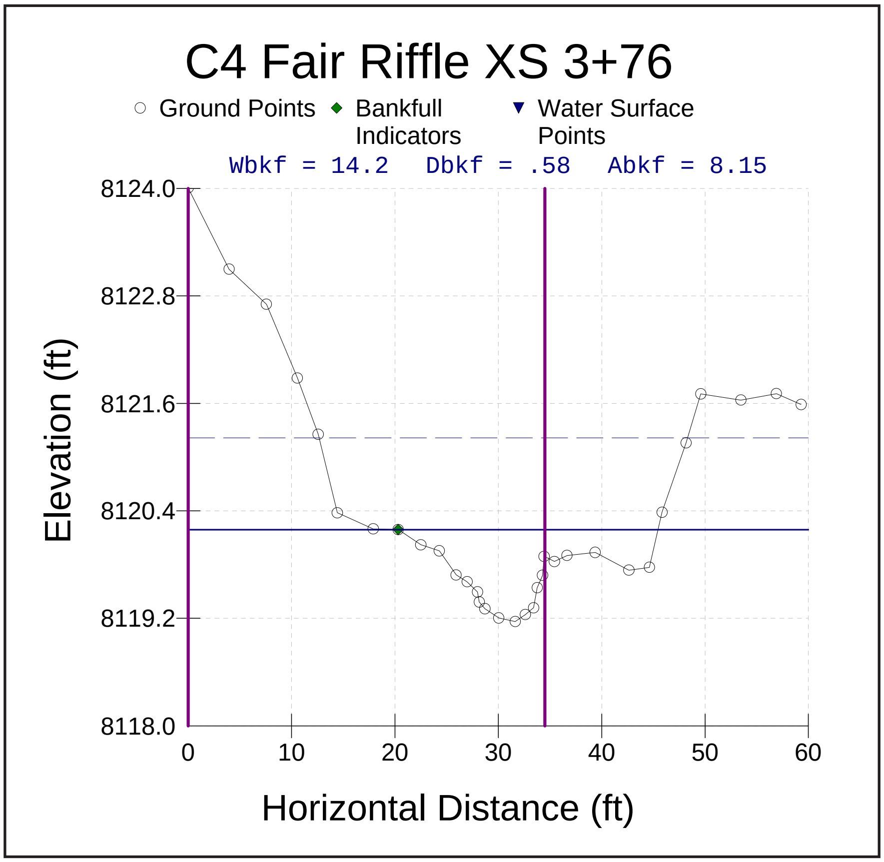
Survey Summary



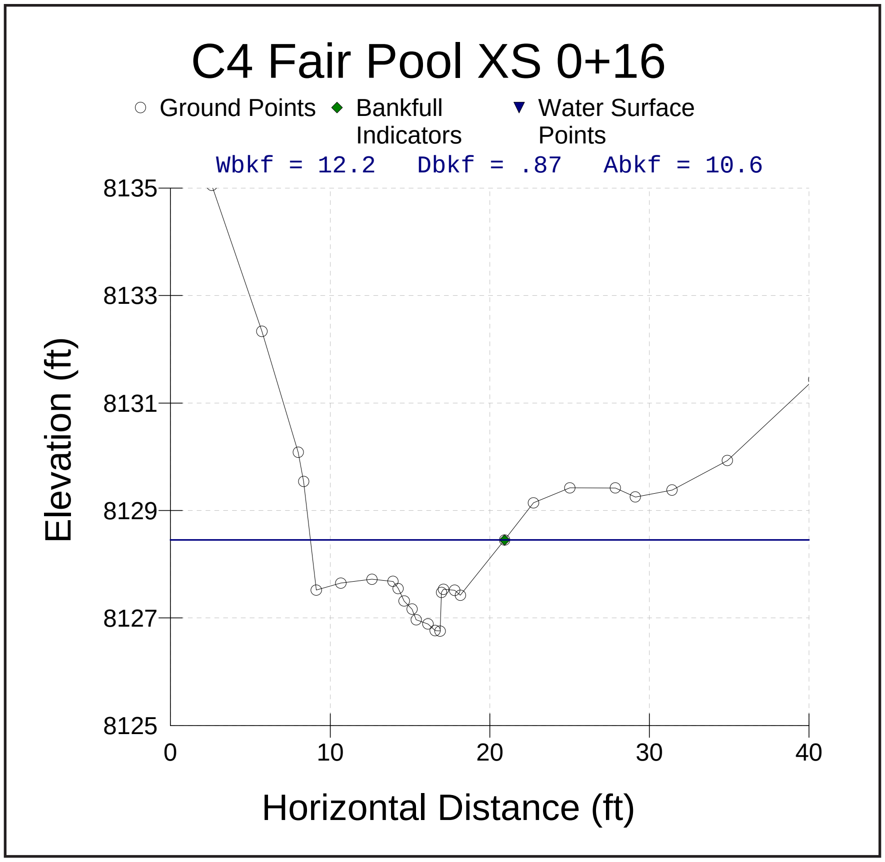
Longitudinal Profile (graph generated from RIVERMorph^{TM})



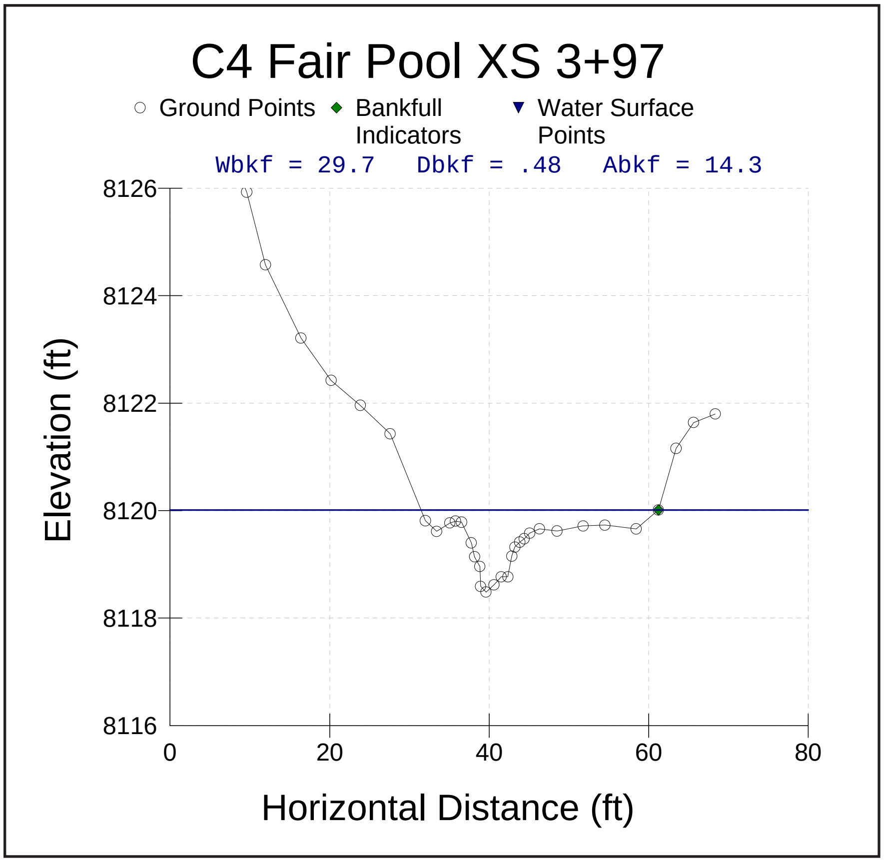
Riffle Cross-section 0+36 (graph generated from RIVERMorph™)



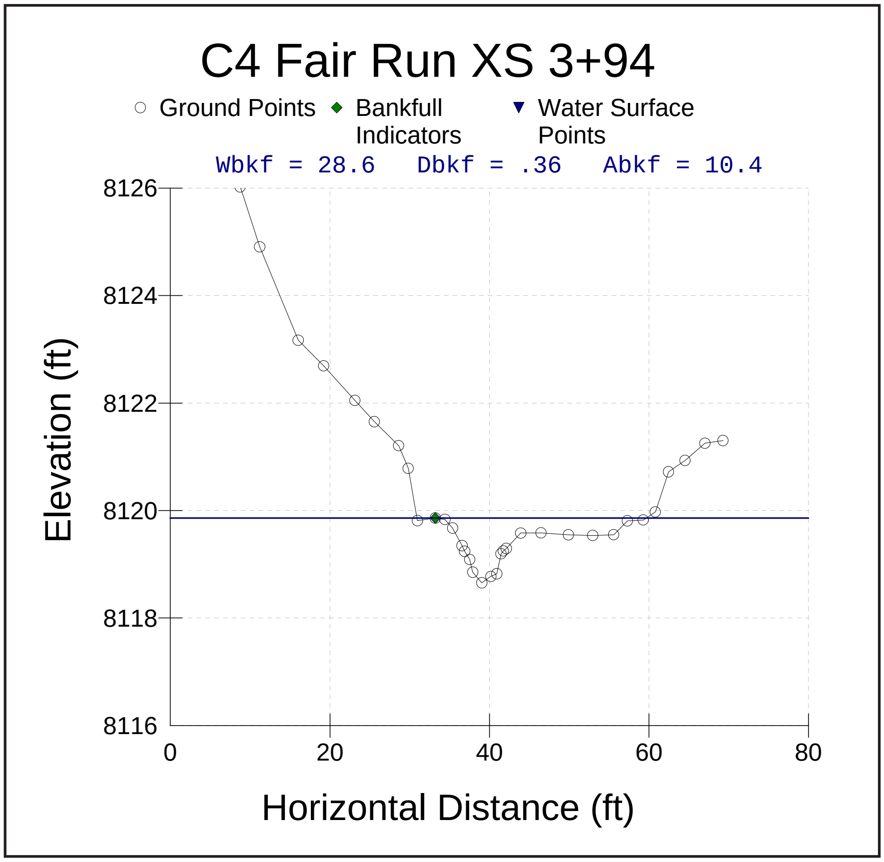
Representative Riffle Cross-section 3+76 (graph generated from RIVERMorph™)



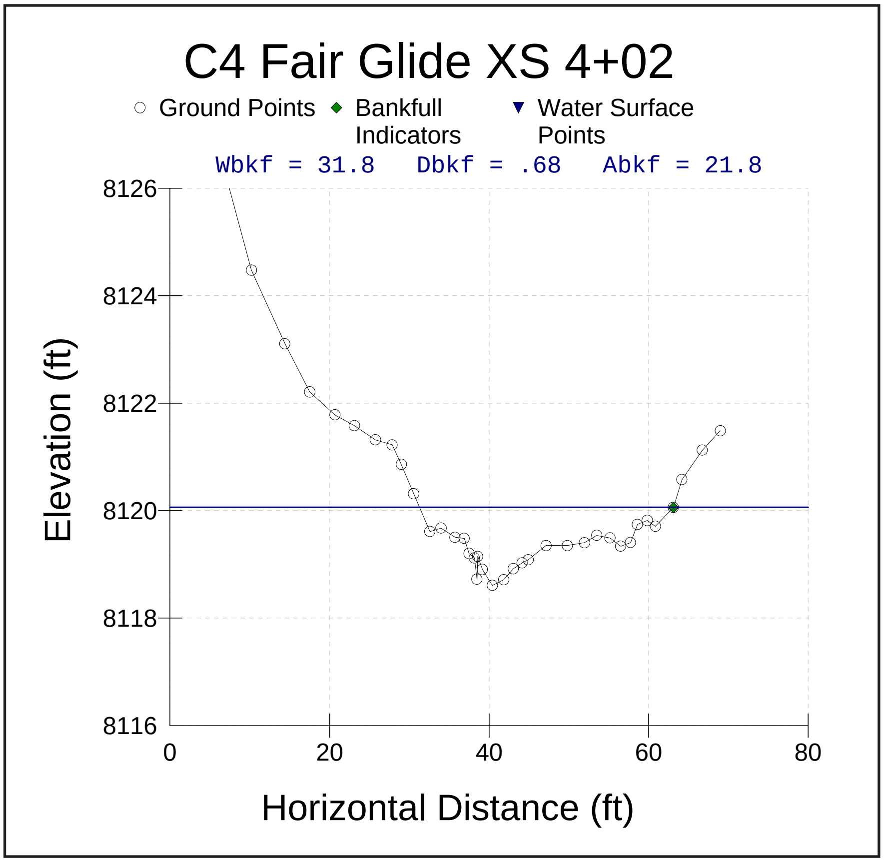
Pool Cross-section 0+16 (graph generated from RIVERMorph^{TM})



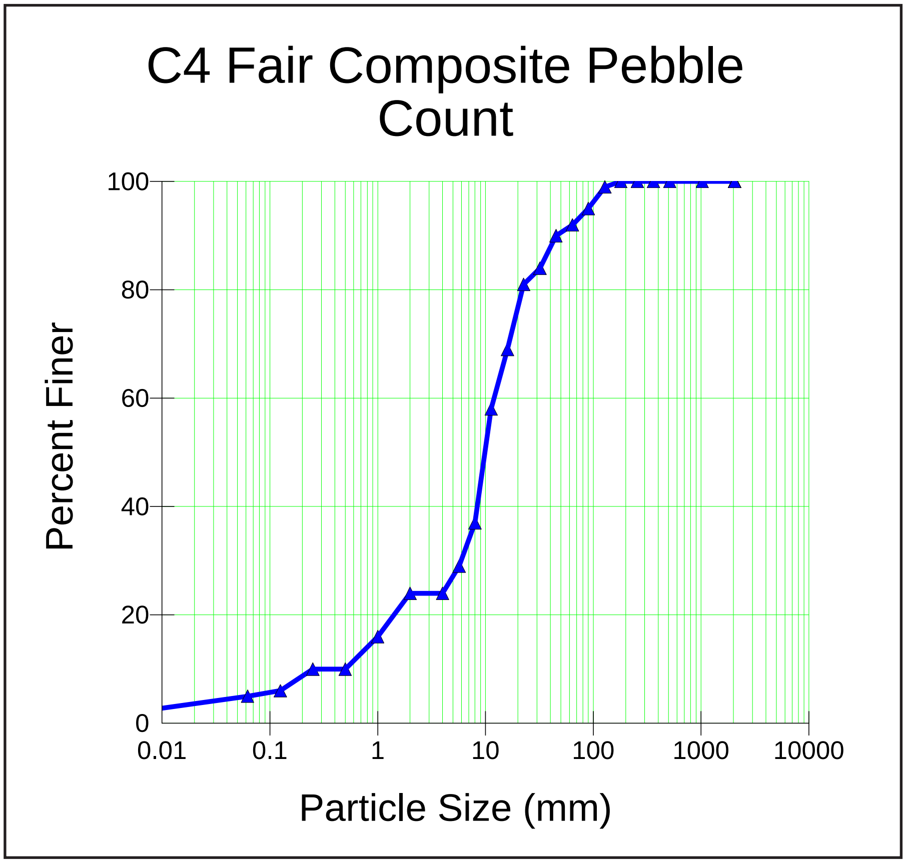
Pool Cross-section 3+97 (graph generated from RIVERMorph^{TM})



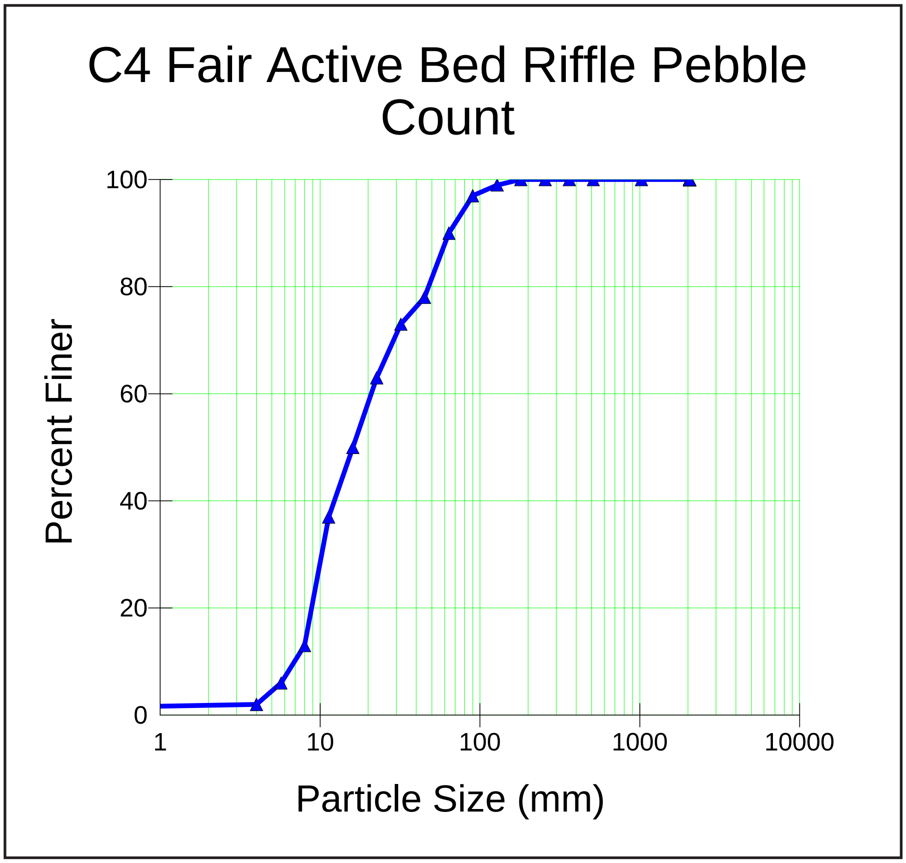
Run Cross-section 3+94 (graph generated from RIVERMorph^{TM})



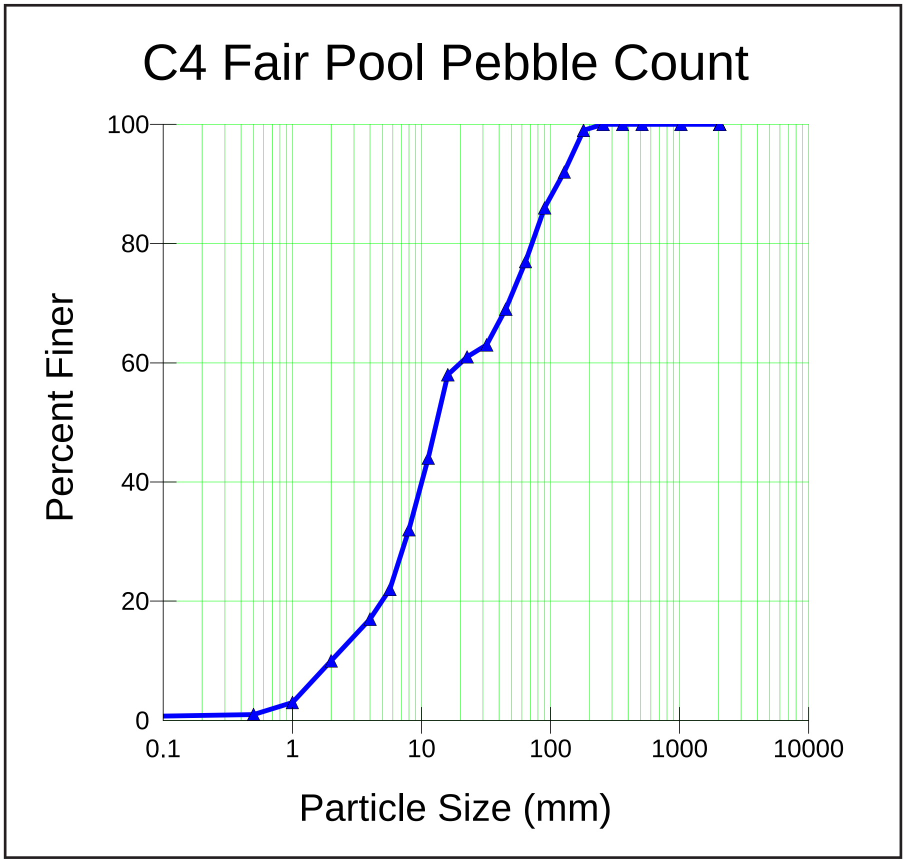
Glide Cross-section 4+02 (graph generated from RIVERMorph^{TM})



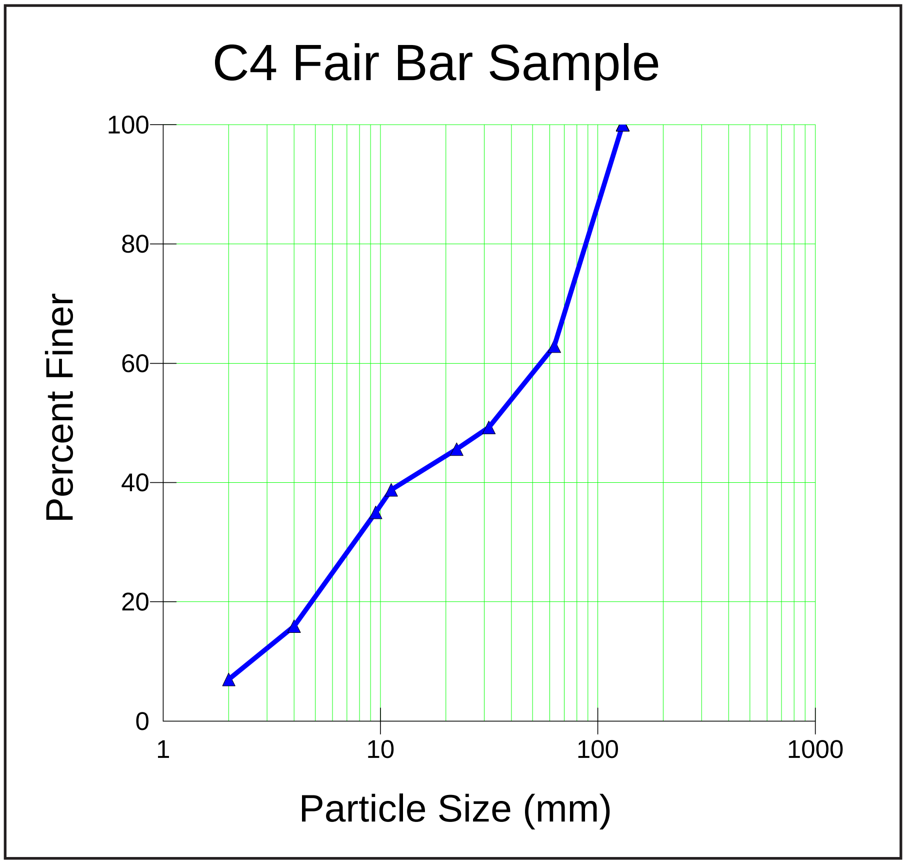
Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Pool Pebble Count (graph generated from RIVERMorph™)



Bar Sample (graph generated from RIVERMorph™)

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, C4 Fair Reach**	Location:	**X-Sec 3+76, Pike N.F., Colorado**
Date:	**8/22/2010**	Stream Type:	**C4**
Valley Type:	**VIII**		
Observers:	**K. Wright & B. Kasun**	HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**8.15**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.58**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**14.2**	**W_{bkf}** (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**15.31**	**W_p** (ft)
D_{84} at Riffle	**54.5**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.18**	**D_{84}** (ft)
Bankfull SLOPE	**0.018**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.53**	**R** (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**2.98**	**R / D_{84}**
Drainage Area	**10.15**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.555**	**u*** (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**3.06**	ft / sec	**24.95**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.055**	**2.39**	ft / sec	**19.46**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.04**	**3.28**	ft / sec	**26.75**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.031**	**4.24**	ft / sec	**34.56**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Limerinos**	**3.27**	ft / sec	**26.8**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves **u = Q / A** **Return Period for Bankfull Discharge** **Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data **u = Q / A**		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, C4 Fair Reach, Riffle XS 3+76**

Basin: Drainage Area: acres **10.15** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **39.10042 Lat / 105.19497 Long** Date: **08/21/10**

Observers: **K. Wright & B. Kasun** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**14.2**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.58**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**8.15**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**24.41**	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.	**1.03**	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.	**35.67**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.52**	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.	**10.04**	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.	**0.018**	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).	**1.05**	

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

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/25/2010** Valley Type: **VIII** 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})	12.6	11.1	14.2	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	9.3	8.2	10.4
Mean Riffle Depth (d_{bkf})	0.76	0.58	0.94	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	18.1	11.8	24.4
Maximum Riffle Depth (d_{max})	1.22	1.03	1.40	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	1.633	1.489	1.776
Width of Flood-Prone Area (W_{fpa})	31.1	26.6	35.7	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	2.46	2.40	2.52
Riffle Inner Berm Width (W_{ib})	6.0	5.8	6.2	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.474	0.457	0.491
Riffle Inner Berm Depth (d_{ib})	0.42	0.25	0.34	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.553	0.329	0.441
Riffle Inner Berm Area (A_{ib})	2.0	1.4	2.6	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.219	0.153	0.284
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	18.9	14.8	23.0					

Pool Dimensions*, **, ***

Pool Dimensions*' **' ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	21.0	12.2	29.8	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.661	0.964	2.361
Mean Pool Depth (d_{bkfp})	0.68	0.48	0.87	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.895	0.632	1.145
Pool Cross-Sectional Area (A_{bkfp})	12.5	10.6	14.4	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.349	1.148	1.550
Maximum Pool Depth (d_{maxp})	1.61	1.53	1.69	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.118	2.013	2.224
Pool Inner Berm Width (W_{ibp})	3.8	3.6	4.0	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.180	0.169	0.191
Pool Inner Berm Depth (d_{ibp})	0.36	0.33	0.38	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.522	0.485	0.559
Pool Inner Berm Area (A_{ibp})	1.335	1.330	1.340	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.107	0.106	0.107
Point Bar Slope (S_{pb})	0.300	0.260	0.340	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	6.67	6.65	6.68

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	28.6			ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	2.270		
Mean Run Depth (d_{bkfr})	0.36			ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	0.474		
Run Cross-Sectional Area (A_{bkfr})	10.4			ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.127		
Maximum Run Depth (d_{maxr})	1.20			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.579		
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	79.5			ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	29.6			ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	2.346		
Mean Glide Depth (d_{bkfg})	0.49			ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.645		
Glide Cross-Sectional Area (A_{bkfg})	14.4			ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.557		
Maximum Glide Depth (d_{maxg})	1.21			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.592		
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	60.4			ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	28.93		
Glide Inner Berm Width (W_{ibg})	8.4			ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.284		
Glide Inner Berm Depth (d_{ibg})	0.29			ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.592		
Glide Inner Berm Area (A_{ibg})	2.5			ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.170		

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/25/2010** Valley Type: **VIII** Stream Type: **C4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.27**	ft/sec	Estimation Method	**Limerinos**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**26.8**	cfs	Drainage Area	**10.2**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**94.4**	**51.0**	**124.8**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**7.48**	**4.04**	**9.89**
Stream Meander Length (L_m)	**101.3**	**72.5**	**125.5**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**8.03**	**5.75**	**9.95**
Radius of Curvature (R_c)	**43.9**	**21.6**	**66.5**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**3.48**	**1.71**	**5.27**
Belt Width (W_{blt})	**18.3**	**17.2**	**19.8**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.45**	**1.37**	**1.57**
Arc Length (L_a)	**33.1**	**19.3**	**50.9**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**2.62**	**1.53**	**4.03**
Riffle Length (L_r)	**31.4**	**22.9**	**38.2**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**2.49**	**1.82**	**3.03**
Individual Pool Length (L_p)	**8.0**	**7.1**	**8.6**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.64**	**0.57**	**0.68**
Pool to Pool Spacing (P_s)	**41.6**	**26.0**	**53.6**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**3.30**	**2.06**	**4.25**

Channel Profile

Valley Slope (S_{val})	**0.0189**	ft/ft	Average Water Surface Slope (S)	**0.0180**	ft/ft	Sinuosity (S_{val} / S)	**1.05**
Stream Length (SL)	**474.6**	ft	Valley Length (VL)	**454.6**	ft	Sinuosity (SL / VL)	**1.04**

Low Bank Height (LBH)	start	**1.40**	ft	Max Bankfull Depth (d_{max})	start	**1.40**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.0**
	end	**1.03**	ft		end	**1.03**	ft		end	**1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0910**	**0.0140**	**0.0240**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**5.0556**	**0.7778**	**1.3333**
Run Slope (S_{run})	**0.0600**	**0.0390**	**0.0770**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**3.3333**	**2.1667**	**4.2778**
Pool Slope (S_p)	**0.0040**	**0.0001**	**0.0070**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.2222**	**0.0056**	**0.3889**
Glide Slope (S_g)	**0.0100**	**0.0060**	**0.0140**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.5556**	**0.3333**	**0.7778**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.42**	**1.24**	**1.49**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.868**	**1.632**	**1.961**
Max Run Depth (d_{maxr})	**1.22**	**1.18**	**1.26**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**1.605**	**1.553**	**1.658**
Max Pool Depth (d_{maxp})	**1.79**	**1.69**	**1.89**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.355**	**2.224**	**2.487**
Max Glide Depth (d_{maxg})	**1.38**	**1.35**	**1.43**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.816**	**1.776**	**1.882**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**5**	**0**	**0**	D_{16}	**1.00**	**8.41**	**4.03**		mm
% Sand	**19**	**0**	**7**	D_{35}	**7.42**	**11.03**	**9.50**		mm
% Gravel	**68**	**90**	**57**	D_{50}	**10.04**	**16.00**	**33.25**		mm
% Cobble	**8**	**10**	**36**	D_{84}	**32.00**	**54.50**	**101.12**		mm
% Boulder				D_{95}	**90.00**	**82.57**	**120.98**		mm
% Bedrock				D_{100}	**179.99**	**179.99**	**130.00**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, C4 Fair Reach**
Location: **Pike National Forest, Colorado**
Observers: **K. Wright & B. Kasun**
Reference reach ☐
Disturbed (impacted reach) ☒
Date: **8/21/10**
Existing species composition: **Willow, Pine, Spruce, Carex**
Potential species composition: **Same but without invasives**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**5%**	**25%**	**Willow**	**90%**
				P. Pine	**5%**
				Spruce	**5%**
					100%
2. Understory	Shrub layer	▨	**40%**	**Willow**	**75%**
				Raspberry	**5%**
				Thistle	**5%**
				Mullen	**10%**
				Nettles	**5%**
					100%
3. Ground level	Herbaceous	▨	**31%**	**Forbs**	**13%**
				Annual Grasses	**50%**
				Thistle	**12%**
				Carex/Juncus	**25%**
					100%
	Leaf or needle litter	▨	**4%**		
	Bare ground	▨	**5%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Eradication of invasives

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/21/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, C4 Fair Reach**

Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun**

Date: **8/21/2010**

Stream Size Category and Order ☞ **S-3(4)**

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 5-9. Meander patterns.

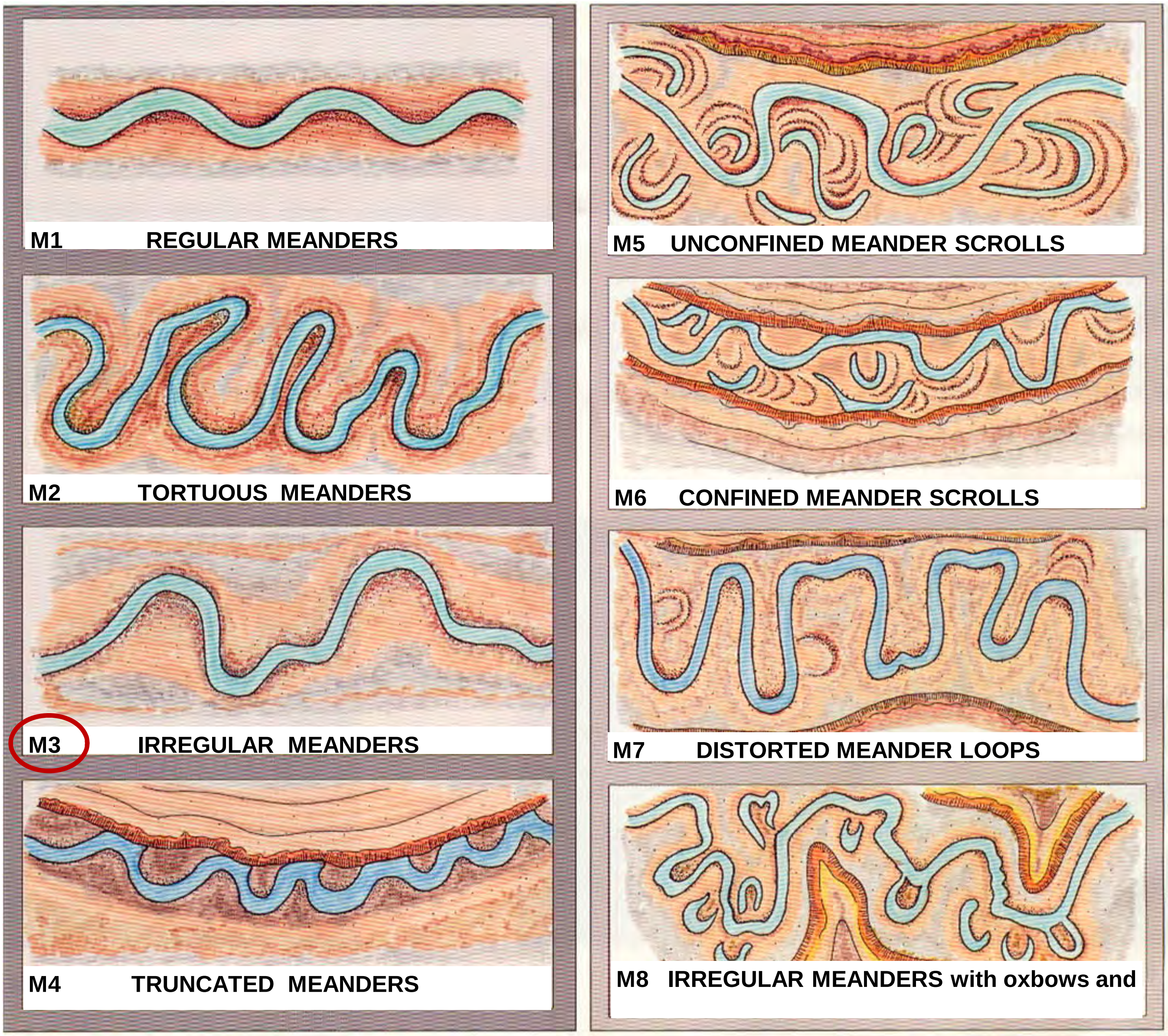
Meander Patterns

Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, CO**

Observers: **K. Wright & B. Kasun** Date: **8/21/2010**

List ALL CATEGORIES that APPLY ☞	**M3**				

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



Worksheet 5-10. Depositional patterns.

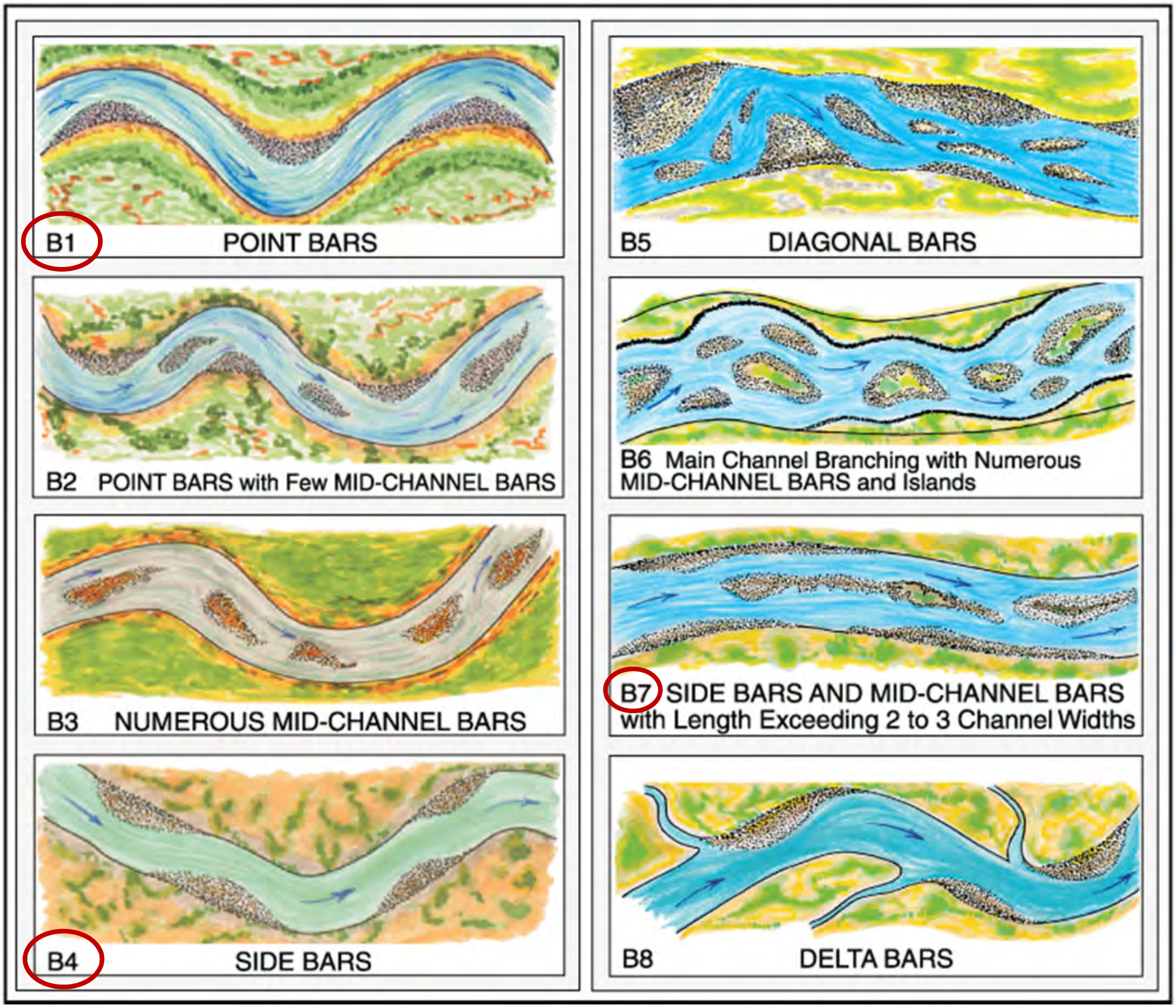
Depositional Patterns

Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/21/2010**

List ALL CATEGORIES that APPLY ☞	**B1**	**B4**	**B7**		

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



Worksheet 5-11. Channel blockages.

Channel Blockages		
Stream: **Trail Creek, C4 Fair Reach**	Location: **Pike National Forest, Colorado**	
Observers: **K. Wright & B. Kasun**	Date: **8/21/2010**	
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.	☐

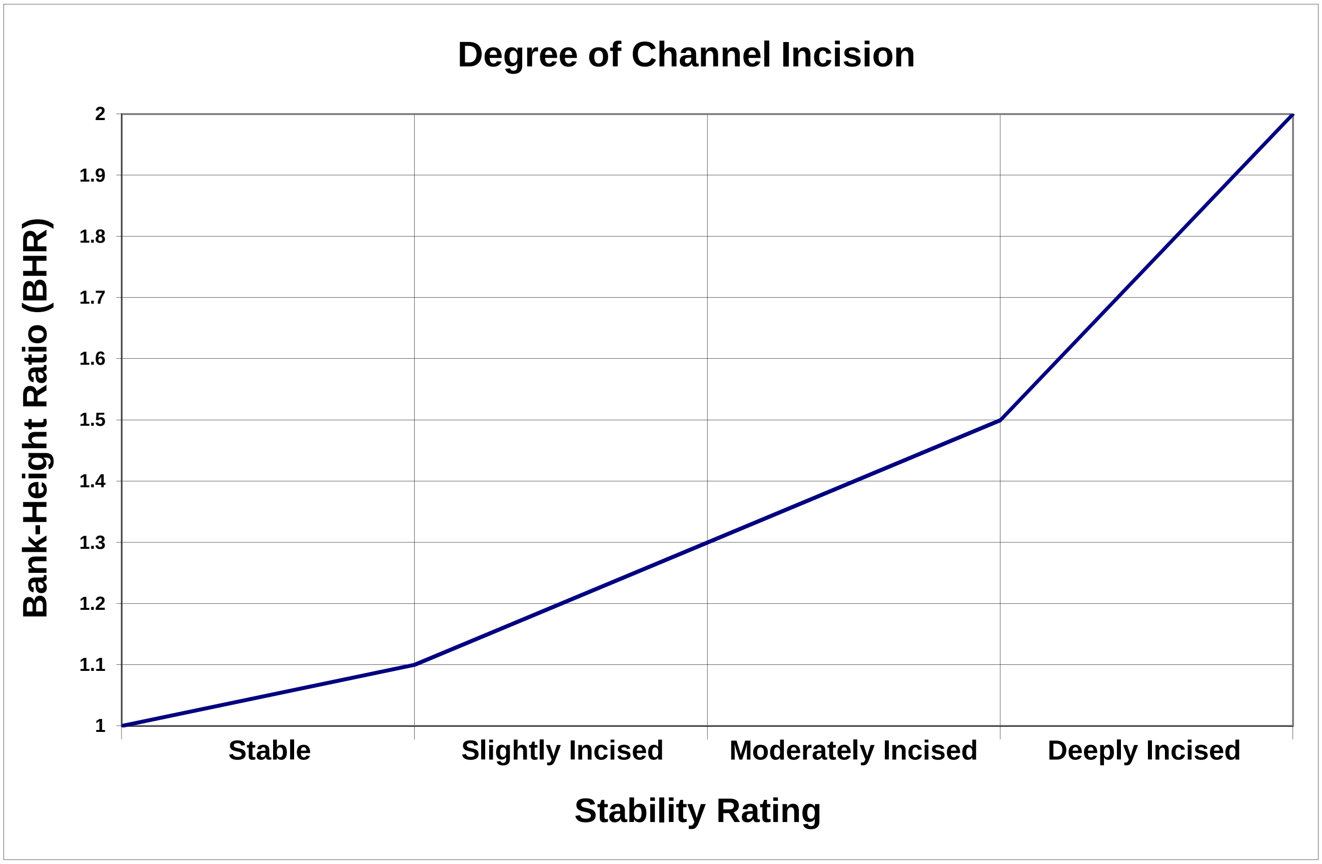
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**1.03**
Max Bankfull Depth:	**1.03**

Bank-Height Ratio:	**1.0**

Degree of Channel Incision Stability Rating ☞	**Stable**



Worksheet 5-13. Width/depth ratio state.

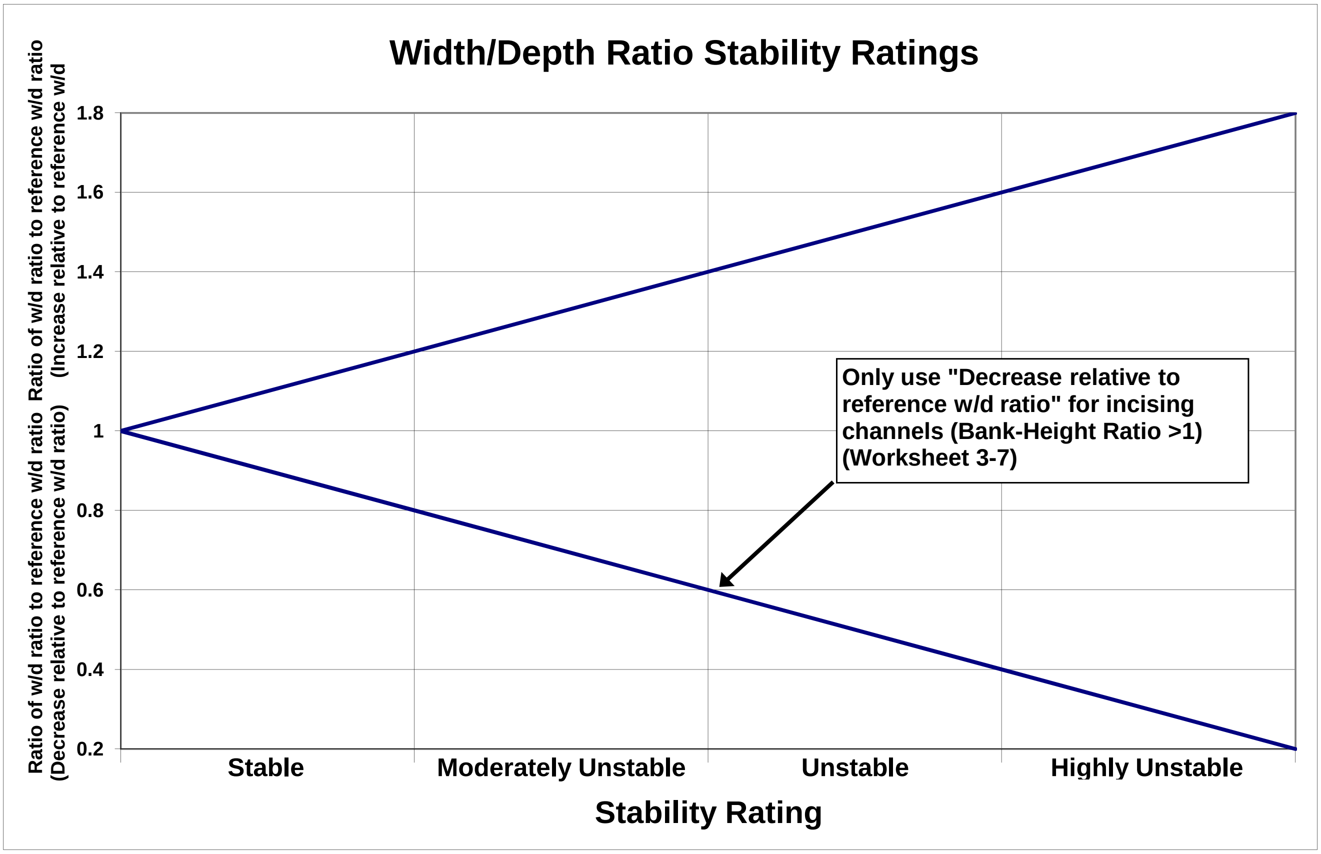
Width/Depth Ratio State

Existing Width/Depth Ratio: **24.41**

Reference Width/Depth Ratio: **13.7-19**

Ratio of existing W/d to reference W/d: **1.28**

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

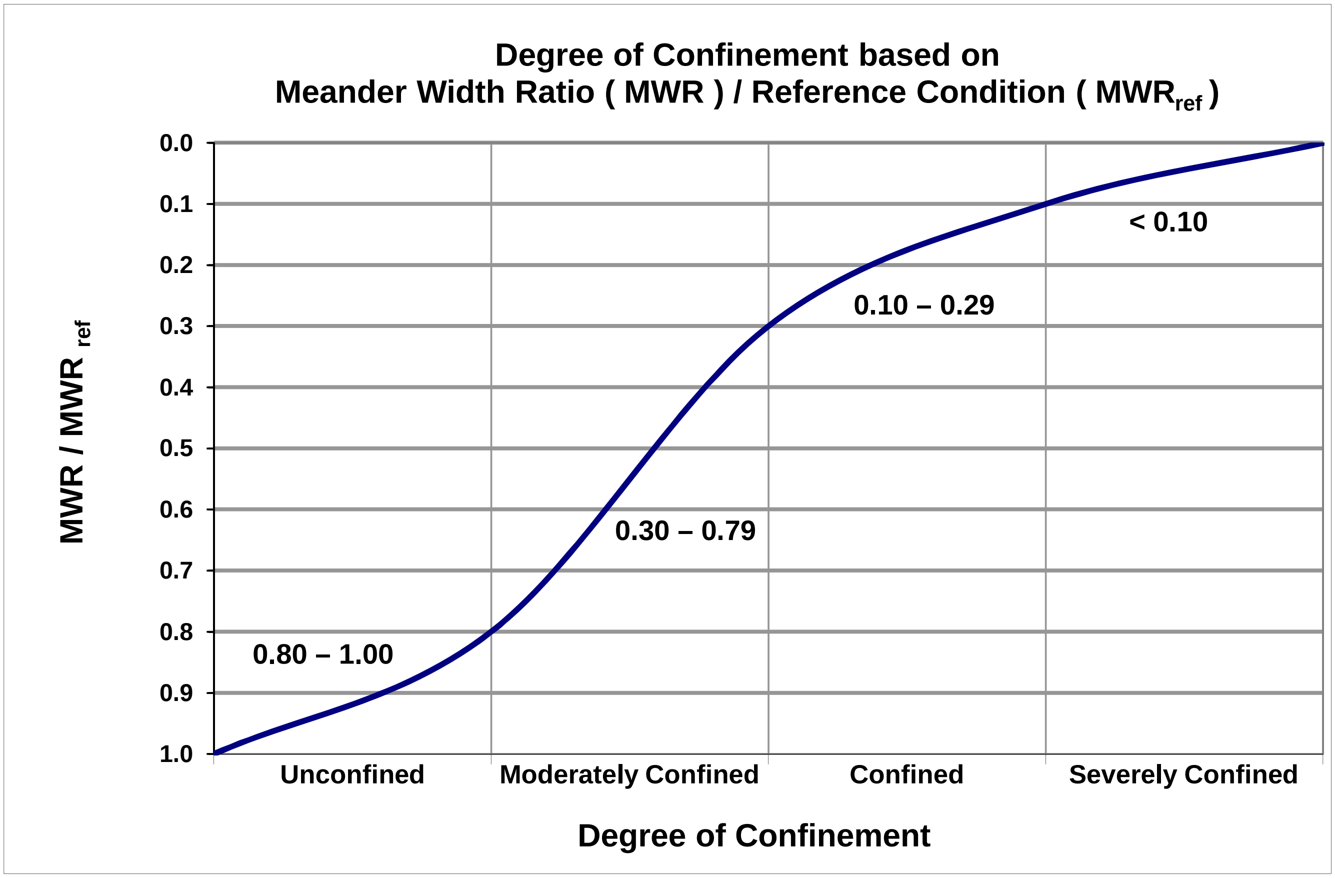
Degree of Confinement

Existing Meander Width Ratio (MWR): **1.45**

Reference Meander Width Ratio (MWR_{ref}): **4.50**

Ratio of MWR to MWR_{ref}: **0.32**

Degree of Confinement Stability Rating ☞ **Moderately Confined**



Degree of Confinement based on
Meander Width Ratio (MWR) / Reference Condition (MWR_{ref})

Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, C4 Fair Reach **Location:** Pike National Forest **Valley Type:** VIII **Observers:** K. Wright & B. Kasun **Date:** 8/21/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	[✓ 5]	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ 12]
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	[✓ 6]	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	[✓ 2]	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	[✓ 7]	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 2]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	[✓ 7]	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	[✓ 12]	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	[✓ 5]	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	[✓ 12]	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	[✓ 12]	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	4	Good total =	39	Fair total =	31	Poor total =	20

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	[✓ C4]	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	94
Existing stream type =	C4
*Potential stream type =	C4
Modified channel stability rating =	Fair

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

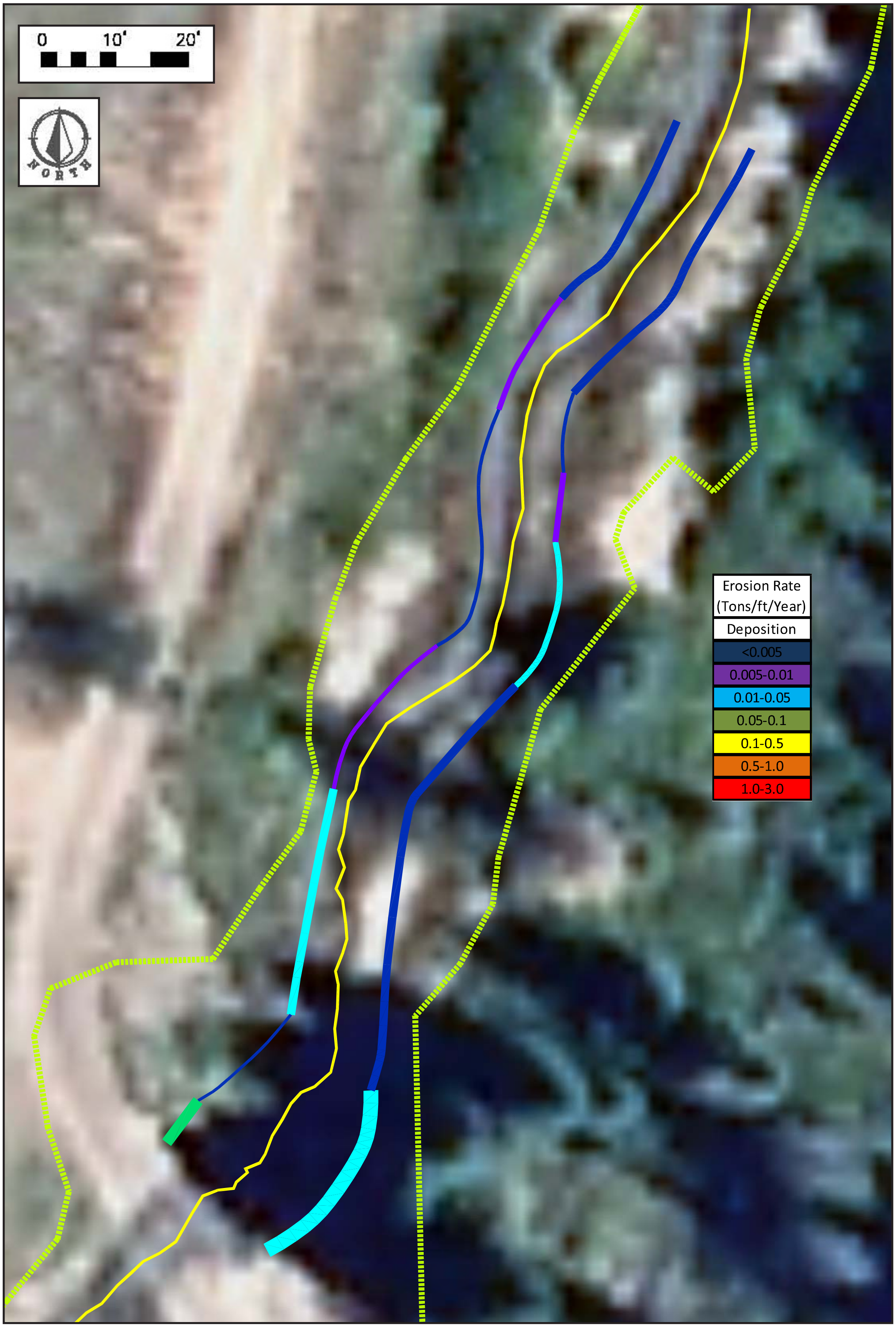
Stream: **Trail Creek, C4 Fair Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **215** Date: **8/21/2010**

Observers: **K. Wright & B. Kasun** Valley Type: **VIII** Stream Type: **C4**

(1) Station (ft)	(2) BEHI rating (Worksheet 5-16) (adjective)	(3) NBS rating (Worksheet 5-17) (adjective)	(4) Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. BR 0+00 to 0+20 Right	Very High	Moderate	0.37957	20.0	2.5	18.98	0.04569
2. BR 0+00 to 0+07 Left	High	High	0.57533	7.0	1.9	7.65	0.05263
3. BR 0+07 to 0+45 Left	Very Low	Low	0.00386	38.0	0.5	0.07	0.00009
4. BR 0+20 to 0+86 Right	Low	High	0.15505	66.0	1.4	14.33	0.01045
5. BR 0+45 to 0+65 Left	Moderate	High	0.42031	20.0	1.4	11.77	0.02833
6. BR 0+65 to 1+11 Left	Low	High	0.15505	46.0	0.7	4.99	0.00523
7. BR 0+86 to 1+00 Right	Moderate	High	0.42031	14.0	1.0	5.88	0.02024
8 BR 1+00 to 1+16 Right	Low	High	0.15505	16.0	1.0	2.48	0.00747
9 BR 1+16 to 1+39 Right	Low	Low	0.03566	23.0	0.6	0.49	0.00103
10 BR 1+39 to 2+15 Right	Moderate	Moderate	0.25348	76.0	1.1	21.19	0.01343
11 BR 1+11 to 1+39 Left	Low	Low	0.03566	28.0	0.7	0.65	0.00112
12 BR 1+39 to 1+66 Left	Low	High	0.15505	27.0	0.9	3.77	0.00672
13 BR 1+66 to 2+15 Left	Low	Moderate	0.07435	49.0	1.3	4.74	0.00465
14							
15							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total Erosion (ft^3/yr)	96.99	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					Total Erosion (yds^3/yr)	3.59	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					Total Erosion (tons/yr)	4.67	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					Total Erosion (tons/yr/ft)	0.0217	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**26.8**	**0.0160**	**21.55**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**68.2**													
0.10%	**58.5**	**0.05%**	**0.09%**	**0.34**	**63.3**	**2.363**	**7.461**	**27.50**	**6.670**	**10.18**	**21.7**	**9.43**	**3.49**	**12.93**
0.25%	**50.6**	**0.08%**	**0.15%**	**0.55**	**54.6**	**2.036**	**5.232**	**16.61**	**4.809**	**7.34**	**29.9**	**9.10**	**4.02**	**13.11**
0.50%	**43.7**	**0.13%**	**0.25%**	**0.91**	**47.2**	**1.761**	**3.706**	**10.18**	**3.494**	**5.33**	**43.1**	**9.29**	**4.87**	**14.15**
0.75%	**37.4**	**0.13%**	**0.25%**	**0.91**	**40.5**	**1.513**	**2.592**	**6.12**	**2.502**	**3.82**	**37.0**	**5.58**	**3.48**	**9.06**
1%	**32.3**	**0.13%**	**0.25%**	**0.91**	**34.8**	**1.300**	**1.817**	**3.68**	**1.790**	**2.73**	**31.8**	**3.36**	**2.49**	**5.85**
1.5%	**27.7**	**0.25%**	**0.50%**	**1.83**	**30.0**	**1.120**	**1.289**	**2.25**	**1.289**	**1.97**	**54.8**	**4.11**	**3.59**	**7.70**
2%	**23.1**	**0.25%**	**0.50%**	**1.83**	**25.4**	**0.949**	**0.886**	**1.31**	**0.893**	**1.36**	**46.4**	**2.39**	**2.49**	**4.88**
3%	**19.5**	**0.50%**	**1.00%**	**3.65**	**21.3**	**0.795**	**0.600**	**0.74**	**0.602**	**0.92**	**77.8**	**2.72**	**3.35**	**6.07**
4%	**16.6**	**0.50%**	**1.00%**	**3.65**	**18.1**	**0.674**	**0.424**	**0.45**	**0.415**	**0.63**	**65.9**	**1.63**	**2.31**	**3.94**
5%	**14.8**	**0.50%**	**1.00%**	**3.65**	**15.7**	**0.587**	**0.322**	**0.29**	**0.304**	**0.46**	**57.4**	**1.08**	**1.69**	**2.77**
10%	**9.3**	**2.50%**	**5.00%**	**18.25**	**12.1**	**0.450**	**0.200**	**0.14**	**0.165**	**0.25**	**220.2**	**2.56**	**4.59**	**7.15**
20%	**5.1**	**5.00%**	**10.00%**	**36.50**	**7.2**	**0.269**	**0.103**	**0.04**	**0.045**	**0.07**	**262.7**	**1.57**	**2.53**	**4.10**
30%	**3.4**	**5.00%**	**10.00%**	**36.50**	**4.2**	**0.158**	**0.075**	**0.02**	**0.006**	**0.01**	**154.5**	**0.67**	**0.36**	**1.03**
40%	**2.4**	**5.00%**	**10.00%**	**36.50**	**2.9**	**0.108**	**0.068**	**0.01**	**0.000**	**0.00**	**105.6**	**0.42**	**0.00**	**0.42**
50%	**1.8**	**5.00%**	**10.00%**	**36.50**	**2.1**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**77.3**	**0.30**	**0.00**	**0.30**
60%	**1.4**	**5.00%**	**10.00%**	**36.50**	**1.6**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**59.2**	**0.22**	**0.00**	**0.22**
70%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.3**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**46.4**	**0.17**	**0.00**	**0.17**
80%	**1.0**	**5.00%**	**10.00%**	**36.50**	**1.1**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**38.6**	**0.14**	**0.00**	**0.14**
90%	**0.7**	**5.00%**	**10.00%**	**36.50**	**0.8**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**30.9**	**0.11**	**0.00**	**0.11**
100%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.4**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**15.5**	**0.06**	**0.00**	**0.06**
									Annual Totals:		**1,476.5** (cfs) **2,928.6** (acre-ft)	**54.9** (tons/yr)	**39.3** (tons/yr)	**94.2** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	26.8	0.0290	38.00
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**89.6**													
0.10%	**79.9**	**0.05%**	**0.09%**	**0.34**	**84.8**	**3.163**	**15.000**	**130.47**	**12.657**	**34.97**	**29.1**	**44.76**	**12.00**	**56.76**
0.25%	**72.1**	**0.08%**	**0.15%**	**0.55**	**76.0**	**2.836**	**11.549**	**90.07**	**9.962**	**27.52**	**41.6**	**49.31**	**15.07**	**64.38**
0.50%	**65.2**	**0.13%**	**0.25%**	**0.91**	**68.6**	**2.561**	**9.046**	**63.70**	**7.962**	**22.00**	**62.6**	**58.13**	**20.07**	**78.20**
0.75%	**58.8**	**0.13%**	**0.25%**	**0.91**	**62.0**	**2.313**	**7.094**	**45.12**	**6.368**	**17.59**	**56.6**	**41.18**	**16.05**	**57.23**
1%	**53.8**	**0.13%**	**0.25%**	**0.91**	**56.3**	**2.100**	**5.633**	**32.53**	**5.149**	**14.22**	**51.4**	**29.68**	**12.98**	**42.66**
1.5%	**48.9**	**0.25%**	**0.50%**	**1.83**	**51.3**	**1.915**	**4.523**	**23.81**	**4.203**	**11.61**	**93.7**	**43.46**	**21.19**	**64.65**
2%	**44.0**	**0.25%**	**0.50%**	**1.83**	**46.4**	**1.732**	**3.567**	**16.99**	**3.372**	**9.32**	**84.7**	**31.01**	**17.00**	**48.02**
3%	**40.3**	**0.50%**	**1.00%**	**3.65**	**42.2**	**1.573**	**2.839**	**12.28**	**2.726**	**7.53**	**153.9**	**44.82**	**27.49**	**72.31**
4%	**35.8**	**0.50%**	**1.00%**	**3.65**	**38.1**	**1.420**	**2.234**	**8.72**	**2.176**	**6.01**	**138.9**	**31.84**	**21.95**	**53.79**
5%	**31.7**	**0.50%**	**1.00%**	**3.65**	**33.7**	**1.259**	**1.686**	**5.84**	**1.668**	**4.61**	**123.1**	**21.30**	**16.82**	**38.12**
10%	**19.7**	**2.50%**	**5.00%**	**18.25**	**25.7**	**0.959**	**0.907**	**2.39**	**0.913**	**2.52**	**469.0**	**43.62**	**46.06**	**89.68**
20%	**6.9**	**5.00%**	**10.00%**	**36.50**	**13.3**	**0.497**	**0.237**	**0.32**	**0.207**	**0.57**	**486.0**	**11.80**	**20.92**	**32.72**
30%	**3.5**	**5.00%**	**10.00%**	**36.50**	**5.2**	**0.194**	**0.082**	**0.04**	**0.017**	**0.05**	**189.9**	**1.59**	**1.67**	**3.26**
40%	**2.4**	**5.00%**	**10.00%**	**36.50**	**3.0**	**0.110**	**0.068**	**0.02**	**0.000**	**0.00**	**107.8**	**0.75**	**0.00**	**0.75**
50%	**1.8**	**5.00%**	**10.00%**	**36.50**	**2.1**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**77.3**	**0.52**	**0.00**	**0.52**
60%	**1.4**	**5.00%**	**10.00%**	**36.50**	**1.6**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**59.2**	**0.39**	**0.00**	**0.39**
70%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.3**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**46.4**	**0.31**	**0.00**	**0.31**
80%	**1.0**	**5.00%**	**10.00%**	**36.50**	**1.1**	**0.039**	**0.064**	**0.01**	**0.000**	**0.00**	**38.6**	**0.25**	**0.00**	**0.25**
90%	**0.7**	**5.00%**	**10.00%**	**36.50**	**0.8**	**0.032**	**0.064**	**0.01**	**0.000**	**0.00**	**30.9**	**0.20**	**0.00**	**0.20**
100%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.4**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**15.5**	**0.10**	**0.00**	**0.10**
									Annual Totals:		**2,356.1** (cfs) **4,673.3** (acre-ft)	**455.0** (tons/yr)	**249.3** (tons/yr)	**704.3** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "GOOD-FAIR" Curves)** Date: **08/27/10**

Observers: **S=.0189, Q=27, 21.3, Bed.=.0638, S.Sand=19** Stream Type: **C4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.14**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.71**	**0.43**	**0.44**	**3.86**	**0.11**	**0.93**	**0.0189**	**0.13**	**0.51**	**0.13**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**0.99**	**0.85**	**0.73**	**4.75**	**0.15**	**1.16**	**0.0189**	**0.18**	**1.00**	**0.21**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.13**	**1.06**	**0.85**	**5.02**	**0.17**	**1.23**	**0.0189**	**0.20**	**1.25**	**0.25**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.41**	**1.27**	**0.96**	**5.25**	**0.18**	**1.29**	**0.0189**	**0.21**	**1.50**	**0.29**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.00%	**1.83**	**1.62**	**1.14**	**5.63**	**0.20**	**1.39**	**0.0189**	**0.24**	**1.91**	**0.34**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.40**	**2.12**	**1.39**	**6.09**	**0.23**	**1.51**	**0.0189**	**0.27**	**2.50**	**0.41**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.51**	**2.96**	**1.76**	**6.67**	**0.26**	**1.66**	**0.0189**	**0.31**	**3.49**	**0.52**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**6.90**	**5.21**	**2.67**	**7.99**	**0.33**	**1.95**	**0.0189**	**0.39**	**6.14**	**0.77**	**10%**	**36.50**	**0.04**	**0.02**	**1.46**	**0.73**	**2.19**
10.00%	**19.73**	**13.32**	**4.98**	**9.19**	**0.54**	**2.66**	**0.0189**	**0.62**	**15.71**	**1.71**	**10%**	**36.50**	**0.56**	**0.16**	**20.44**	**5.84**	**26.28**
5.00%	**31.65**	**25.69**	**8.17**	**11.63**	**0.70**	**3.15**	**0.0189**	**0.80**	**30.30**	**2.61**	**5%**	**18.25**	**2.46**	**1.17**	**44.89**	**21.35**	**66.24**
4.00%	**35.79**	**33.72**															
3.00%	**40.31**	**38.05**															
2.00%	**43.97**	**42.14**															
1.50%	**48.86**	**46.42**															
1.00%	**53.75**	**51.31**															
0.75%	**58.79**	**56.27**															
0.50%	**65.17**	**61.98**															
0.25%	**72.06**	**68.62**															
0.10%	**79.92**	**75.99**															
0.0060%	**89.58**	**84.75**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**66.8**	**29.0**	**95.8**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, C4 Fair Riffle XS 3+76** Location: **Pike National Forest, Colorado (Used "GOOD-FAIR" Curves)** Date: **08/27/10**

Observers: **S=.0189, Q=27, 21.3, Bed.=.0638, S.Sand=19** Stream Type: **C4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.14**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.71**	**0.43**	**0.47**	**4.50**	**0.10**	**0.81**	**0.0189**	**0.12**	**0.51**	**0.11**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**0.99**	**0.85**	**0.77**	**5.27**	**0.15**	**1.06**	**0.0189**	**0.17**	**1.00**	**0.19**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.13**	**1.06**	**0.89**	**5.35**	**0.17**	**1.14**	**0.0189**	**0.19**	**1.25**	**0.23**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.41**	**1.27**	**1.00**	**5.44**	**0.18**	**1.22**	**0.0189**	**0.21**	**1.50**	**0.28**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.00%	**1.83**	**1.62**	**1.19**	**5.59**	**0.21**	**1.36**	**0.0189**	**0.25**	**1.91**	**0.34**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.40**	**2.12**	**1.42**	**5.92**	**0.24**	**1.46**	**0.0189**	**0.28**	**2.50**	**0.42**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.51**	**2.96**	**1.82**	**6.49**	**0.28**	**1.63**	**0.0189**	**0.32**	**3.49**	**0.54**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**6.90**	**5.21**	**2.97**	**9.49**	**0.31**	**1.76**	**0.0189**	**0.36**	**6.14**	**0.65**	**10%**	**36.50**	**0.04**	**0.02**	**1.46**	**0.73**	**2.19**
10.00%	**19.73**	**13.32**	**7.23**	**21.73**	**0.33**	**1.83**	**0.0189**	**0.39**	**15.71**	**0.72**	**10%**	**36.50**	**0.04**	**0.05**	**1.46**	**1.83**	**3.29**
5.00%	**31.65**	**25.69**	**11.40**	**25.15**	**0.45**	**2.25**	**0.0189**	**0.53**	**30.30**	**1.20**	**5%**	**18.25**	**0.26**	**0.20**	**4.75**	**3.65**	**8.40**
4.00%	**35.79**	**33.72**															
3.00%	**40.31**	**38.05**															
2.00%	**43.97**	**42.14**															
1.50%	**48.86**	**46.42**															
1.00%	**53.75**	**51.31**															
0.75%	**58.79**	**56.27**															
0.50%	**65.17**	**61.98**															
0.25%	**72.06**	**68.62**															
0.10%	**79.92**	**75.99**															
0.0060%	**89.58**	**84.75**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**7.7**	**7.3**	**15.0**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**66.8**	**29.0**	**95.8**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-59.1**	**-21.7**	**-80.8**
Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, ≈ 84% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, C4 Fair Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/21/10**

Enter Required Information for Existing Condition

16.0	D_{50}	Riffle bed material D_{50} (mm)			
33.3	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.43	D_{max}	Largest particle from bar sample (ft)	**130**	**(mm)**	304.8 mm/ft
0.018	S	Existing bankfull water surface slope (ft/ft)			
0.58	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.48	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
8.13	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

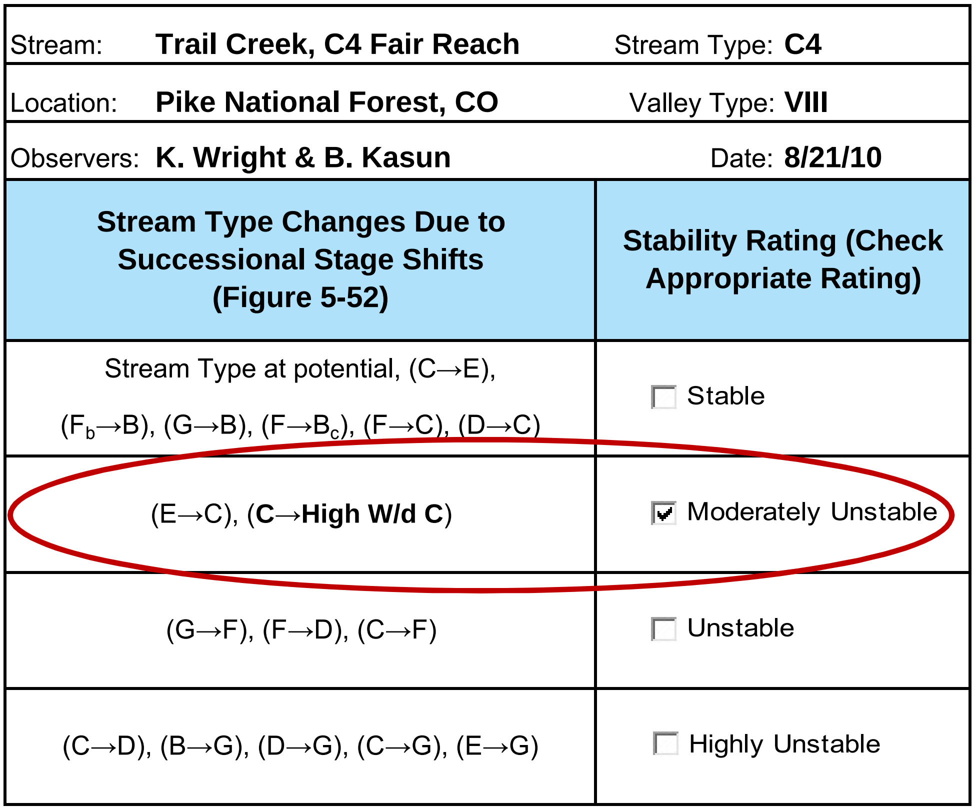
Sediment Competence Using Dimensional Shear Stress

0.651		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 **46**	CO **120**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.7**	CO **0.7**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **1.51**	CO **0.62**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \dfrac{\tau}{\gamma S}$
Shields **0.0470**	CO **0.0193**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \dfrac{\tau}{\gamma d}$

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.



Stream: **Trail Creek, C4 Fair Reach** Stream Type: **C4**

Location: **Pike National Forest, CO** Valley Type: **VIII**

Observers: **K. Wright & B. Kasun** Date: **8/21/10**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (**C→High W/d C**)	☑ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **Trail Creek, C4 Fair Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright & B. Kasun** Date: **8/21/10**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**4**
	(2)	**1.3** [✓ **(4)**]	**(6)**	**(8)**	
2 **Depositional Patterns (Worksheet 5-10)**	**B1**, B2	**B4**, B8	B3	B5, B6, **B7**	**3**
	B1 **(1)**	**B4** **(2)**	[✓ **(3)**]	**B7** **(4)**	
3 **Meander Patterns (Worksheet 5-9)**	M1, **M3**, M4		M2, M5, M6, M7, M8		**1**
	M3 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
	[✓ **(2)**]	**(4)**	**(5)**	**(8)**	
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**2**
	(1)	**0.32** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**12**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☑	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, C4 Fair Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/21/10**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**4**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**4**
	(2)	**1.3** [✓ **(4)**]	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	**(C→High W/d C)**, (B→High W/d B), (C→F)	(C→D), (F→D)	**6**
	(2)	**(4)**	[✓ **(6)**]	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	**B1**	B2, **B4**	B3, B5	B6, **B7**, B8	**3**
	B1 **(1)**	**B4** **(2)**	[✓ **(3)**]	**B7** **(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	**D1**, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D1 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**26**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability − degradation.

Stream:	**Trail Creek, C4 Fair Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/21/10**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**2**
	(1)	**0.32** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**10**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, C4 Fair Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright & B. Kasun**	Date:	**8/21/10**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(**C→High W/d C**), (E→C) [✓ **(4)**]	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**4**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* [✓ **(4)**]	*Unstable* **(6)**	*Highly Unstable* **(8)**	**4**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**16**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream: **Trail Creek, C4 Fair Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright & B. Kasun** Date: **8/21/10**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	1	2
	Mod. Unstable	[✓ 2]	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	1	3
	Mod. Deposition	2	
	Excess Deposition	[✓ 3]	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	2
	Slight Increase	[✓ 2]	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*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* 5 ☐	*Moderate* 6 – 10 ☑	*High* 11 – 15 ☐	*Very High* 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, C4 Fair Reach**							Location:	**Pike National Forest, Colorado**					
Observers:	**K. Wright & B. Kasun**			Date:	**8/21/2010**			Stream Type:	**C4**		Valley Type:	**VIII**		
Channel Dimension (Riffle XS 3+76)	Mean Bankfull Depth (ft):	**0.58**	Bankfull Width (ft):	**14.2**	Cross-Sectional Area (ft^2):	**8.15**	Width of Flood-Prone Area (ft):	**35.67**	Entrenchment Ratio:	**2.52**				
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**7.48** **4.04-9.89**	L_m/W_{bkf}:	**8.03** **5.75-9.95**	R_c/W_{bkf}:	**3.48** **1.71-5.27**	MWR:	**1.45** **1.37-1.57**	Sinuosity:	**1.05**			
River Profile & Bed Features	Check:	☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed								
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope					
		1.42	**1.79**		**1.87**	**2.36**		**3.3**	Valley:	**0.0189**	Water Surface:	**0.018**		
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:	**Willow,Pine,Spruce,Carex**	Potential Composition/Density:	**Same but without invasives**	Remarks: Condition, Vigor & Usage of Existing Reach:	**Eradication of invasives**							
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**M3**	Depositional Patterns:	**B1, B4, B7**	Debris/Channel Blockages:	**D1**				
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**94 (Fair)**								
	Width/depth Ratio (W/d):	**24.4**	Reference W/d Ratio (W/d_{ref}):	**13.7-19**	Width/Depth Ratio State $(W/d)/(W/d_{ref})$:	**1.28**	W/d Ratio State Stability Rating:	**Moderately Unstable**						
	Meander Width Ratio (MWR):	**1.45**	Reference MWR_{ref}:	**4.5**	Degree of confinement (MWR/MWR_{ref}):	**0.32**	MWR/MWR_{ref} Stability Rating:	**Moderately Confined**						
Bank Erosion Summary	Length of Reach Studied (ft):	**215**	Annual Streambank Erosion Rate:	**4.67** (tons/yr)	**0.0217** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:						
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity	Remarks: ≈ **84% Reduction in Transport Capacity**										
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**130**	$\tau =$	**0.651**	$\tau^* =$	**N/A**	Existing Depth:	**0.58**	Required Depth:	**0.62**	Existing Slope:	**0.018**	Required Slope:	**0.019**
Successional Stage Shift	C → G → F → [✓ C] → →						Existing Stream State (Type):	**C4** **HWD**	Potential Stream State (Type):	**C4**				
Lateral Stability	☐ *Stable*	☑ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:									
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:									
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:									
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:									
Sediment Supply (Channel Source)	☐ *Low*	☑ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:									

Appendix C7

C4 Stream Type

Poor Stability Reach

Table of Contents

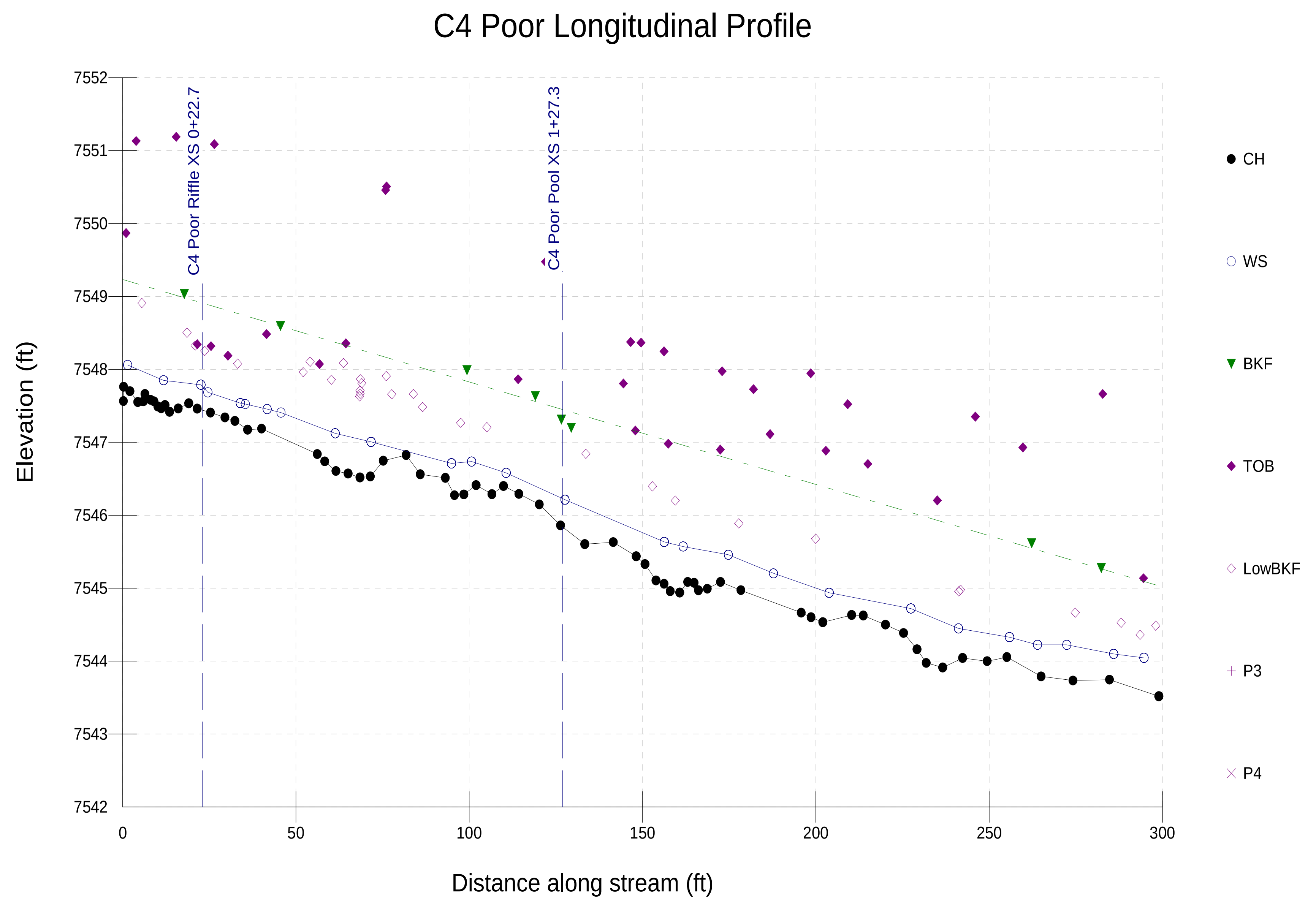
Appendix C7: C4 PoorReach

C4 Poor Reach Location & Overview

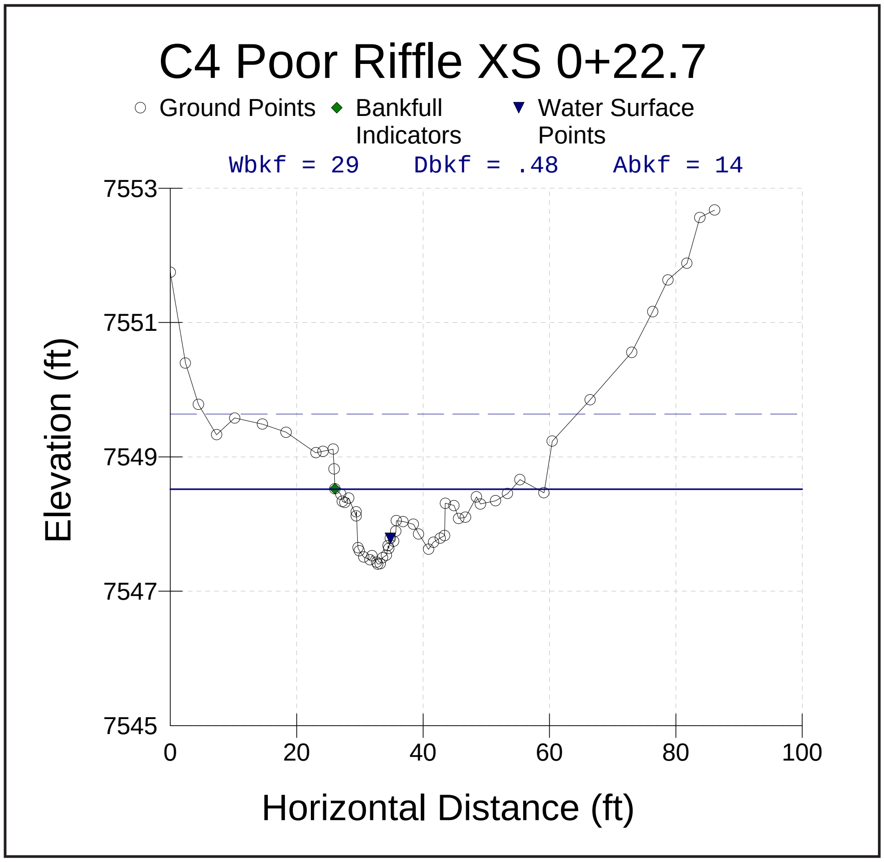
The C4 Poor representative reach is a 4th order, perennial stream located in main Trail Creek (**Figure C-2**). The higher width/depth ratio than the reference condition has led to excess sediment deposition in the channel as the POWERSED sediment transport capacity model and the sediment competency calculations both indicate aggradation. The stability rating is "Poor" due to a "Poor" Pfankuch stability rating and the relatively high streambank erosion rate of *0.0472 tons/yr/ft* compared to the C4 reference rate of *0.0063 tons/yr/ft*. The sediment supply rating is *High* due primarily to the streambank erosion source and increase in stored sediment in the channel bed. This rating indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows compared to the reference C4 condition. The WRENSS model indicates a water yield increase due to the fire of *2,733 acre-ft*. As a result, bedload increased from *45 tons/yr* to *5,117 tons/yr*, and suspended sediment increased from *144 tons/yr* to *9,512 tons/yr*, representing a total increase in sediment of *14,441 tons/yr*. These are extremely high values for a C4 stream type of this size (48 cfs), which reflect the accelerated sediment yield due to flow related sediment.

The photograph depicts the typical character of this representative C4 Poor stream type with minimum vegetative influence. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

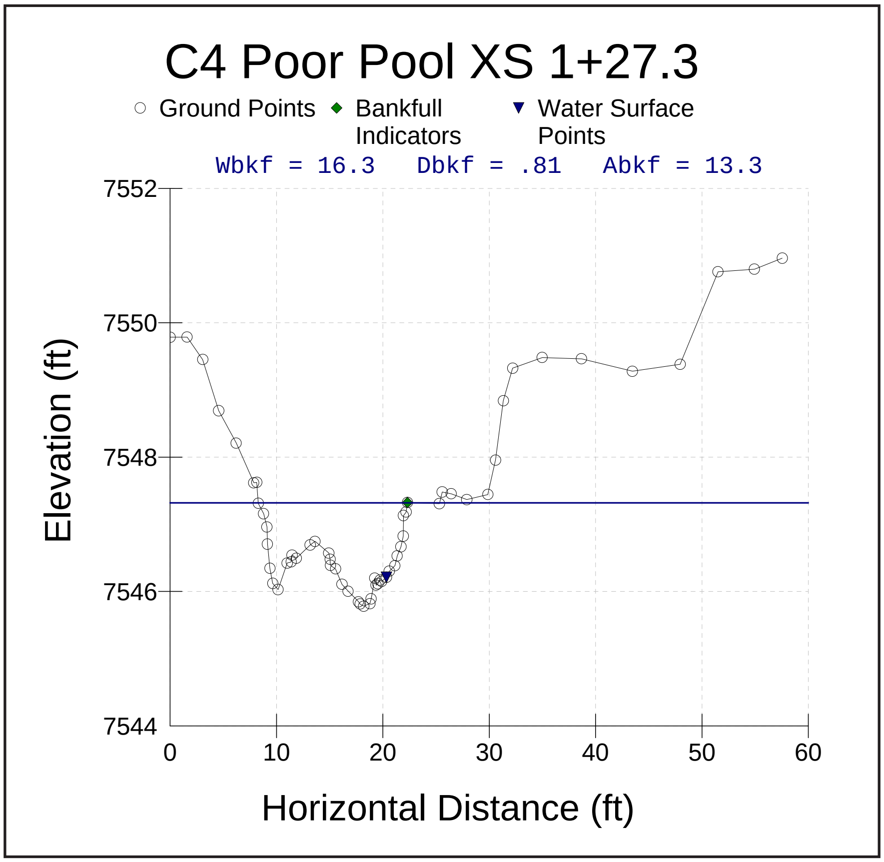
Survey Summary



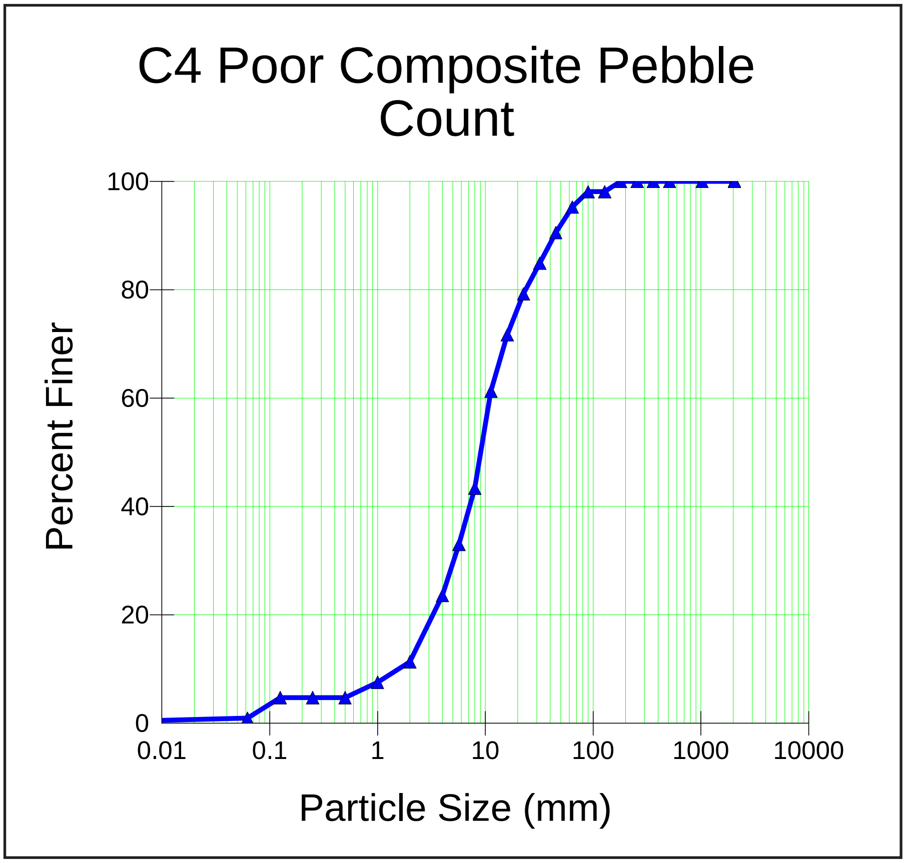
Longitudinal Profile (graph generated from RIVERMorph^{TM})



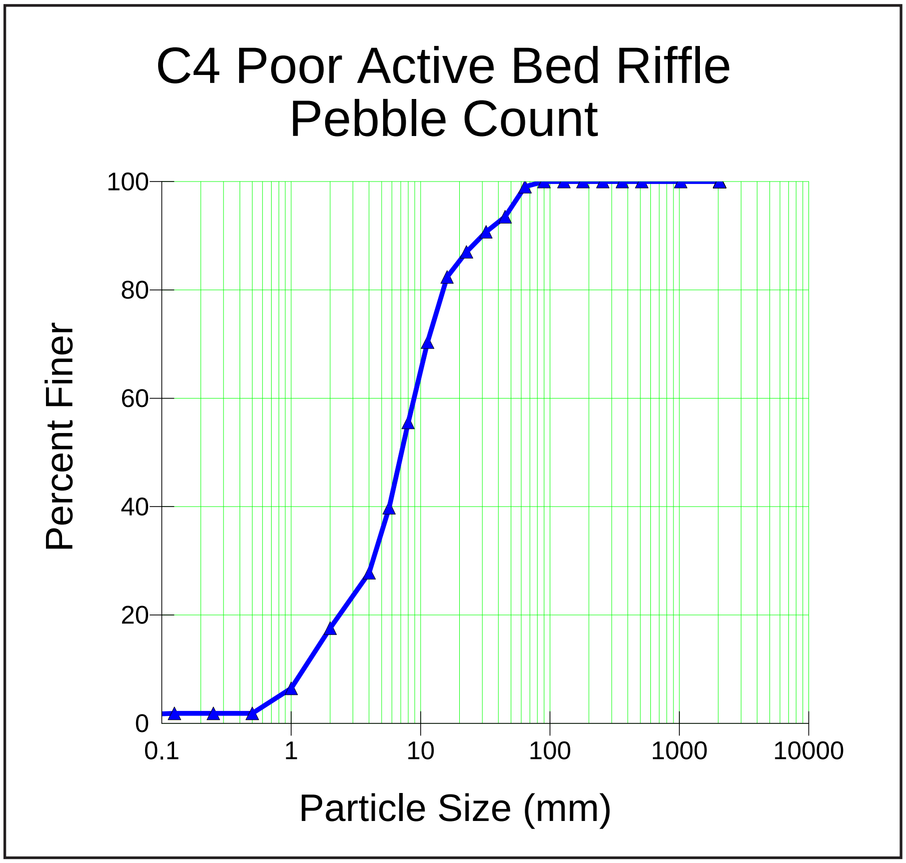
Representative Riffle Cross-section 0+22.7 (graph generated from RIVERMorph^{TM})



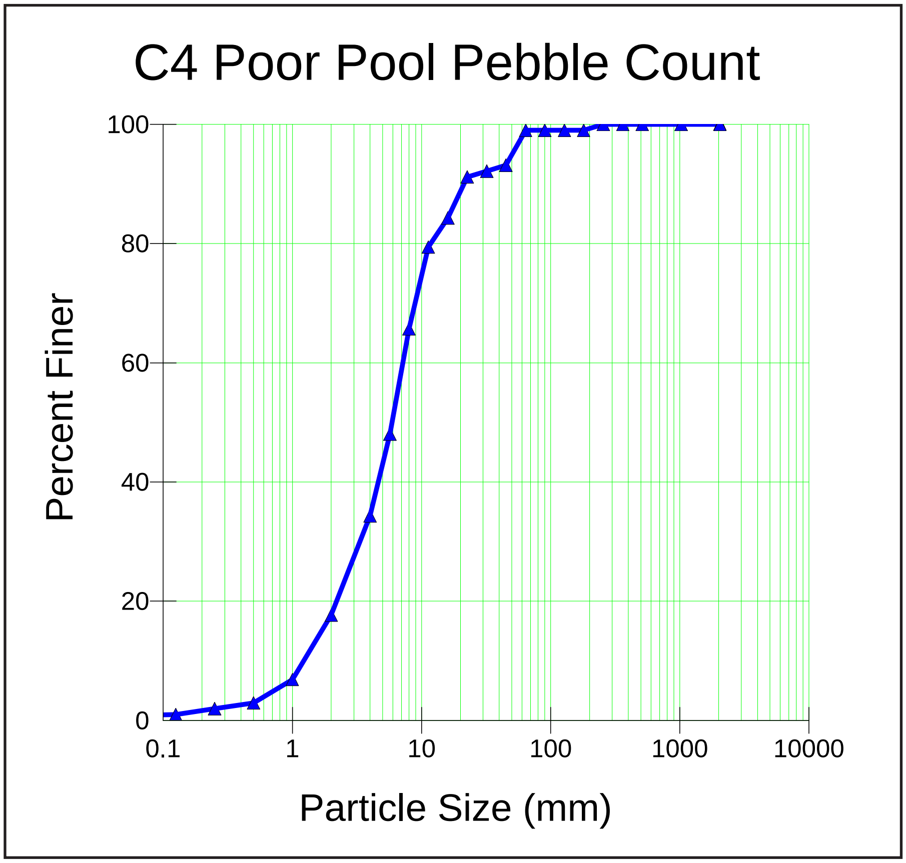
Pool Cross-section 1+27.3 (graph generated from RIVERMorph^{TM})



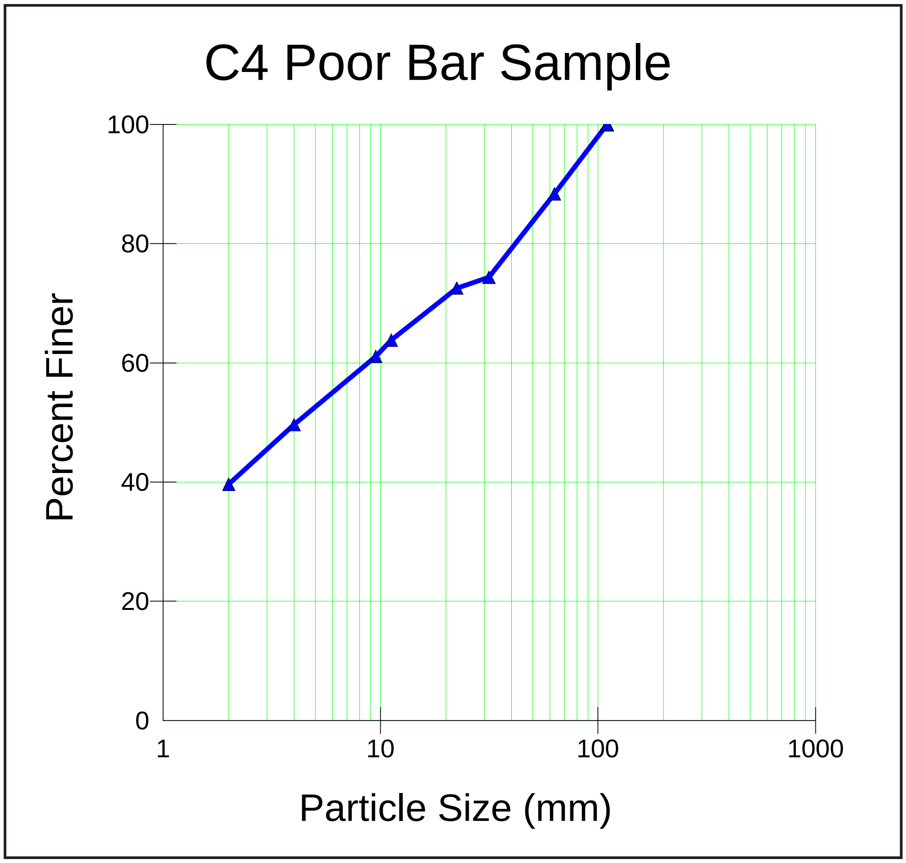
Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Pool Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, C4 Poor Reach**			Location:	**XS 0+22.7, Pike N.F., Colorado**
Date:	**8/18/2010**	Stream Type:	**C4**	Valley Type:	**VIII**
Observers:	**L. Chavez *et al*.**			HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**14.0**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.48**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**29.0**	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**29.98**	W_p (ft)
D_{84} at Riffle	**18.3**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.06**	D_{84} (ft)
Bankfull SLOPE	**0.0140**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.47**	**R** (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**7.76**	**R / D_{84}**
Drainage Area	**15.9**	**DA** (mi^2)	Shear Velocity $u* = (gRS)^{½}$	**0.458**	**u*** (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\,2.83 + 5.66 * Log\{R / D_{84}\}\,]\,u*$	**3.60**	ft / sec	**50.26**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.0253**	**4.18**	ft / sec	**58.37**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.031**	**3.41**	ft / sec	**47.64**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.087**	**1.22**	ft / sec	**16.96**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Limerinos**	**3.81**	ft / sec	**53.1**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, C4 Poor Reach**

Basin: **South Platte** Drainage Area: **10176** acres **15.9** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 0+22.7** Date: **08/19/10**

Observers: **L. Chavez *et al*.** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**29.02**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.48**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**13.95**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**60.46**	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.	**1.12**	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.	**59**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.03**	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.	**9.22**	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.	**0.014**	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 **C4** (See **Figure 2-14**)

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **L. Chavez *et al*.** Date: **8/18/2010** Valley Type: **VIII** 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 (Wbkf)	29.0			ft	Riffle Cross-Sectional Area (Abkf) (ft2)	14.0		
Mean Riffle Depth (dbkf)	0.48			ft	Riffle Width/Depth Ratio (Wbkf / dbkf)	60.5		
Maximum Riffle Depth (dmax)	1.12			ft	Max Riffle Depth to Mean Riffle Depth (dmax/dbkf)	2.333		
Width of Flood-Prone Area (Wfpa)	59.0			ft	Entrenchment Ratio (Wfpa / Wbkf)	2.0		
Riffle Inner Berm Width (W_{ib})	14.4			ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.496		
Riffle Inner Berm Depth (d_{ib})	0.35			ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.729		
Riffle Inner Berm Area (A_{ib})	5.0			ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.358		
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	41.1							

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	16.3			ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.563		
Mean Pool Depth (d_{bkfp})	0.81			ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.688		
Pool Cross-Sectional Area (A_{bkfp})	13.3			ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	0.951		
Maximum Pool Depth (d_{maxp})	1.54			ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	3.208		
Pool Inner Berm Width (W_{ibp})	12.7			ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.778		
Pool Inner Berm Depth (d_{ibp})	0.50			ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.617		
Pool Inner Berm Area (A_{ibp})	6.4			ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.483		
Point Bar Slope (S_{pb})	0.220			ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	25.4		

Run Dimensions*

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

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **L. Chavez et al.** Date: **8/18/2010** Valley Type: **VIII** Stream Type: **C4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.41**	ft/sec	Estimation Method	**"n" by Stream Type**
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**47.6**	cfs	Drainage Area	**15.9** mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)	**123.0**			ft	Stream Meander Length Ratio (L_m / W_{bkf})	**4.24**		
Radius of Curvature (R_c)	**34.2**	**19.5**	**55.3**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**1.18**	**0.67**	**1.91**
Belt Width (W_{blt})	**40.1**	**24.1**	**48.2**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.38**	**0.83**	**1.66**
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)	**18.8**	**16.1**	**23.2**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.65**	**0.55**	**0.80**
Individual Pool Length (L_p)	**6.7**	**2.0**	**12.0**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.23**	**0.07**	**0.41**
Pool to Pool Spacing (P_s)	**33.4**	**8.8**	**131.0**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**1.15**	**0.30**	**4.51**

Channel Profile

Valley Slope (S_{val})	**0.0148**	ft/ft	Average Water Surface Slope (S)	**0.014**	ft/ft	Sinuosity (S_{val} / S)	**1.08**
Stream Length (SL)	**168.1**	ft	Valley Length (VL)	**158.2**	ft	Sinuosity (SL / VL)	**1.06**
Low Bank Height (LBH)	start **1.12** ft end **1.54** ft		Max Bankfull Depth (d_{max})	start **1.12** ft end **1.54** ft		Bank-Height Ratio (BHR) (LBH / d_{max})	start **1.0** end **1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0160**			ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.1679**		
Run Slope (S_{run})	**0.0240**			ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**1.7518**		
Pool Slope (S_p)	**0.0110**			ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.8029**		
Glide Slope (S_g)	**0.0170**			ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**1.2409**		
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.56**	**1.34**	**1.71**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**3.250**	**2.792**	**3.563**
Max Run Depth (d_{maxr})	**1.50**	**1.35**	**1.65**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**3.125**	**2.813**	**3.438**
Max Pool Depth (d_{maxp})	**1.77**	**1.60**	**1.99**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**3.688**	**3.333**	**4.146**
Max Glide Depth (d_{maxg})	**1.66**	**1.59**	**1.82**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**3.458**	**3.313**	**3.792**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0.9**	**0.0**	**0.0**	D_{16}	**2.8**	**1.9**	**0.0**		mm
% Sand	**10.4**	**17.6**	**39.6**	D_{35}	**6.1**	**5.0**	**0.0**		mm
% Gravel	**84.0**	**81.5**	**49.1**	D_{50}	**9.2**	**7.2**	**4.2**		mm
% Cobble	**4.7**	**0.9**	**11.3**	D_{84}	**30.5**	**18.3**	**53.2**		mm
% Boulder				D_{95}	**62.9**	**50.1**	**89.8**		mm
% Bedrock				D_{100}	**180.0**	**90.0**	**110.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, C4 Poor Reach**

Location: **Pike National Forest, Colorado**

Observers: **L. Chavez *et al*.**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/18/10**

Existing species composition: **Spruce, Willow, Shrubs, Grasses**

Potential species composition: **Higher density of existing species without invasives**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	15%	20%	Spruce	60%
				Willow	40%
					100%
2. Understory	Shrub layer	▨	28%	Willow	98%
				River Birch	1%
				Raspberry	1%
					100%
3. Ground level	Herbaceous	▨	10%	Horseweed	10%
				Grasses	30%
				Fireweed & Unc forbs	30%
				Invasives	27%
				Carex	1%
				Rushes, Phacelix	2%
					100%
	Leaf or needle litter	▨	2%		
	Bare ground	▨	40%		
			Column total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Remarks:
Condition, vigor and/or usage of existing reach:
Grasses, Fescue - Streambank; Invasives: Cheatgrass, Mullen, Canada Thistle, Yellow sweet clover

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **L. Chavez *et al*.** Date: **8/18/2010**

List ALL COMBINATIONS that APPLY..............☞	**P2**	**P8**						

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, C4 Poor Reach**
Location: **Pike National Forest, Colorado**
Observers: **L. Chavez *et al* .**
Date: **8/18/2010**

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

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 5-9. Meander patterns.

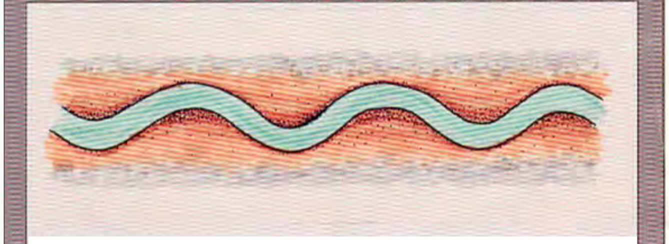
Meander Patterns

Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, CO**

Observers: **L. Chavez *et al* .** Date: **8/18/2010**

List ALL CATEGORIES that APPLY ☞	**M3**				

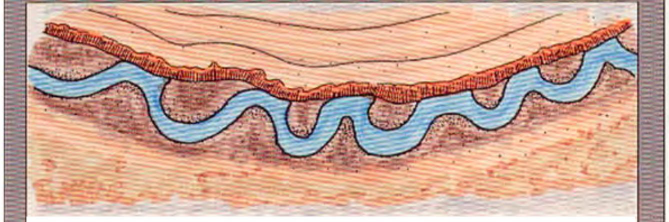
Various Meander Pattern variables modified from Galay et al. (1973)



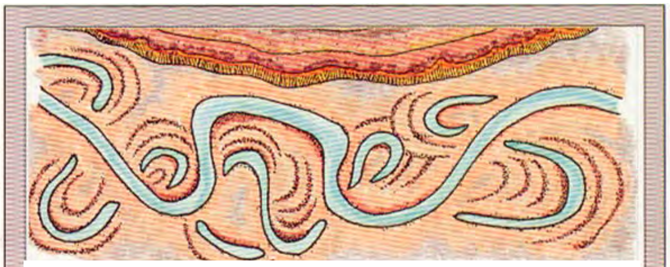
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

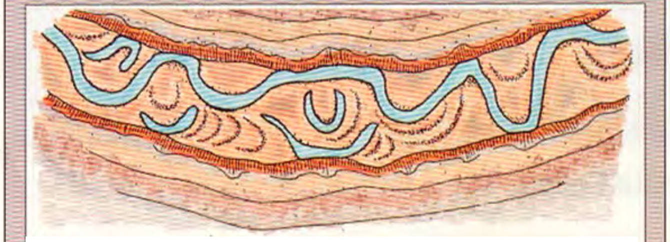
[✓ M3] IRREGULAR MEANDERS



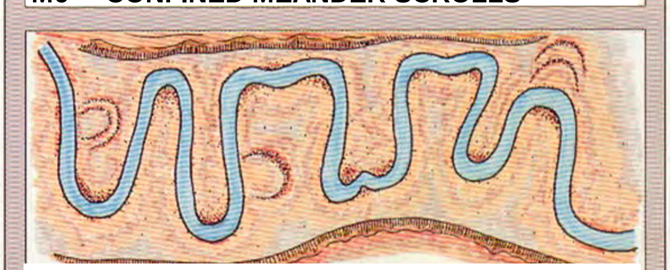
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

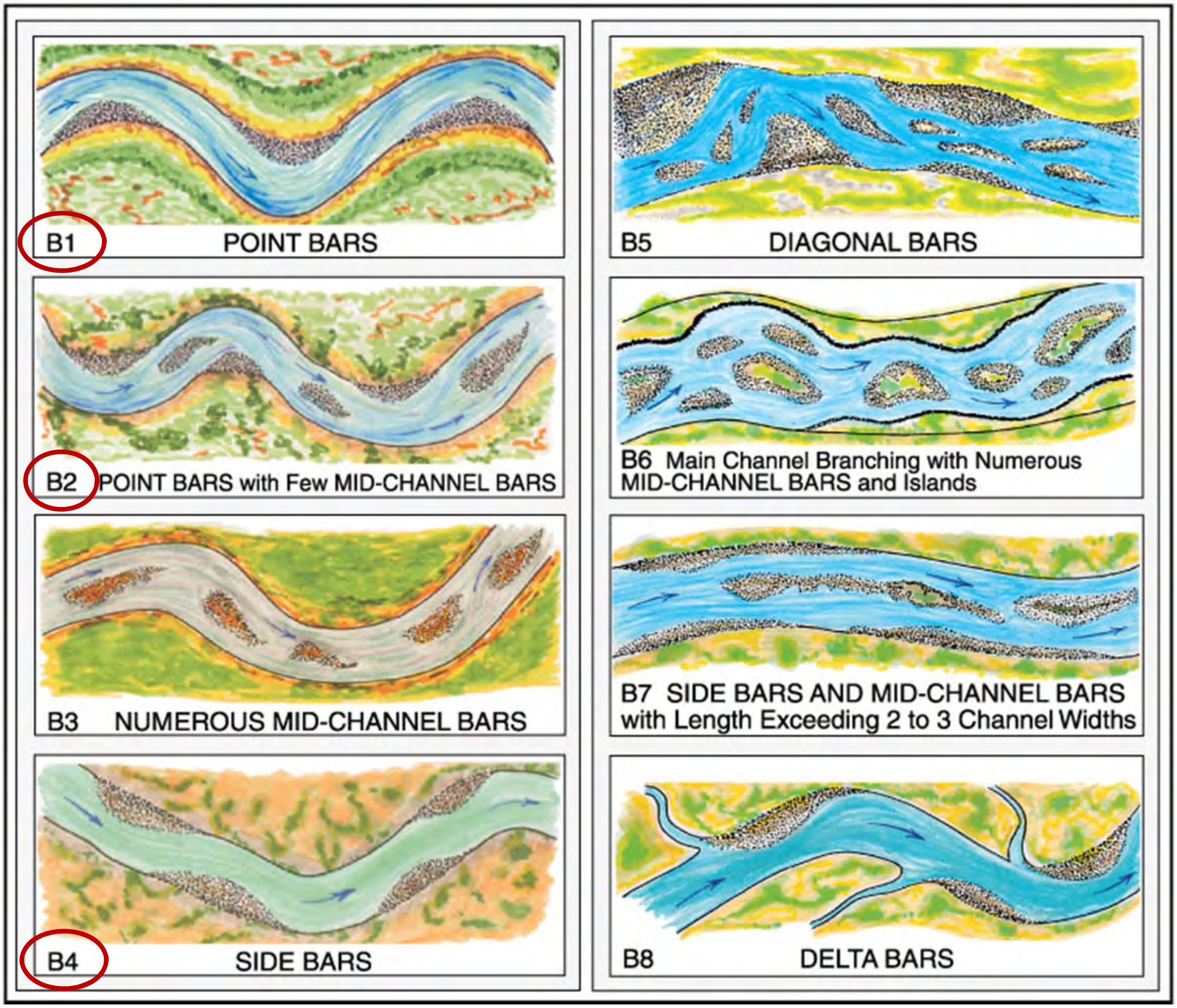
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**Trail Creek, C4 Poor Reach**	Location:	**Pike National Forest, Colorado**
Observers:	**L. Chavez *et al* .**	Date:	**8/18/2010**

List ALL CATEGORIES that APPLY ☞	**B1**	**B2**	**B4**		

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **L. Chavez *et al* .** Date: **8/18/2010**

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 5-12. Degree of channel incision.

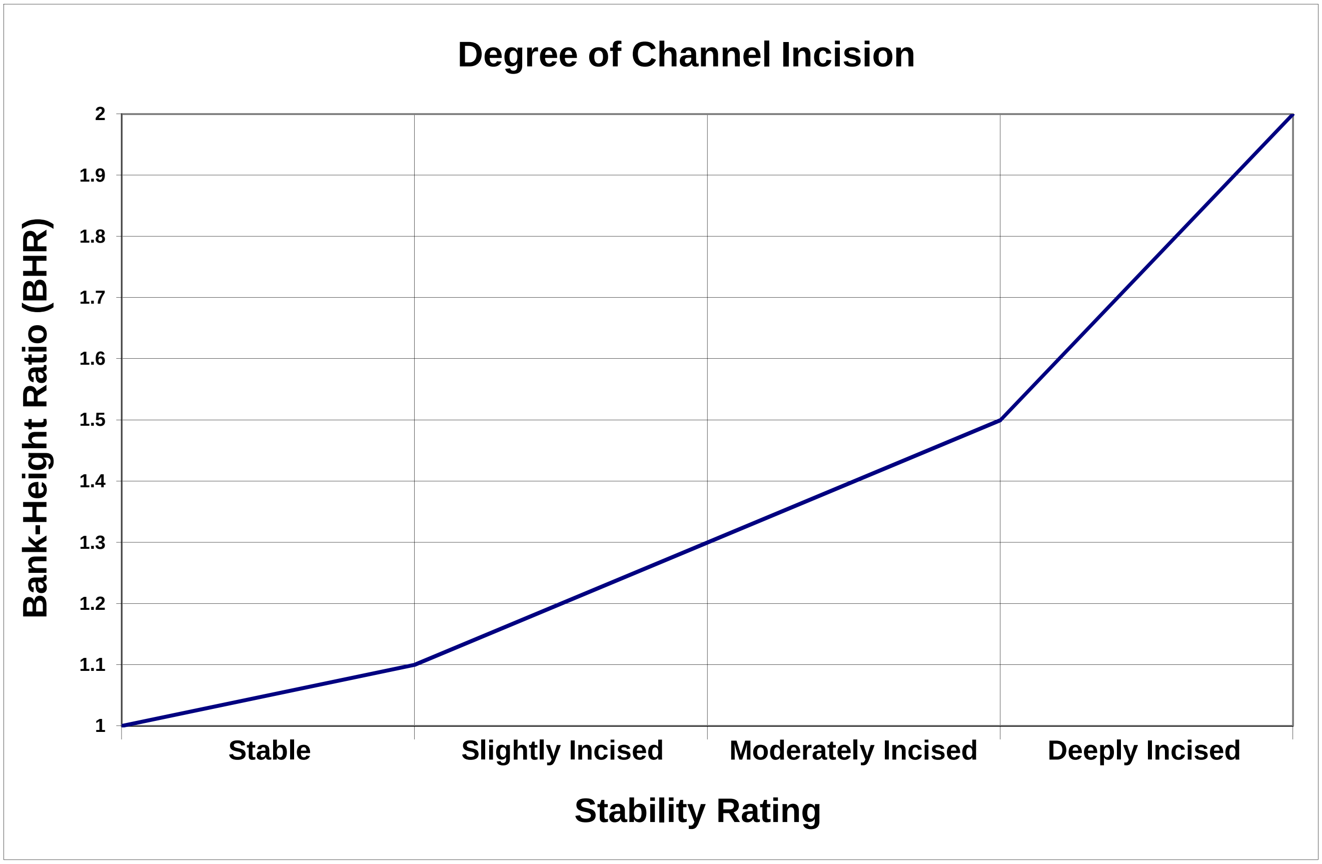
Degree of Channel Incision

Low Bank Height: **1.12**

Max Bankfull Depth: **1.12**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

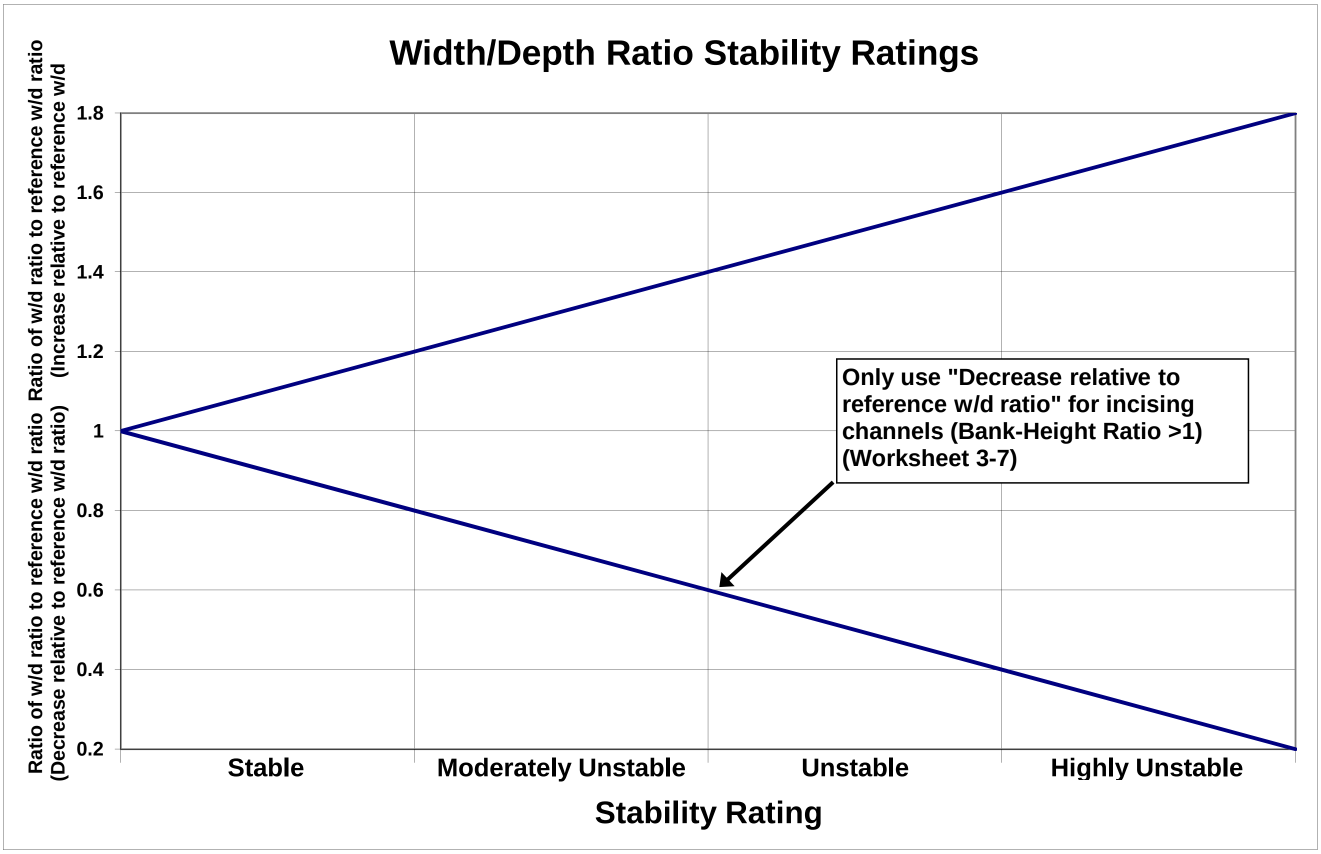
Width/Depth Ratio State

Existing Width/Depth Ratio: **60**

Reference Width/Depth Ratio: **13.7**

Ratio of existing W/d to reference W/d: **4.38**

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



Worksheet 5-14. Degree of channel confinement (lateral containment).

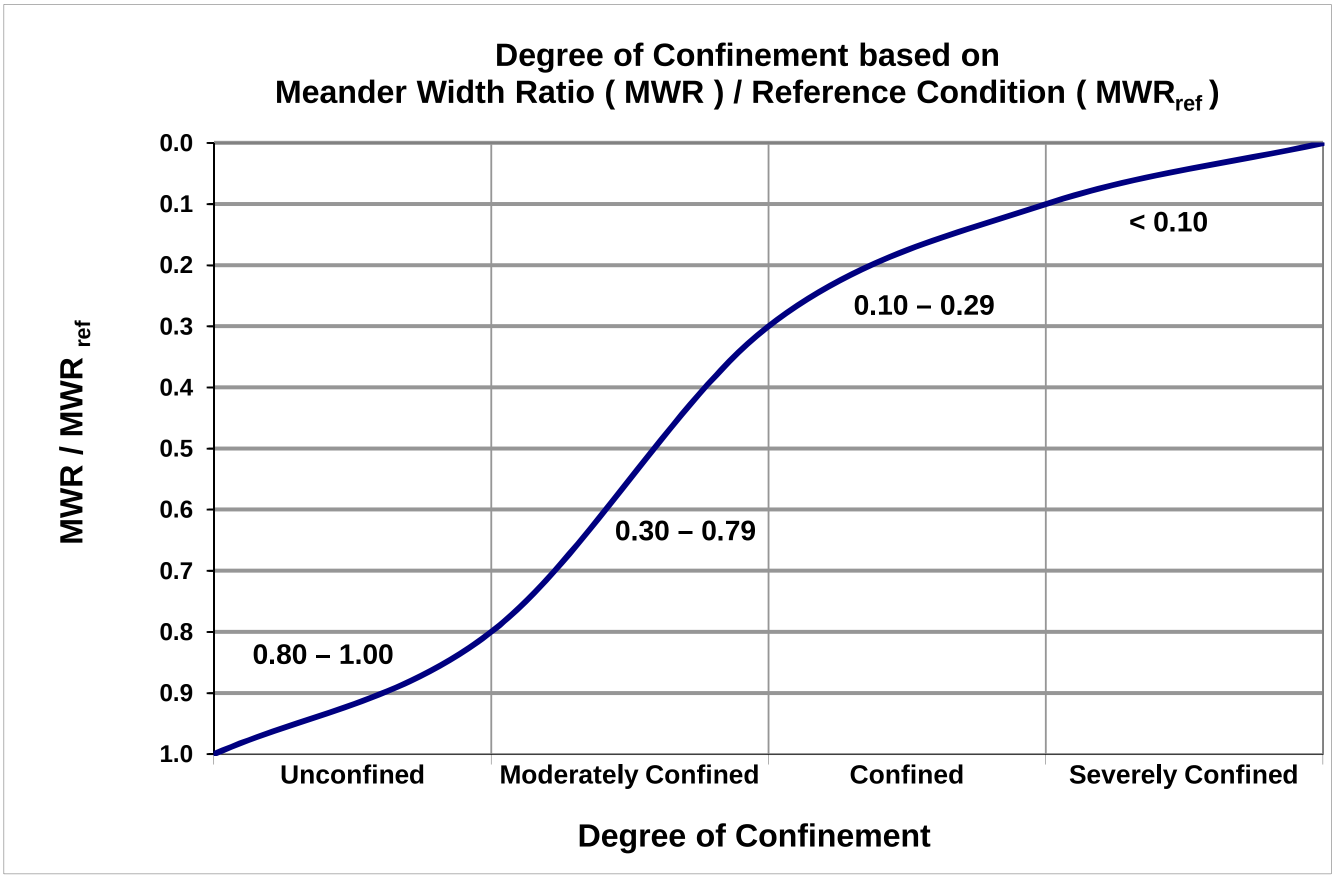
Degree of Confinement

Existing Meander Width Ratio (MWR): **1.4**

Reference Meander Width Ratio (MWR_{ref}): **4.5**

Ratio of MWR to MWR_{ref}: **0.31**

Degree of Confinement Stability Rating ☞ **Mod. Confined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, C4 Poor Reach **Location: Pike National Forest, CO** **Valley Type: VIII** **Observers: L. Chavez *et al*.** **Date: 8/18/2010**

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	5	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	**0**	**Good total =**	**19**	**Fair total =**	**6**	**Poor total =**	**108**

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	**133**
Existing stream type =	**C4**
***Potential stream type =**	**C4**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

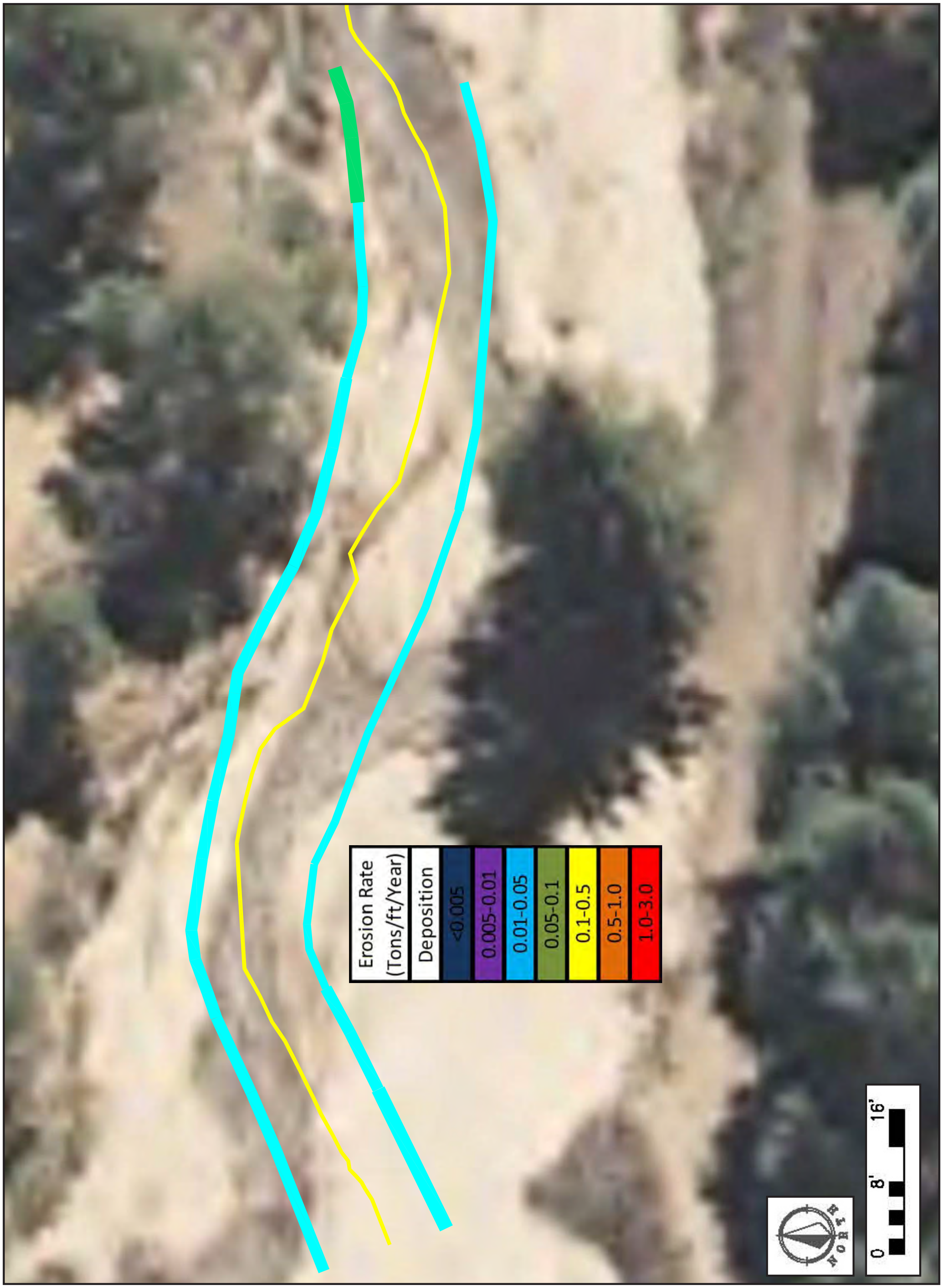
Stream: **Trail Creek, C4 Poor Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **160** Date: **8/19/2010**

Observers: **L. Chavez *et al*.** Valley Type: **VIII** Stream Type: **C4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+00 - 0+16 LB**	**High**	**Low**	**0.25042**	**16.0**	**1.5**	**6.01**	**0.01809**
2. **0+00 - 0+16 RB**	**Very High**	**Very Low**	**0.16522**	**16.0**	**1.8**	**4.76**	**0.01432**
3. **0+16 - 0+30 LB**	**Very High**	**Moderate**	**0.37957**	**14.0**	**1.5**	**7.97**	**0.02741**
4. **0+16 - 0+110 RB**	**Very High**	**Low**	**0.25042**	**94.0**	**1.0**	**23.54**	**0.01206**
5. **0+30 - 0+95 LB**	**High**	**Moderate**	**0.37957**	**65.0**	**1.5**	**37.01**	**0.02741**
6. **110 - 160 RB**	**Very High**	**High**	**0.57533**	**50.0**	**1.2**	**34.52**	**0.03324**
7. **0+95 - 117 LB**	**Moderate**	**Low**	**0.15287**	**22.0**	**1.5**	**5.04**	**0.01104**
8 **117-140 LB**	**High**	**High**	**0.57533**	**23.0**	**1.3**	**17.20**	**0.03601**
9 **140 - 160 LB**	**Very High**	**High**	**0.57533**	**20.0**	**1.8**	**20.71**	**0.04986**
10							
11							
12							
13							
14							
15							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**156.77**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**5.81**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**7.55**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0472**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	47.64	0.0182	31.70
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	121.1													
0.10%	104.0	0.05%	0.09%	0.34	112.6	2.363	7.461	71.89	6.670	11.59	38.6	24.67	3.98	28.64
0.25%	90.0	0.08%	0.15%	0.55	97.0	2.036	5.232	43.43	4.809	8.35	53.1	23.78	4.57	28.35
0.50%	77.8	0.13%	0.25%	0.91	83.9	1.761	3.706	26.61	3.494	6.07	76.5	24.28	5.54	29.82
0.75%	66.4	0.13%	0.25%	0.91	72.1	1.513	2.592	15.99	2.502	4.35	65.8	14.59	3.97	18.56
1%	57.4	0.13%	0.25%	0.91	61.9	1.300	1.817	9.63	1.790	3.11	56.5	8.79	2.84	11.63
1.5%	49.3	0.25%	0.50%	1.83	53.4	1.120	1.289	5.89	1.289	2.24	97.4	10.75	4.09	14.83
2%	41.1	0.25%	0.50%	1.83	45.2	0.949	0.886	3.43	0.893	1.55	82.5	6.26	2.83	9.09
3%	34.6	0.50%	1.00%	3.65	37.9	0.795	0.600	1.95	0.602	1.05	138.2	7.10	3.82	10.92
4%	29.6	0.50%	1.00%	3.65	32.1	0.674	0.424	1.17	0.415	0.72	117.2	4.25	2.63	6.89
5%	26.3	0.50%	1.00%	3.65	28.0	0.587	0.322	0.77	0.304	0.53	102.1	2.81	1.93	4.74
10%	16.6	2.50%	5.00%	18.25	21.4	0.450	0.200	0.37	0.165	0.29	391.4	6.70	5.23	11.93
20%	9.0	5.00%	10.00%	36.50	12.8	0.269	0.103	0.11	0.045	0.08	466.9	4.11	2.88	6.99
30%	6.0	5.00%	10.00%	36.50	7.5	0.158	0.075	0.05	0.006	0.01	274.6	1.75	0.41	2.16
40%	4.3	5.00%	10.00%	36.50	5.1	0.108	0.068	0.03	0.000	0.00	187.7	1.09	0.00	1.09
50%	3.3	5.00%	10.00%	36.50	3.8	0.079	0.066	0.02	0.000	0.00	137.3	0.77	0.00	0.77
60%	2.5	5.00%	10.00%	36.50	2.9	0.061	0.065	0.02	0.000	0.00	105.3	0.58	0.00	0.58
70%	2.0	5.00%	10.00%	36.50	2.3	0.047	0.064	0.01	0.000	0.00	82.4	0.45	0.00	0.45
80%	1.8	5.00%	10.00%	36.50	1.9	0.039	0.064	0.01	0.000	0.00	68.7	0.38	0.00	0.38
90%	1.3	5.00%	10.00%	36.50	1.5	0.032	0.064	0.01	0.000	0.00	54.9	0.30	0.00	0.30
100%	0.3	5.00%	10.00%	36.50	0.8	0.016	0.064	0.00	0.000	0.00	27.5	0.15	0.00	0.15
									Annual Totals:		2,624.6 (cfs) 5,205.8 (acre-ft)	143.6 (tons/yr)	44.7 (tons/yr)	188.3 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Poor" Pagosa**	$y = 0.07176+1.02176x^{2.3772}$	**47.64**	**0.4699**	**223.46**
2. Suspended Sediment	**"Poor" Pagosa**	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**154.7**													
0.10%	**137.6**	**0.05%**	**0.09%**	**0.34**	**146.2**	**3.068**	**55.803**	**4921.27**	**14.753**	**660.40**	**50.1**	**1688.49**	**226.58**	**1915.07**
0.25%	**123.6**	**0.08%**	**0.15%**	**0.55**	**130.6**	**2.741**	**36.984**	**2914.12**	**11.303**	**505.99**	**71.5**	**1595.48**	**277.03**	**1872.51**
0.50%	**111.4**	**0.13%**	**0.25%**	**0.91**	**117.5**	**2.466**	**25.143**	**1782.14**	**8.805**	**394.17**	**107.2**	**1626.21**	**359.68**	**1985.88**
0.75%	**100.0**	**0.13%**	**0.25%**	**0.91**	**105.7**	**2.218**	**17.100**	**1090.35**	**6.862**	**307.19**	**96.4**	**994.95**	**280.31**	**1275.26**
1%	**91.0**	**0.13%**	**0.25%**	**0.91**	**95.5**	**2.005**	**11.845**	**682.66**	**5.412**	**242.27**	**87.2**	**622.93**	**221.07**	**844.00**
1.5%	**82.4**	**0.25%**	**0.50%**	**1.83**	**86.7**	**1.820**	**8.349**	**436.86**	**4.317**	**193.24**	**158.3**	**797.27**	**352.65**	**1149.92**
2%	**73.8**	**0.25%**	**0.50%**	**1.83**	**78.1**	**1.639**	**5.722**	**269.63**	**3.381**	**151.34**	**142.5**	**492.07**	**276.20**	**768.27**
3%	**67.3**	**0.50%**	**1.00%**	**3.65**	**70.5**	**1.480**	**3.970**	**168.95**	**2.668**	**119.45**	**257.4**	**616.66**	**435.98**	**1052.64**
4%	**59.6**	**0.50%**	**1.00%**	**3.65**	**63.4**	**1.331**	**2.725**	**104.29**	**2.090**	**93.54**	**231.5**	**380.65**	**341.43**	**722.08**
5%	**52.7**	**0.50%**	**1.00%**	**3.65**	**56.2**	**1.179**	**1.781**	**60.35**	**1.583**	**70.84**	**205.0**	**220.26**	**258.57**	**478.83**
10%	**32.9**	**2.50%**	**5.00%**	**18.25**	**42.8**	**0.898**	**0.722**	**18.64**	**0.864**	**38.67**	**781.2**	**340.10**	**705.80**	**1045.90**
20%	**11.9**	**5.00%**	**10.00%**	**36.50**	**22.4**	**0.470**	**0.157**	**2.12**	**0.241**	**10.80**	**816.8**	**77.35**	**394.30**	**471.65**
30%	**6.2**	**5.00%**	**10.00%**	**36.50**	**9.0**	**0.190**	**0.101**	**0.55**	**0.091**	**4.09**	**330.1**	**20.12**	**149.39**	**169.51**
40%	**4.3**	**5.00%**	**10.00%**	**36.50**	**5.2**	**0.110**	**0.099**	**0.31**	**0.077**	**3.45**	**191.1**	**11.44**	**126.02**	**137.46**
50%	**3.3**	**5.00%**	**10.00%**	**36.50**	**3.8**	**0.079**	**0.099**	**0.22**	**0.074**	**3.32**	**137.3**	**8.20**	**121.25**	**129.45**
60%	**2.5**	**5.00%**	**10.00%**	**36.50**	**2.9**	**0.061**	**0.099**	**0.17**	**0.073**	**3.27**	**105.3**	**6.28**	**119.37**	**125.66**
70%	**2.0**	**5.00%**	**10.00%**	**36.50**	**2.3**	**0.047**	**0.099**	**0.13**	**0.072**	**3.24**	**82.4**	**4.92**	**118.44**	**123.35**
80%	**1.8**	**5.00%**	**10.00%**	**36.50**	**1.9**	**0.039**	**0.099**	**0.11**	**0.072**	**3.23**	**68.7**	**4.10**	**118.02**	**122.12**
90%	**1.3**	**5.00%**	**10.00%**	**36.50**	**1.5**	**0.032**	**0.099**	**0.09**	**0.072**	**3.22**	**54.9**	**3.28**	**117.70**	**120.98**
100%	**0.3**	**5.00%**	**10.00%**	**36.50**	**0.8**	**0.016**	**0.099**	**0.04**	**0.072**	**3.21**	**27.5**	**1.64**	**117.34**	**118.98**
									Annual Totals:		**4,002.5** (cfs) **7,938.9** (acre-ft)	**9,512.4** (tons/yr)	**5,117.1** (tons/yr)	**14,629.5** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/27/10**

Observers: **S=.014, Q=48, 38, Bed.=1.0337, S.Sand=111.73** Stream Type: **C4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.25**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**1.26**	**0.76**	**0.77**	**5.15**	**0.15**	**0.98**	**0.0140**	**0.13**	**0.66**	**0.13**	**10%**	**36.50**	**3.20**	**0.02**	**116.80**	**0.73**	**117.53**
80.00%	**1.76**	**1.51**	**1.25**	**6.17**	**0.20**	**1.19**	**0.0140**	**0.18**	**1.32**	**0.21**	**10%**	**36.50**	**3.20**	**0.05**	**116.80**	**1.83**	**118.63**
70.00%	**2.01**	**1.89**	**1.47**	**6.55**	**0.22**	**1.27**	**0.0140**	**0.19**	**1.65**	**0.25**	**10%**	**36.50**	**3.24**	**0.06**	**118.26**	**2.19**	**120.45**
60.00%	**2.52**	**2.27**	**1.67**	**6.88**	**0.24**	**1.34**	**0.0140**	**0.21**	**1.98**	**0.29**	**10%**	**36.50**	**3.24**	**0.07**	**118.26**	**2.56**	**120.82**
50.00%	**3.27**	**2.90**	**2.00**	**7.41**	**0.27**	**1.45**	**0.0140**	**0.23**	**2.53**	**0.34**	**10%**	**36.50**	**3.28**	**0.09**	**119.72**	**3.28**	**123.00**
40.00%	**4.28**	**3.78**	**2.41**	**7.93**	**0.30**	**1.55**	**0.0140**	**0.26**	**3.30**	**0.42**	**10%**	**36.50**	**3.33**	**0.11**	**121.55**	**4.01**	**125.56**
30.00%	**6.23**	**5.26**	**3.05**	**8.72**	**0.35**	**1.71**	**0.0140**	**0.30**	**4.60**	**0.53**	**10%**	**36.50**	**3.46**	**0.16**	**126.29**	**5.84**	**132.13**
20.00%	**11.91**	**9.07**	**4.54**	**10.32**	**0.44**	**1.99**	**0.0140**	**0.38**	**7.92**	**0.77**	**10%**	**36.50**	**4.06**	**0.28**	**148.19**	**10.22**	**158.41**
10.00%	**32.94**	**22.43**	**8.32**	**11.88**	**0.70**	**2.69**	**0.0140**	**0.59**	**19.59**	**1.65**	**10%**	**36.50**	**10.67**	**1.05**	**389.45**	**38.33**	**427.78**
5.00%	**52.81**	**42.88**	**12.90**	**13.23**	**0.98**	**3.32**	**0.0140**	**0.82**	**37.46**	**2.83**	**5%**	**18.25**	**38.10**	**9.17**	**695.33**	**167.35**	**862.68**
4.00%	**59.69**	**56.25**															
3.00%	**67.38**	**63.54**															
2.00%	**73.93**	**70.66**															
1.50%	**82.58**	**78.26**															
1.00%	**91.23**	**86.91**															
0.75%	**100.22**	**95.73**															
0.50%	**111.62**	**105.92**															
0.25%	**123.90**	**117.76**															
0.10%	**137.93**	**130.92**															
0.0060%	**155.15**	**146.54**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**2070.7**	**236.3**	**2307.0**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, C4 Poor, Riffle XS 0+22.7** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/27/10**

Observers: **S=.014, Q=48, 38, Bed.=1.0337, S.Sand=111.73** Stream Type: **C4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.25**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**1.26**	**0.76**	**0.54**	**4.60**	**0.12**	**1.36**	**0.0140**	**0.10**	**0.66**	**0.14**	**10%**	**36.50**	**3.20**	**0.02**	**116.80**	**0.73**	**117.53**
80.00%	**1.76**	**1.51**	**0.91**	**5.79**	**0.16**	**1.63**	**0.0140**	**0.13**	**1.32**	**0.23**	**10%**	**36.50**	**3.20**	**0.05**	**116.80**	**1.83**	**118.63**
70.00%	**2.01**	**1.89**	**1.09**	**6.45**	**0.17**	**1.73**	**0.0140**	**0.14**	**1.65**	**0.26**	**10%**	**36.50**	**3.24**	**0.06**	**118.26**	**2.19**	**120.45**
60.00%	**2.52**	**2.27**	**1.27**	**7.18**	**0.18**	**1.77**	**0.0140**	**0.15**	**1.98**	**0.28**	**10%**	**36.50**	**3.24**	**0.07**	**118.26**	**2.56**	**120.82**
50.00%	**3.27**	**2.90**	**1.57**	**8.39**	**0.19**	**1.84**	**0.0140**	**0.16**	**2.53**	**0.30**	**10%**	**36.50**	**3.24**	**0.09**	**118.26**	**3.28**	**121.54**
40.00%	**4.28**	**3.78**	**1.91**	**9.38**	**0.20**	**1.95**	**0.0140**	**0.17**	**3.30**	**0.35**	**10%**	**36.50**	**3.28**	**0.11**	**119.72**	**4.01**	**123.73**
30.00%	**6.23**	**5.26**	**2.40**	**10.04**	**0.24**	**2.15**	**0.0140**	**0.20**	**4.60**	**0.46**	**10%**	**36.50**	**3.37**	**0.16**	**123.01**	**5.84**	**128.85**
20.00%	**11.91**	**9.07**	**3.49**	**11.13**	**0.31**	**2.57**	**0.0140**	**0.26**	**7.92**	**0.71**	**10%**	**36.50**	**3.89**	**0.28**	**141.99**	**10.22**	**152.21**
10.00%	**32.94**	**22.43**	**7.22**	**17.24**	**0.42**	**3.10**	**0.0140**	**0.35**	**19.59**	**1.14**	**10%**	**36.50**	**6.83**	**0.84**	**249.30**	**30.66**	**279.96**
5.00%	**52.81**	**42.88**	**12.75**	**27.51**	**0.46**	**3.35**	**0.0140**	**0.39**	**37.46**	**1.36**	**5%**	**18.25**	**8.51**	**1.78**	**155.31**	**32.48**	**187.79**
4.00%	**59.69**	**56.25**															
3.00%	**67.38**	**63.54**															
2.00%	**73.93**	**70.66**															
1.50%	**82.58**	**78.26**															
1.00%	**91.23**	**86.91**															
0.75%	**100.22**	**95.73**															
0.50%	**111.62**	**105.92**															
0.25%	**123.90**	**117.76**															
0.10%	**137.93**	**130.92**															
0.0060%	**155.15**	**146.54**															
Notes:														Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**1377.7**	**93.8**	**1471.5**
														Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**2070.7**	**236.3**	**2307.0**
														Difference in sediment transport capacity (tons/yr) (+ or -):	**-693.0**	**-142.5**	**-835.5**
														Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, > 35% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, C4 Poor Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**L. Chavez *et al*.**	Date:	**8/18/2010**

Enter Required Information for Existing Condition

7.2	D_{50}	Riffle bed material D_{50} (mm)			
4.2	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.36	D_{max}	Largest particle from bar sample (ft)	**110**	**(mm)**	304.8 mm/ft
0.014	S	Existing bankfull water surface slope (ft/ft)			
0.48	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.71	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
15.28	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

0.419		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 **30**	CO **80**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **1.6**	CO **0.66**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **1.83**	CO **0.76**	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 **0.0534**	CO **0.0220**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, C4 Poor Reach** Stream Type: **C4**
Location: **Pike National Forest, CO** Valley Type: **VIII**
Observers: **L. Chavez *et al*.** Date: **8/18/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (**C→High W/d C**)	☑ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, C4 Poor Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**L. Chavez *et al*.**	Date:	**8/18/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**8**
	(2)	**(4)**	**(6)**	**4.4** [✓ **(8)**]	
2 **Depositional Patterns (Worksheet 5-10)**	**B1, B2**	**B4**, B8	B3	B5, B6, B7	**2**
	(1)	**B1, B2, B4** [✓ **(2)**]	**(3)**	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	M1, **M3**, M4		M2, M5, M6, M7, M8		**1**
	M3 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**6**
	(2)	**(4)**	**VH/M,VH/H** [✓ **(6)**]	**(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**2**
	(1)	**0.31** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**19**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trail Creek, C4 Poor Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **L. Chavez *et al*.** Date: **8/18/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**6**
	(2)	**(4)**	[✓ **(6)**]	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
	(2)	**(4)**	**(6)**	**4.4** [✓ **(8)**]	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→**High W/d C**), (B→High W/d B), (C→F)	(C→D), (F→D)	**6**
	(2)	**(4)**	[✓ **(6)**]	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	**B1**	**B2, B4**	B3, B5	B6, B7, B8	**2**
	(1)	**B1, B2, B4** [✓ **(2)**]	**(3)**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**31**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☑

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, C4 Poor Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**L. Chavez *et al*.**	Date:	**8/18/2010**

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 5-22)**	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**
	Insufficient [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	Insufficient [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**2**
	(1)	**0.32** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**10**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, C4 Poor Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **L. Chavez *et al*.** Date: **8/18/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→**High W/d C**), (E→C) [✓ **(4)**]	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**4**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* [✓ **(6)**]	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* [✓ **(8)**]	**8**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**20**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream: **Trail Creek, C4 Poor Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **L. Chavez *et al*.** Date: **8/18/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	1	3
	Mod. Unstable	2	
	Unstable	[✓ 3]	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	1	4
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	[✓ 4]	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	3
	Slight Increase	2	
	Mod. Increase	[✓ 3]	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	1	4
	Fair: Mod. Unstable	2	
	Poor: Unstable	[✓ 4]	
		Total Points	15

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	*Low* 5 ☐	*Moderate* 6 – 10 ☐	*High* 11 – 15 ☑	*Very High* 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, C4 Poor Reach**			Location: **Pike National Forest, Colorado**				
Observers:	**L. Chavez *et al*.**		Date: **8/18/2010**		Stream Type: **C4**		Valley Type: **VIII**	
Channel Dimension (Riffle XS 0+22.7)	Mean Bankfull Depth (ft): **0.48**		Bankfull Width (ft): **29.02**	Cross-Sectional Area (ft^2): **13.95**	Width of Flood-Prone Area (ft): **59**		Entrenchment Ratio: **2.03**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:		L_m/W_{bkf}:	R_c/W_{bkf}: **1.18** **0.67-1.91**	MWR: **1.38** **0.83-1.66**	Sinuosity: **1.08**	
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed		
	Max Bankfull Depth (ft):	Riffle **1.56**	Pool **1.77**	Depth Ratio (max to mean):	Riffle **3.25**	Pool **3.69**	Pool-to-Pool Spacing: Ratio **1.15**	Slope Valley: **0.0148** Water Surface: **0.014**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Spruce,Willow,Shrubs,Grass**		Potential Composition/Density: **Higher Density w/o Invasives**		Remarks: Condition, Vigor & Usage of Existing Reach: **Banks - grasses/fescue; eradicate invasives**		
	Flow Regime: **P2, P8**	Stream Size & Order: **S-4(4)**		Meander Patterns: **M3**		Depositional Patterns: **B1, B2, B4**	Debris/Channel Blockages: **D2**	
	Degree of Incision (Bank-Height Ratio): **1.0**		Degree of Incision Stability Rating: **Stable**		Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **133 (Poor)**			
	Width/depth Ratio (W/d): **60**	Reference W/d Ratio (W/d_{ref}): **13.7**		Width/Depth Ratio State $(W/d) / (W/d_{ref})$: **4.38**		W/d Ratio State Stability Rating: **Highly Unstable**		
	Meander Width Ratio (MWR): **1.4**	Reference MWR_{ref}: **4.5**		Degree of confinement (MWR / MWR_{ref}): **0.31**		MWR / MWR_{ref} Stability Rating: **Moderately Confined**		
Bank Erosion Summary	Length of Reach Studied (ft): **160**	Annual Streambank Erosion Rate: **7.55** (tons/yr)	**0.0472** (tons/yr/ft)	Curve Used: **Colorado**		Remarks: **Not fully recovered, see NBS - unveg banks**		
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity		Remarks: **> 30% Reduction in Transport**			
Entrainment/ Competence	Largest Particle from Bar Sample (mm): **110**	$\tau =$ **0.419**	$\tau^* =$ **N/A**	Existing Depth: **0.48**	Required Depth: **0.76**	Existing Slope: **0.014**	Required Slope: **0.022**	
Successional Stage Shift	C → D → G → F → C →				Existing Stream State (Type): **C4 HWD**		Potential Stream State (Type): **C4**	
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes: **Hayman Fire - unveg banks**			
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☑ *Aggradation*	Remarks/causes: **Pikes Peak granitics, not fully recovered**			
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes: **Pikes Peak granitics, not fully recovered**			
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes: **Pikes Peak granitics, not fully recovered**			
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes: **Pikes Peak granitics, not fully recovered**			

Appendix C8

D4a+ Stream Type

Poor Stability Reach

Table of Contents

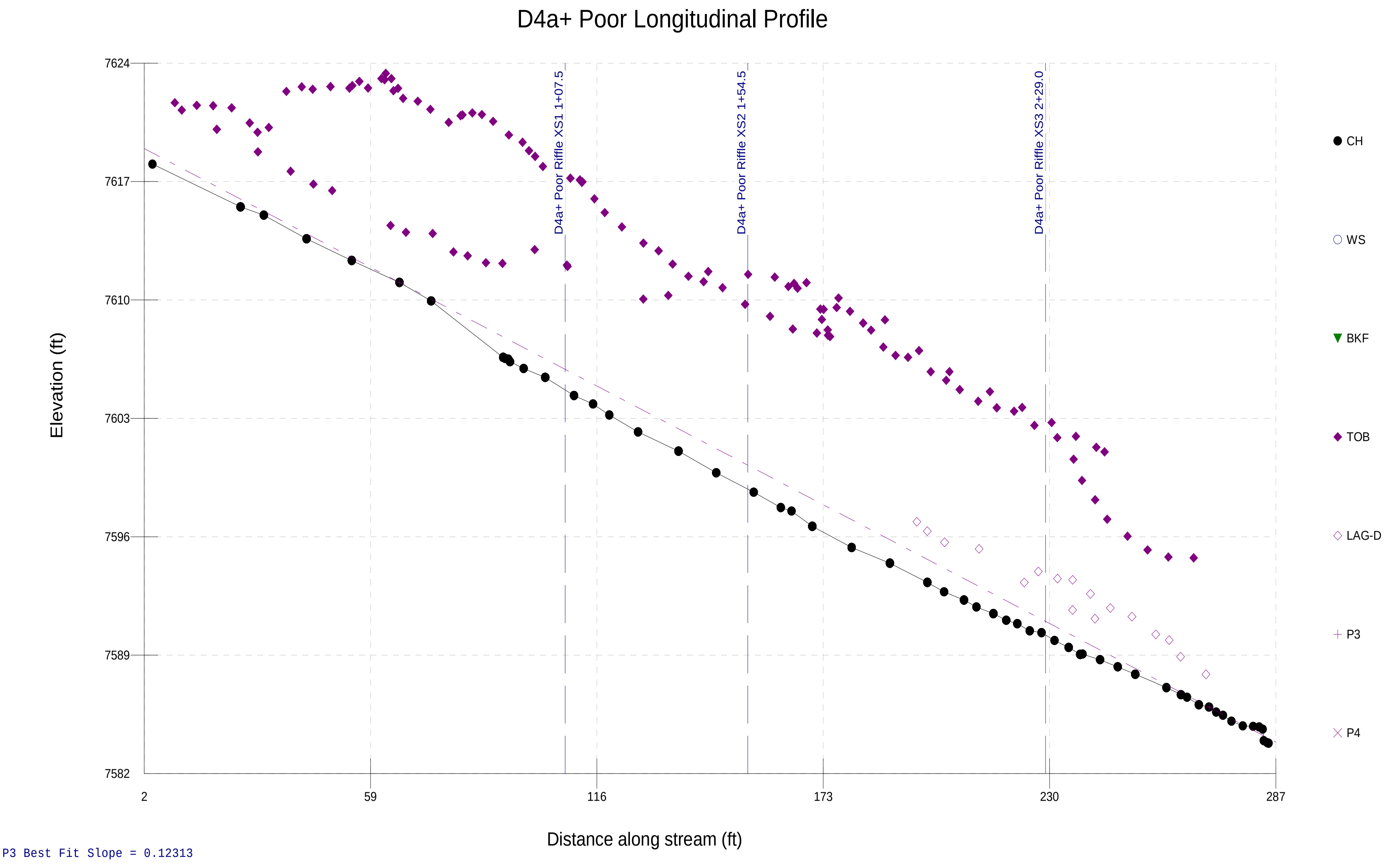
Appendix C8: D4a+ Reach

D4a+ Poor Reach Location & Overview

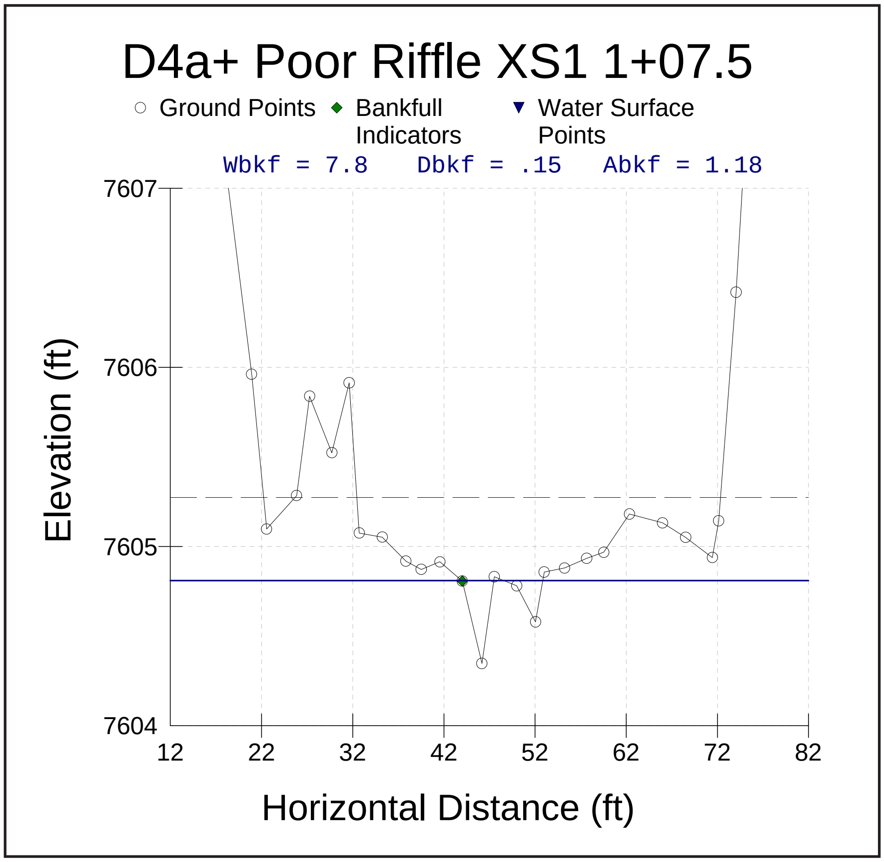
The D4a+ Poor reach is an ephemeral, 2nd order, steep, braided stream located as a main tributary to Trail Creek (see location map **Figure C-2**). The stream is widening and aggrading as the extreme width/depth ratio has led to excess sediment deposition in the channel. The potential stable stream type in this valley fill (Valley Type VIII) is a B4a stream type. The stability rating is “Poor” due to a “Poor” Pfankuch stability rating and the extremely high streambank erosion rate of *0.7183 tons/yr/ft*. This rate is more than two orders of magnitude higher than the B4 reference rate of *0.0048 tons/yr/ft*. The POWERSED sediment transport capacity model indicates aggradation. The sediment supply rating is *High* due primarily to the streambank erosion source and increase in stored sediment in the channel bed. This rating indicates a potential accelerated increase in flow-related sediment based on increased post-fire streamflow peak flows compared to the reference B4 condition. The WRENSS model indicates a water yield increase due to the fire of *59 acre-ft*. Consequently, bedload increased from *13 tons/yr* to *144 tons/yr*, and suspended sediment increased from *0.3 tons/yr* to *119 tons/yr*, representing a total increase in sediment of *250 tons/yr*. These are extremely high values for a very small (4 cfs) D4a+ stream type, which reflect the accelerated sediment yield due to flow-related sediment and very high contributions from streambank erosion.

The photograph depicts the typical character of this representative D4a+ Poor stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall “Poor” rating.

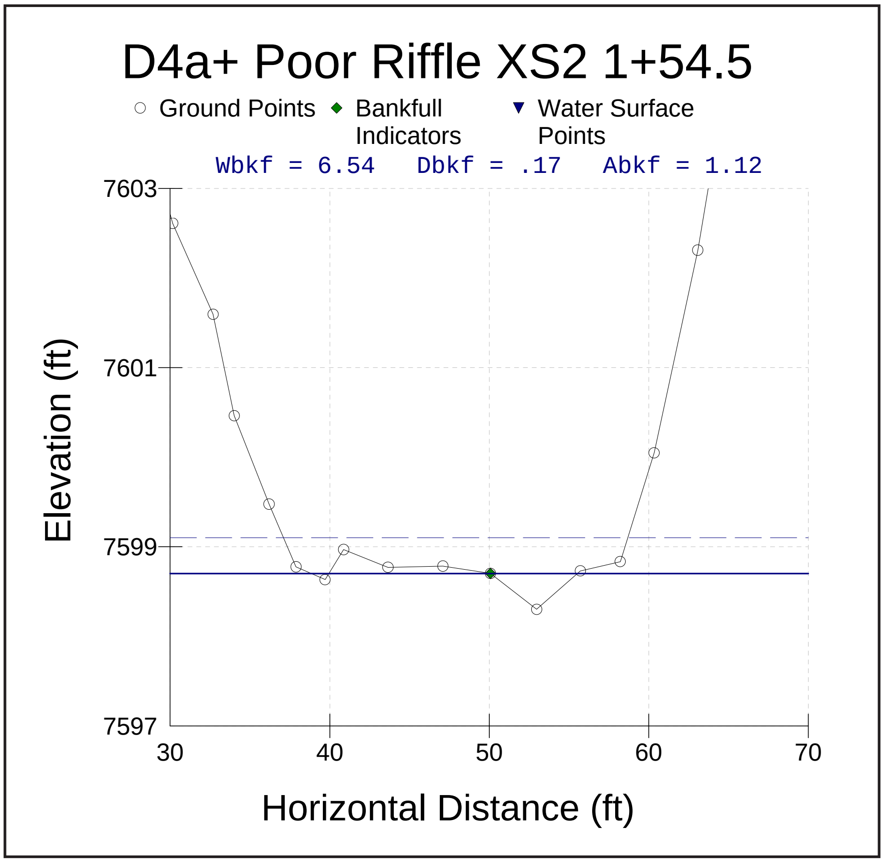
Survey Summary



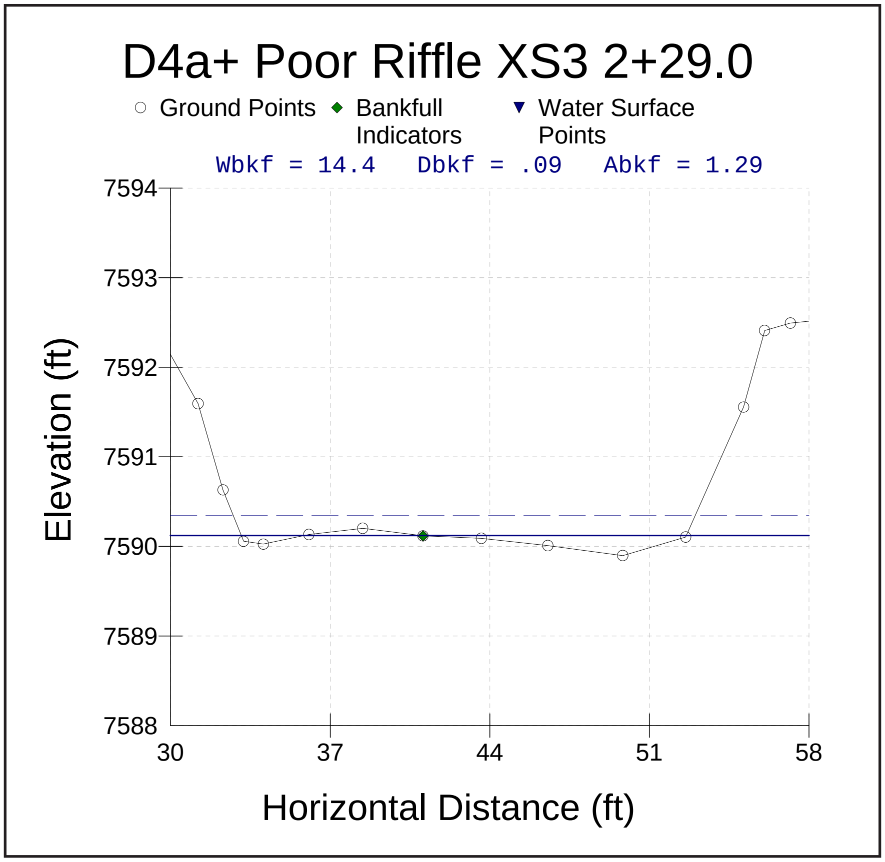
Longitudinal Profile (graph generated from RIVERMorph^{TM})



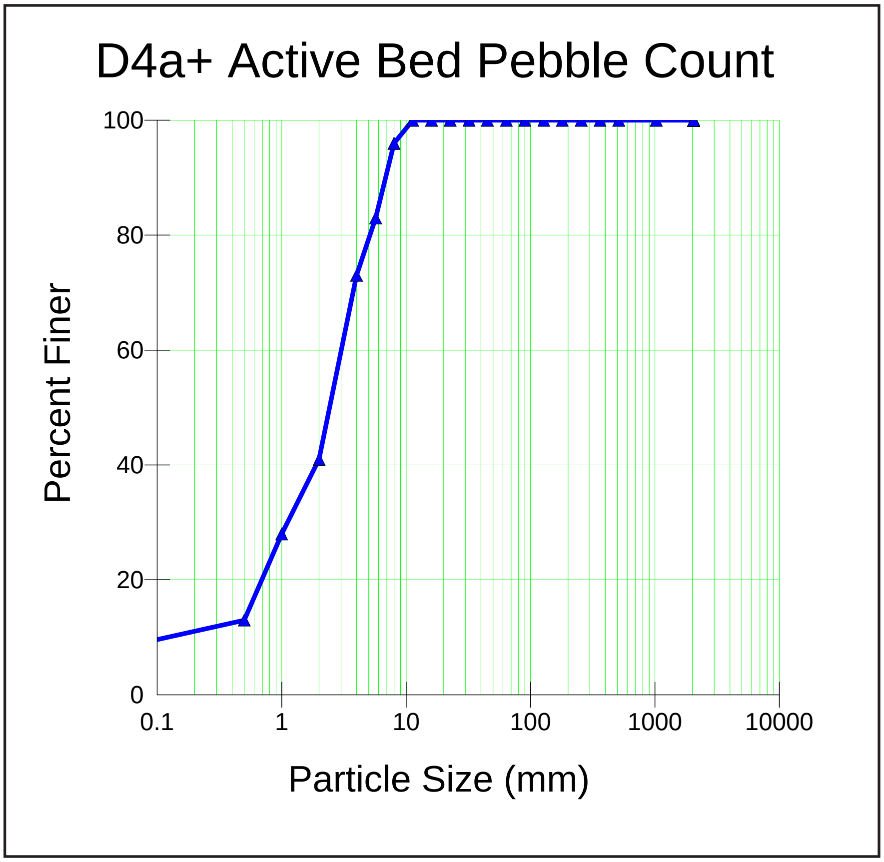
Representative Cross-section 1+07.5 (graph generated from RIVERMorph^{TM})



Cross-section 1+54.5 (graph generated from RIVERMorph^{TM})



Cross-section 2+29 (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek Trib., D4a+ Poor**	Location:	**Riffle XS 1+07.5, Pike N.F., Colorado**
Date:	**8/15/2010**	Stream Type:	**D4a**
		Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	HUC:	__ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	1.18	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.15	d_{bkf} (ft)
Bankfull Riffle WIDTH	7.8	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	8.10	W_p (ft)
D_{84} at Riffle	5.9	Dia. (mm)	D_{84} (mm) / 304.8	0.02	D_{84} (ft)
Bankfull SLOPE	0.12	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.15	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	7.53	R / D_{84}
Drainage Area	0.2	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	0.750	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\, 2.83 + 5.66 * Log \{ R / D_{84} \} \,] u^*$	3.87	ft / sec	4.57	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49{*}R^{2/3}{*}S^{1/2} / n$ $n =$ 0.043	3.32	ft / sec	3.92	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49{*}R^{2/3}{*}S^{1/2} / n$ $n =$		ft / sec		cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49{*}R^{2/3}{*}S^{1/2} / n$ $n = 0.39{*}S^{0.38}{*}R^{-0.16}$ $n =$ 0.237 Note: This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for	0.60	ft / sec	0.71	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Limerinos n**	4.15	ft / sec	4.9	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach**	3.93	ft / sec	4.6	cfs
4. Continuity Equations: a) Regional Curves $u = Q / A$ **Return Period for Bankfull Discharge** Q = ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data $u = Q / A$		ft / sec		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. Level II stream classification.

Stream: **Trail Creek Trib., D4a+ Poor Reach**

Basin: Drainage Area: acres **0.2** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 1+07.5** Date: **8/15/2010**

Observers: **Rosgen *et al*.** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**7.8**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.15**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**1.18**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**52**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.46**	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.	**43.31**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**5.55**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**2.56**	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.	**0.123**	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 (S_{val} / S).	**1.03**	

Stream Type **D4a+** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek D4a+ Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/15/2010** Valley Type: **VIII** 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})	9.6	6.5	14.4	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	1.2	1.1	1.3
Mean Riffle Depth (d_{bkf})	0.14	0.09	0.17	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	83.5	38.5	159.9
Maximum Riffle Depth (d_{max})	0.36	0.22	0.46	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	2.571	1.571	3.286
Width of Flood-Prone Area (W_{fpa})	28.4	20.3	43.3	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	3.4	1.4	5.6
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek Trib., D4a+ Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/15/2010** Valley Type: **VIII** Stream Type: **D4a**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.32**	ft/sec	Estimation Method	**"n" from FF/RR**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**3.92**	cfs	Drainage Area	**0.2**	mi^2

Channel Pattern

Geometry	**Mean**	**Min**	**Max**		**Dimensionless Geometry Ratios**	**Mean**	**Min**	**Max**
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})				ft	Meander Width Ratio (W_{blt} / W_{bkf})			
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.1267**	ft/ft	Average Water Surface Slope (S)	**0.1230**	ft/ft	Sinuosity (S_{val} / S)	**1.03**
Stream Length (SL)		ft	Valley Length (VL)		ft	Sinuosity (SL / VL)	

Low Bank Height (LBH)	start	**0.46**	ft	Max Bankfull Depth (d_{max})	start	**0.46**	ft	Bank-Height Ratio (BHR) (LBH / d_{max}) start	**1.0**
	end	**0.22**	ft		end	**0.22**	ft	end	**1.0**

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

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

Channel Materials

	Reach[b]	**Riffle**[c]	**Bar**		**Reach**[b]	**Riffle**[c]	**Bar**	**Protrusion Height**[d]	
% Silt/Clay		**0**		D_{16}		**0.60**			mm
% Sand		**41**		D_{35}		**1.54**			mm
% Gravel		**59**		D_{50}		**2.56**			mm
% Cobble		**0**		D_{84}		**5.88**			mm
% Boulder		**0**		D_{95}		**7.83**			mm
% Bedrock		**0**		D_{100}		**11.30**			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek Trib., D4a+ Poor Reach**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/16/2010**

Existing species composition: **Ponderosa Pine - 5% Burnt, Annual Grass/Forb, Cheatgrass**

Potential species composition: **Willow, Alder, Grass, Aspen**

	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**	**100%**
					100%
2. Understory	Shrub layer	▨	**0%**		
					100%
3. Ground level	Herbaceous	▨	**5%**	**Mullan** **Cheatgrass** **Ag Spic** **Annual grass** **Forbs**	
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**90%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek Trib., D4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

List ALL COMBINATIONS that APPLY..............☞	**E2**	**E8**	**S2**	**S8**				

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek Trib., D4a+ Poor Reach**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al* .**

Date: **8/16/2010**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

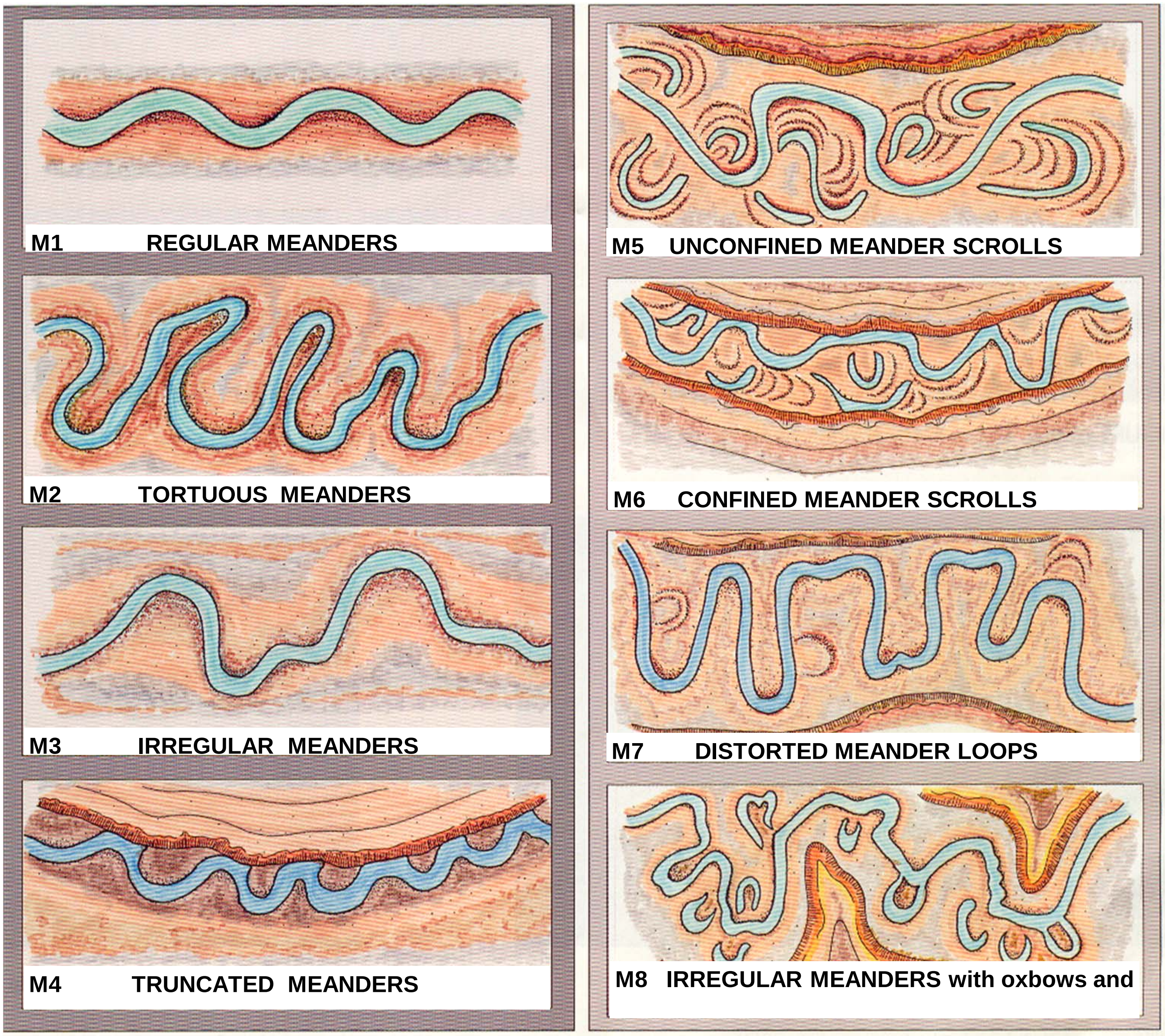
Meander Patterns

Stream: **Trail Creek Trib., D4a+ Poor Reach** Location: **Pike National Forest, CO**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

List ALL CATEGORIES that APPLY ☞	**N/A**				

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



Worksheet 5-10. Depositional patterns.

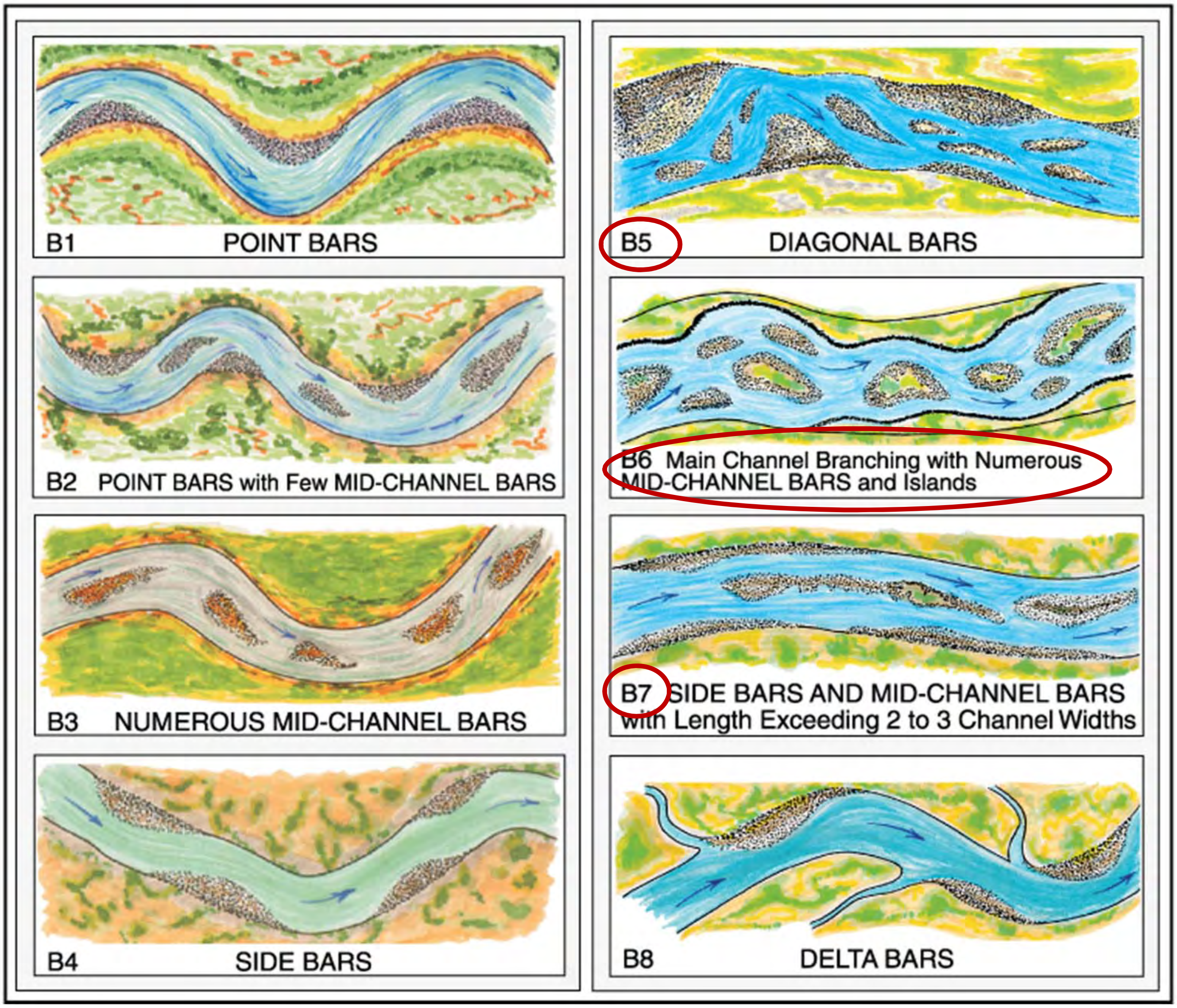
Depositional Patterns

Stream: **Trail Creek Trib., D4a+ Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

List ALL CATEGORIES that APPLY ☞	**B5**	**B6**	**B7**		

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek Trib., D4a+ Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

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 5-12. Degree of channel incision.

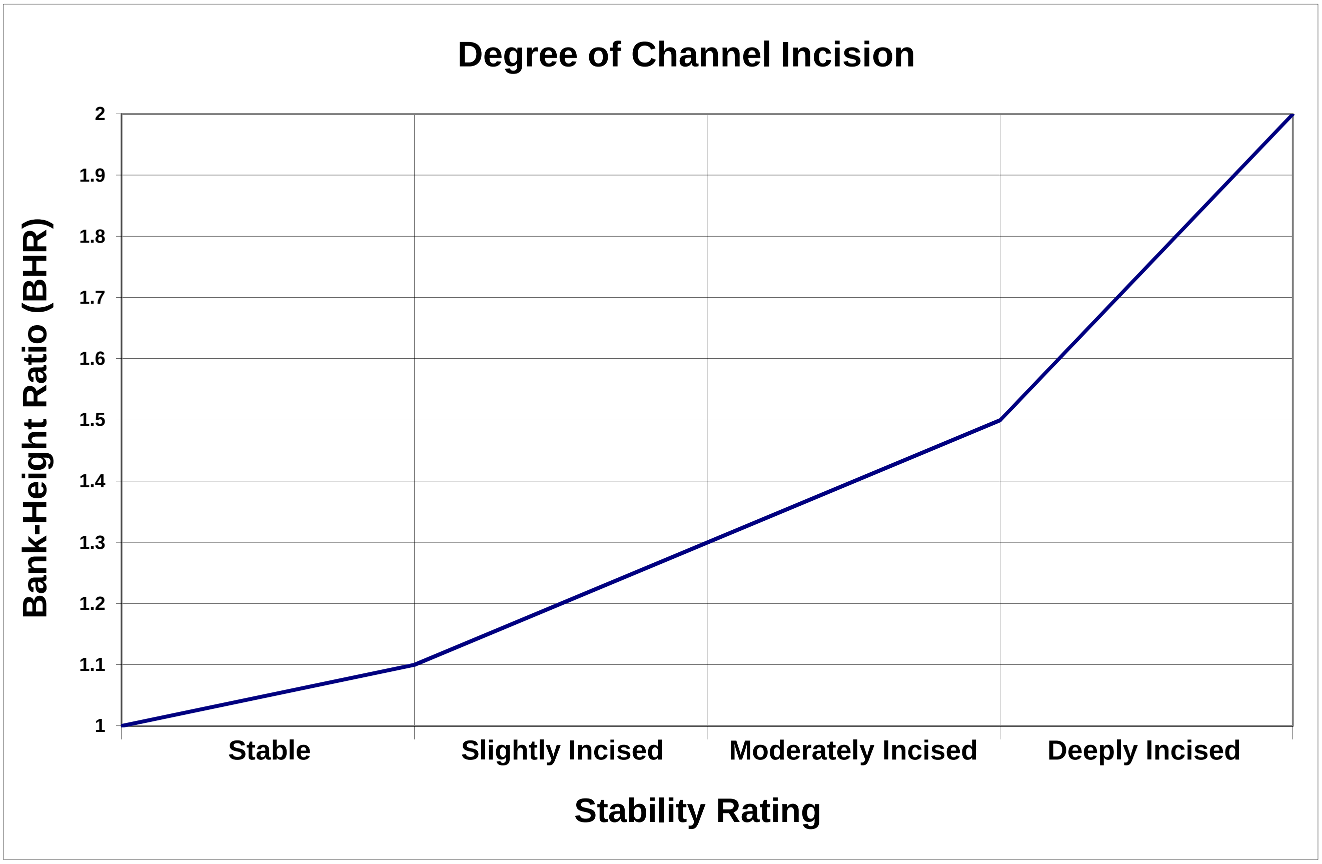
Degree of Channel Incision

Low Bank Height: **0.46**

Max Bankfull Depth: **0.46**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**

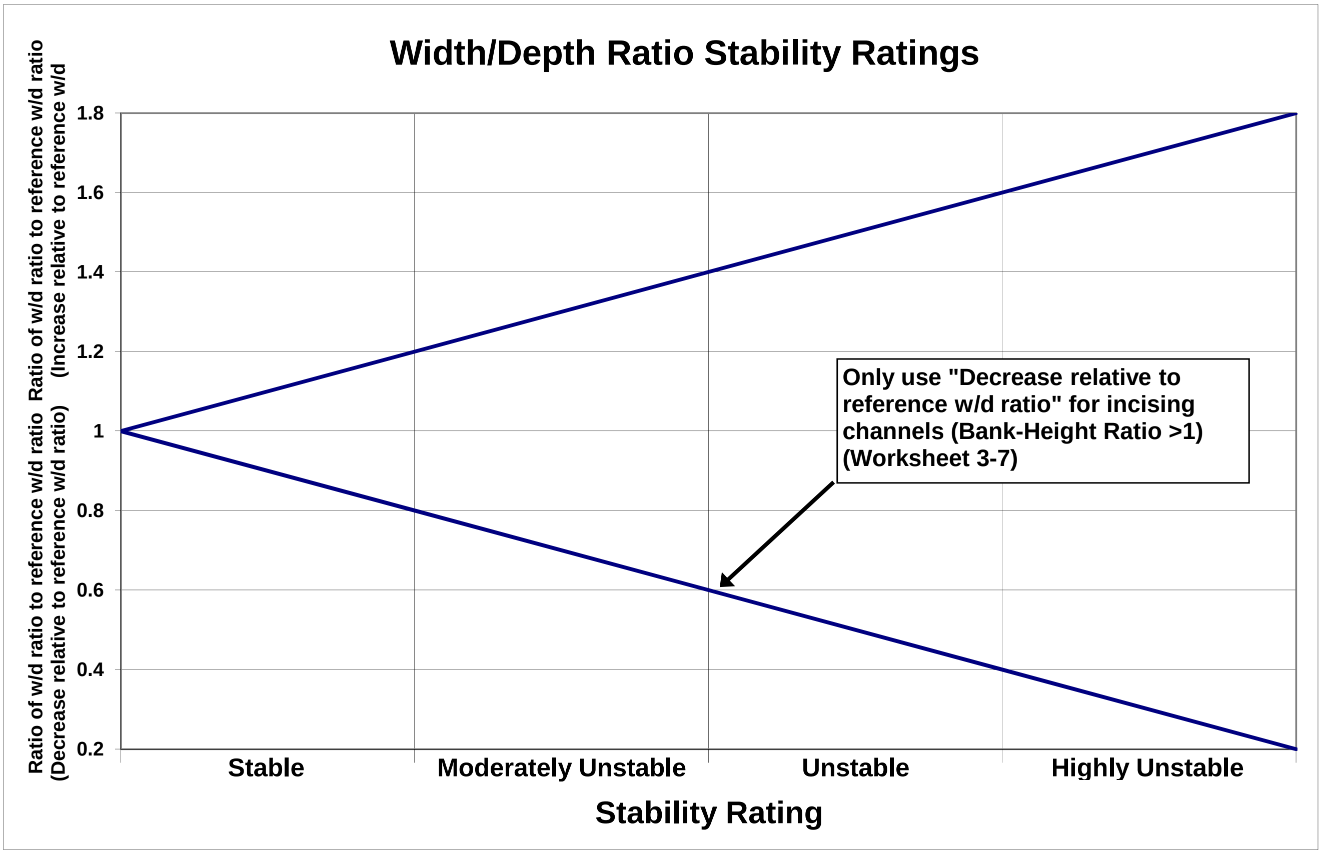


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	52	Ratio of existing W/d to reference W/d:	4.14
Reference Width/Depth Ratio:	12.57		

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



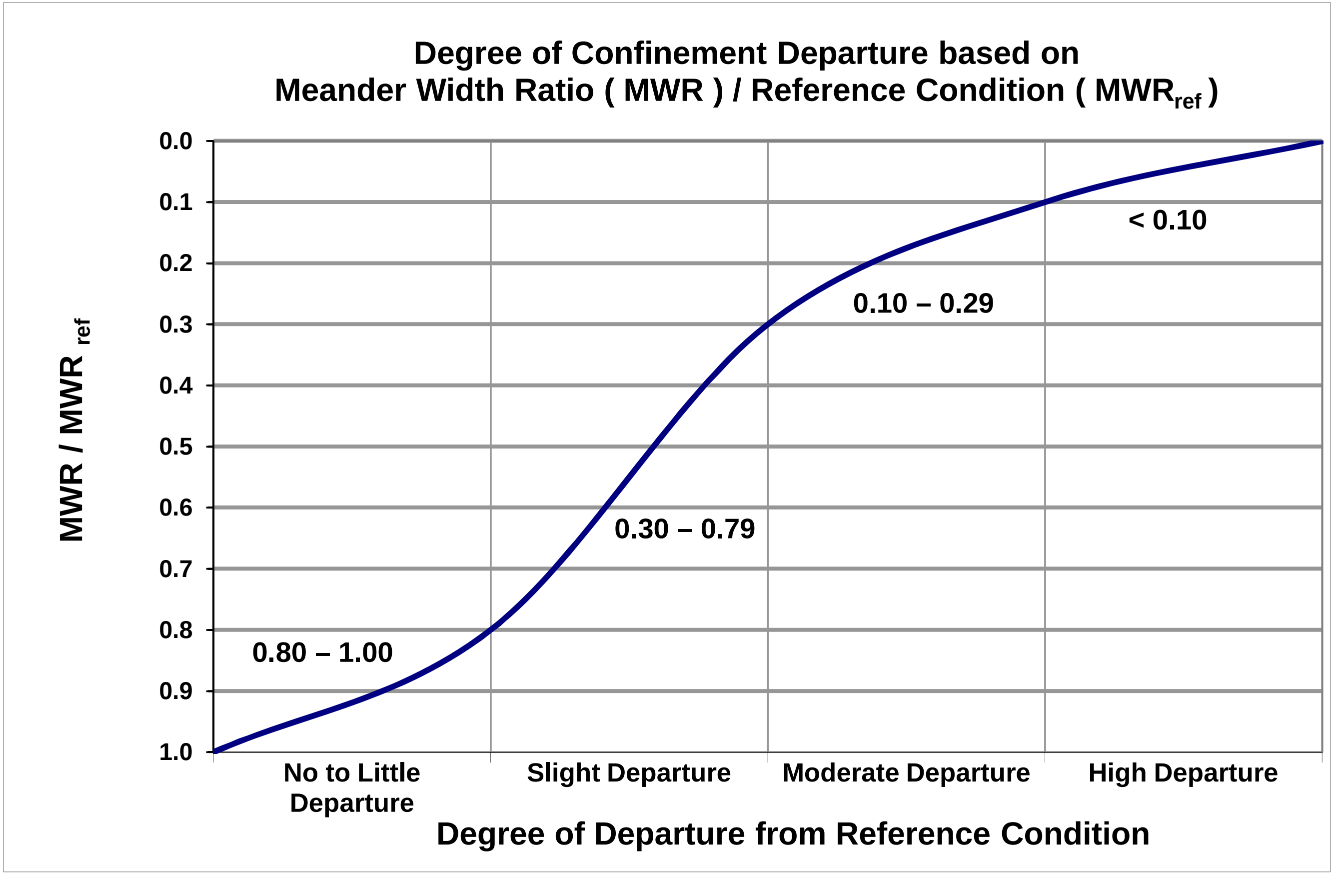
Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**2.04**	Ratio of MWR to MWR_{ref}:	**0.76**
Reference Meander Width Ratio (MWR_{ref}):	**2.7**		

Degree of Confinement Stability Rating ☞ **Slight Departure**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek Trib., D4a+ Poor Reach **Location:** Pike National Forest, CO **Valley Type:** VIII **Observers:** Rosgen *et al*. **Date:** 8/16/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	**8**
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	**12**
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	**6**	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	**12**
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	**4**
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	**8**
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	**4**	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	**16**
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	**16**
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	**4**
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	**4**
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	**8**
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	**16**
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	**24**
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	**4**
			Excellent total =		Good total =	4	Fair total =	6	Poor total =	136

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	146
Existing stream type =	D4a+
*Potential stream type =	B4a
Modified channel stability rating =	Poor

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek Trib., D4a+ Poor Reach** Location: **Pike National Forest, Colorado**

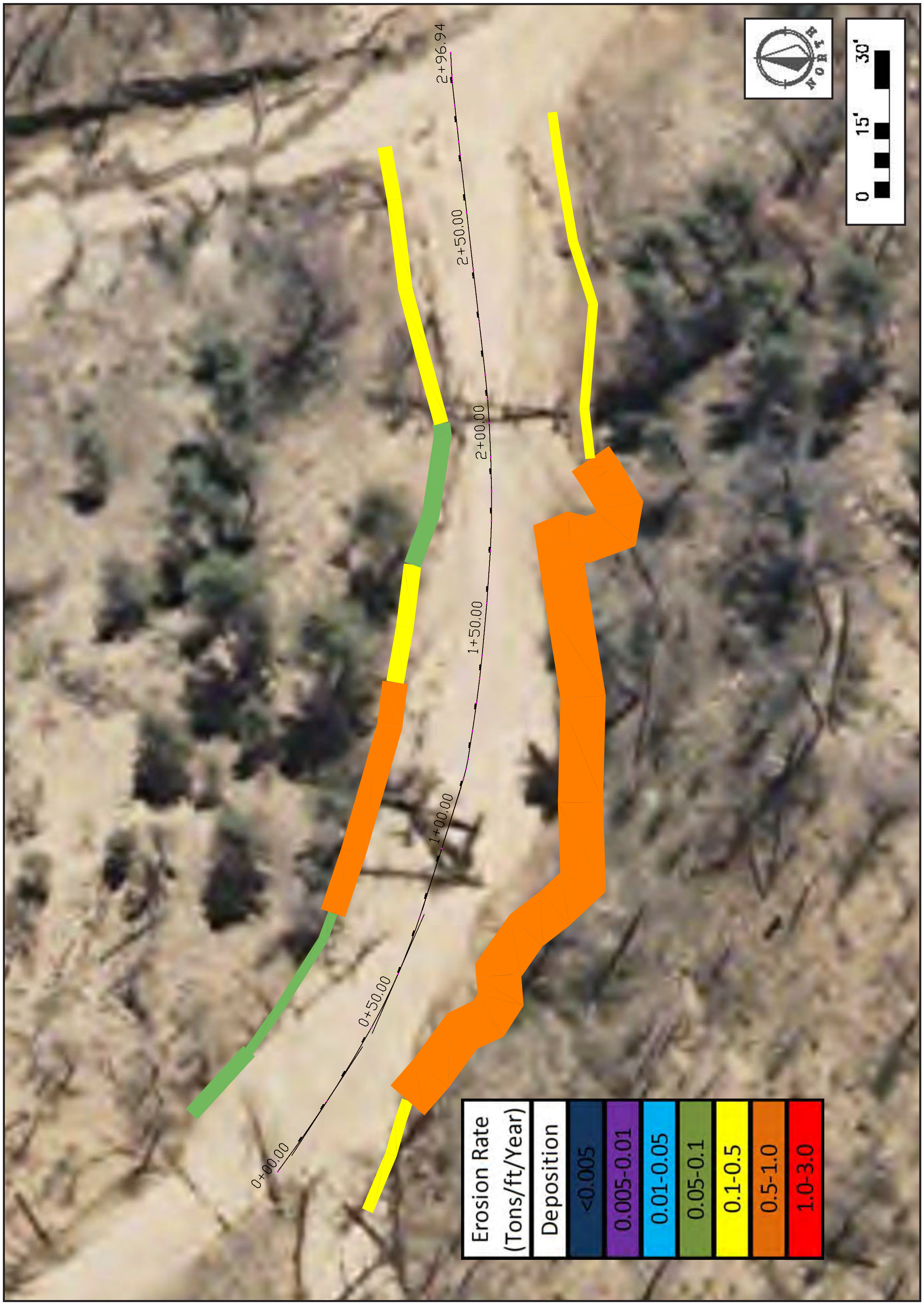
Graph Used: **Colorado** Total Stream Length (ft): **300** Date: **8/15/2010**

Observers: **Rosgen *et al*.** Valley Type: **VIII** Stream Type: **D4a**

(1) Station (ft)	(2) BEHI rating (Worksheet 5-16) (adjective)	(3) NBS rating (Worksheet 5-17) (adjective)	(4) Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 0+00 - 0+20 R	Extreme	Moderate	1.07417	20.0	3.0	64.45	0.15516
2. 0+00 - 0+33 L	Extreme	Low	0.41998	33.0	4.0	55.44	0.08088
3. 0+20 - 0+215 R	Extreme	Moderate	1.07417	195.0	11.5	2408.83	0.59477
4. 0+33 - 0+76 L	Extreme	Low	0.41998	43.0	2.5	45.15	0.05055
5. 0+76 - 0+145 L	Extreme	Extreme	2.76027	69.0	6.5	1237.98	0.86386
6. 0+145 - 0+203 L	Extreme	Moderate	1.07417	25.0	4.5	120.84	0.23274
7. 0+203 - 0+228 L	High	Low	0.25042	25.0	4.5	28.17	0.05426
8 0+215 - 0+300 R	Extreme	Moderate	1.07417	85.0	2.5	228.26	0.12930
9 0+228 - 0+300 L	Extreme	Moderate	1.07417	72.0	3.7	286.16	0.19136
10							
11							
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	**Total Erosion (ft^3/yr)**	**4475.28**
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	**Total Erosion (yds^3/yr)**	**165.75**
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	**Total Erosion (tons/yr)**	**215.48**
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	**Total Erosion (tons/yr/ft)**	**0.7183**

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	3.92	0.0052	0.7368
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional Flow-Duration Curve							From Sediment Rating Curves				Calculate	Calculate Sediment Yield		
(1) Percentage of Time	(2) Daily Mean Discharge	(3) Mid-Ordinate	(4) Time Increment (percent)	(5) Time Increment (days)	(6) Mid-Ordinate Streamflow	(7) Dimension-less Streamflow	(8) Dimension-less Suspended Sediment Discharge	(9) Suspended Sediment Discharge	(10) Dimension-less Bedload Discharge	(11) Bedload Sediment Discharge	(12) Time Adjusted Streamflow [(5)×(6)]	(13) Suspended Sediment [(5)×(9)]	(14) Bedload Sediment [(5)×(11)]	(15) Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	10.0													
0.10%	8.6	0.05%	0.09%	0.34	9.3	2.363	7.461	0.14	6.670	3.27	3.2	0.05	1.12	1.17
0.25%	7.4	0.08%	0.15%	0.55	8.0	2.036	5.232	0.08	4.809	2.36	4.4	0.05	1.29	1.34
0.50%	6.4	0.13%	0.25%	0.91	6.9	1.761	3.706	0.05	3.494	1.71	6.3	0.05	1.56	1.61
0.75%	5.5	0.13%	0.25%	0.91	5.9	1.513	2.592	0.03	2.502	1.23	5.4	0.03	1.12	1.15
1%	4.7	0.13%	0.25%	0.91	5.1	1.300	1.817	0.02	1.790	0.88	4.6	0.02	0.80	0.82
1.5%	4.1	0.25%	0.50%	1.83	4.4	1.120	1.289	0.01	1.289	0.63	8.0	0.02	1.15	1.17
2%	3.4	0.25%	0.50%	1.83	3.7	0.949	0.886	0.01	0.893	0.44	6.8	0.01	0.80	0.81
3%	2.8	0.50%	1.00%	3.65	3.1	0.795	0.600	0.00	0.602	0.30	11.4	0.01	1.08	1.09
4%	2.4	0.50%	1.00%	3.65	2.6	0.674	0.424	0.00	0.415	0.20	9.6	0.01	0.74	0.75
5%	2.2	0.50%	1.00%	3.65	2.3	0.587	0.322	0.00	0.304	0.15	8.4	0.01	0.54	0.55
10%	1.4	2.50%	5.00%	18.25	1.8	0.450	0.200	0.00	0.165	0.08	32.2	0.01	1.48	1.49
20%	0.7	5.00%	10.00%	36.50	1.1	0.269	0.103	0.00	0.045	0.02	38.4	0.01	0.81	0.82
30%	0.5	5.00%	10.00%	36.50	0.6	0.158	0.075	0.00	0.006	0.00	22.6	0.00	0.11	0.12
40%	0.4	5.00%	10.00%	36.50	0.4	0.108	0.068	0.00	0.000	0.00	15.4	0.00	0.00	0.00
50%	0.3	5.00%	10.00%	36.50	0.3	0.079	0.066	0.00	0.000	0.00	11.3	0.00	0.00	0.00
60%	0.2	5.00%	10.00%	36.50	0.2	0.061	0.065	0.00	0.000	0.00	8.7	0.00	0.00	0.00
70%	0.2	5.00%	10.00%	36.50	0.2	0.047	0.064	0.00	0.000	0.00	6.8	0.00	0.00	0.00
80%	0.1	5.00%	10.00%	36.50	0.2	0.039	0.064	0.00	0.000	0.00	5.6	0.00	0.00	0.00
90%	0.1	5.00%	10.00%	36.50	0.1	0.032	0.064	0.00	0.000	0.00	4.5	0.00	0.00	0.00
100%	0.0	5.00%	10.00%	36.50	0.1	0.016	0.064	0.00	0.000	0.00	2.3	0.00	0.00	0.00
								Annual Totals:			216.0 (cfs) 428.4 (acre-ft)	0.3 (tons/yr)	12.6 (tons/yr)	12.9 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Poor" Pagosa	$y = 0.07176{+}1.02176x^{2.3772}$	3.92	0.0230	111.69
2. Suspended Sediment	"Poor" Pagosa	$y = 0.0989{+}0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	10.7													
0.10%	9.3	0.05%	0.09%	0.34	10.0	2.548	28.319	85.29	9.510	20.85	3.4	29.26	7.15	36.42
0.25%	8.1	0.08%	0.15%	0.55	8.7	2.221	17.173	45.08	6.881	15.09	4.8	24.68	8.26	32.94
0.50%	7.1	0.13%	0.25%	0.91	7.6	1.946	10.620	24.42	5.043	11.06	7.0	22.29	10.09	32.38
0.75%	6.2	0.13%	0.25%	0.91	6.7	1.698	6.491	13.03	3.669	8.04	6.1	11.89	7.34	19.23
1%	5.5	0.13%	0.25%	0.91	5.8	1.485	4.011	7.04	2.686	5.89	5.3	6.42	5.37	11.80
1.5%	4.8	0.25%	0.50%	1.83	5.1	1.304	2.531	3.90	1.991	4.37	9.3	7.12	7.97	15.09
2%	4.1	0.25%	0.50%	1.83	4.4	1.130	1.540	2.06	1.438	3.15	8.1	3.75	5.76	9.51
3%	3.6	0.50%	1.00%	3.65	3.8	0.975	0.938	1.08	1.033	2.27	13.9	3.94	8.27	12.22
4%	3.1	0.50%	1.00%	3.65	3.3	0.846	0.599	0.60	0.759	1.66	12.1	2.19	6.08	8.26
5%	2.7	0.50%	1.00%	3.65	2.9	0.742	0.408	0.36	0.575	1.26	10.6	1.31	4.60	5.91
10%	1.7	2.50%	5.00%	18.25	2.2	0.568	0.215	0.14	0.338	0.74	40.6	2.63	13.52	16.15
20%	0.8	5.00%	10.00%	36.50	1.3	0.321	0.113	0.04	0.140	0.31	46.0	1.57	11.24	12.82
30%	0.5	5.00%	10.00%	36.50	0.7	0.166	0.100	0.02	0.086	0.19	23.8	0.72	6.89	7.61
40%	0.4	5.00%	10.00%	36.50	0.4	0.108	0.099	0.01	0.077	0.17	15.5	0.46	6.16	6.62
50%	0.3	5.00%	10.00%	36.50	0.3	0.079	0.099	0.01	0.074	0.16	11.3	0.34	5.94	6.28
60%	0.2	5.00%	10.00%	36.50	0.2	0.061	0.099	0.01	0.073	0.16	8.7	0.26	5.85	6.11
70%	0.2	5.00%	10.00%	36.50	0.2	0.047	0.099	0.01	0.072	0.16	6.8	0.20	5.80	6.00
80%	0.1	5.00%	10.00%	36.50	0.2	0.039	0.099	0.00	0.072	0.16	5.6	0.17	5.78	5.95
90%	0.1	5.00%	10.00%	36.50	0.1	0.032	0.099	0.00	0.072	0.16	4.5	0.13	5.77	5.90
100%	0.0	5.00%	10.00%	36.50	0.1	0.016	0.099	0.00	0.072	0.16	2.3	0.07	5.75	5.82
									Annual Totals:		245.7 (cfs) 487.3 (acre-ft)	119.4 (tons/yr)	143.6 (tons/yr)	263.0 (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/20/10**

Observers: **S=.123, Q=4, 3.1, Bed.=.0506, S.Sand=55.84** Stream Type: **D4a+** Valley Type: **III** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.02**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.10**	**0.06**	**0.10**	**2.22**	**0.05**	**1.23**	**0.1230**	**0.35**	**0.46**	**0.21**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
80.00%	**0.14**	**0.12**	**0.12**	**2.26**	**0.05**	**1.31**	**0.1230**	**0.41**	**0.92**	**0.41**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
70.00%	**0.17**	**0.16**	**0.14**	**2.29**	**0.06**	**1.36**	**0.1230**	**0.47**	**1.23**	**0.54**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
60.00%	**0.21**	**0.19**	**0.15**	**2.31**	**0.06**	**1.39**	**0.1230**	**0.50**	**1.46**	**0.63**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
50.00%	**0.27**	**0.24**	**0.16**	**2.35**	**0.07**	**1.45**	**0.1230**	**0.52**	**1.84**	**0.78**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
40.00%	**0.35**	**0.31**	**0.19**	**2.40**	**0.08**	**1.54**	**0.1230**	**0.60**	**2.38**	**0.99**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
30.00%	**0.50**	**0.43**	**0.23**	**2.49**	**0.09**	**1.68**	**0.1230**	**0.70**	**3.30**	**1.33**	**10%**	**36.50**	**0.17**	**0.01**	**6.21**	**0.36**	**6.57**
20.00%	**0.78**	**0.64**	**0.30**	**2.64**	**0.11**	**1.93**	**0.1230**	**0.86**	**4.91**	**1.86**	**10%**	**36.50**	**0.17**	**0.01**	**6.21**	**0.36**	**6.57**
10.00%	**1.57**	**1.18**	**0.47**	**2.98**	**0.16**	**2.47**	**0.1230**	**1.19**	**9.06**	**3.04**	**10%**	**36.50**	**0.26**	**0.02**	**9.49**	**0.73**	**10.22**
5.00%	**2.50**	**2.04**	**0.68**	**3.29**	**0.21**	**2.96**	**0.1230**	**1.55**	**15.66**	**4.76**	**5%**	**18.25**	**0.60**	**0.05**	**10.95**	**0.91**	**11.86**
4.00%	**2.82**	**2.66**	**0.81**	**3.47**	**0.23**	**3.22**	**0.1230**	**1.74**	**20.42**	**5.88**	**1%**	**3.65**	**0.99**	**0.12**	**3.61**	**0.44**	**4.05**
3.00%	**3.26**	**3.04**	**0.89**	**3.56**	**0.25**	**3.35**	**0.1230**	**1.86**	**23.33**	**6.55**	**1%**	**3.65**	**1.34**	**0.20**	**4.89**	**0.73**	**5.62**
2.00%	**3.80**	**3.53**	**0.99**	**3.68**	**0.27**	**3.52**	**0.1230**	**2.00**	**27.09**	**7.36**	**1%**	**3.65**	**1.81**	**0.36**	**6.61**	**1.31**	**7.92**
1.50%	**4.48**	**4.14**	**1.11**	**3.84**	**0.29**	**3.72**	**0.1230**	**2.14**	**31.78**	**8.28**	**1%**	**1.83**	**2.59**	**0.71**	**4.73**	**1.30**	**6.03**
1.00%	**5.15**	**4.82**															
0.75%	**5.89**	**5.52**															
0.50%	**6.83**	**6.36**															
0.25%	**7.84**	**7.34**															
0.10%	**8.99**	**8.42**															
0.0060%	**10.40**	**9.70**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**90.0**	**6.1**	**96.1**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, D4a+ Poor, Riffle XS 1+07.5** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/20/10**

Observers: **S=.123, Q=4, 3.1, Bed.=.0506, S.Sand=55.84** Stream Type: **D4a+** Valley Type: **III** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.02**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.10**	**0.06**	**0.04**	**0.75**	**0.05**	**1.54**	**0.1230**	**0.39**	**0.46**	**0.61**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
80.00%	**0.14**	**0.12**	**0.06**	**0.90**	**0.07**	**1.72**	**0.1230**	**0.49**	**0.92**	**1.02**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
70.00%	**0.17**	**0.16**	**0.07**	**1.00**	**0.07**	**1.84**	**0.1230**	**0.52**	**1.23**	**1.23**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
60.00%	**0.21**	**0.19**	**0.09**	**1.07**	**0.08**	**1.92**	**0.1230**	**0.62**	**1.46**	**1.36**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
50.00%	**0.27**	**0.24**	**0.10**	**1.19**	**0.08**	**2.07**	**0.1230**	**0.62**	**1.84**	**1.55**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
40.00%	**0.35**	**0.31**	**0.13**	**1.36**	**0.10**	**2.28**	**0.1230**	**0.71**	**2.38**	**1.75**	**10%**	**36.50**	**0.17**	**0.00**	**6.21**	**0.00**	**6.21**
30.00%	**0.50**	**0.43**	**0.17**	**1.67**	**0.10**	**2.46**	**0.1230**	**0.75**	**3.30**	**1.98**	**10%**	**36.50**	**0.17**	**0.01**	**6.21**	**0.36**	**6.57**
20.00%	**0.78**	**0.64**	**0.25**	**2.23**	**0.11**	**2.55**	**0.1230**	**0.83**	**4.91**	**2.20**	**10%**	**36.50**	**0.22**	**0.01**	**8.03**	**0.36**	**8.39**
10.00%	**1.57**	**1.18**	**0.42**	**3.42**	**0.12**	**2.76**	**0.1230**	**0.91**	**9.06**	**2.65**	**10%**	**36.50**	**0.22**	**0.02**	**8.03**	**0.73**	**8.76**
5.00%	**2.50**	**2.04**	**0.65**	**4.60**	**0.14**	**3.05**	**0.1230**	**1.05**	**15.66**	**3.40**	**5%**	**18.25**	**0.35**	**0.04**	**6.39**	**0.73**	**7.12**
4.00%	**2.82**	**2.66**	**0.83**	**5.51**	**0.15**	**3.21**	**0.1230**	**1.13**	**20.42**	**3.71**	**1%**	**3.65**	**0.39**	**0.05**	**1.42**	**0.18**	**1.60**
3.00%	**3.26**	**3.04**	**0.94**	**6.22**	**0.15**	**3.22**	**0.1230**	**1.13**	**23.33**	**3.75**	**1%**	**3.65**	**0.39**	**0.06**	**1.42**	**0.22**	**1.64**
2.00%	**3.80**	**3.53**	**1.09**	**7.14**	**0.15**	**3.24**	**0.1230**	**1.15**	**27.09**	**3.79**	**1%**	**3.65**	**0.39**	**0.07**	**1.42**	**0.26**	**1.68**
1.50%	**4.48**	**4.14**	**1.27**	**8.28**	**0.15**	**3.26**	**0.1230**	**1.15**	**31.78**	**3.84**	**1%**	**1.83**	**0.43**	**0.09**	**0.78**	**0.16**	**0.94**
1.00%	**5.15**	**4.82**															
0.75%	**5.89**	**5.52**															
0.50%	**6.83**	**6.36**															
0.25%	**7.84**	**7.34**															
0.10%	**8.99**	**8.42**															
0.0060%	**10.40**	**9.70**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**71.0**	**3.0**	**74.0**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**90.0**	**6.1**	**96.1**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-19.0**	**-3.1**	**-22.1**
Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, > 23% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek Trib., D4a+ Poor Reach**	Stream Type:	**D4a Poor**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

Enter Required Information for Existing Condition

2.6	D_{50}	Riffle bed material D_{50} (mm)			
	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.04	D_{max}	Largest particle from **Bed Material** (ft)	**11.3**	**(mm)**	304.8 mm/ft
0.123	S	Existing bankfull water surface slope (ft/ft)			
0.15	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

1.151		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 **88**	CO **180**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **0.18**	CO **0.03**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.02**	CO **0.004**	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 **0.0192**	CO **0.0032**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek Trib., D4a+ Poor**	Stream Type: **D4a**
Location: **Pike National Forest, CO**	Valley Type: **VIII**
Observers: **Rosgen *et al*.**	Date: **8/16/2010**
Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☑ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek Trib., D4a+ Poor Reach**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-13)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **4.1** [✓ **(8)**]	**8**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	**B5, B6, B7** **B5, B6, B7** [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 **N/A** [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **Ex/M** [✓ **(8)**]	**8**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 **(1)**	0.3 – 0.79 **0.8** [✓ **(2)**]	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**2**
				Total Points	**23**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☑	

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek Trib., D4a+ Poor Reach**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	Excess [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**7**
	(2)	**(4)**	**(6)**	**> 21%** [✓ **(7)**]	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
	(2)	**(4)**	**(6)**	**4.1** [✓ **(8)**]	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, B4	B3, **B5**	**B6, B7**, B8	**4**
	(1)	**(2)**	**(3)**	**B5, B6, B7** [✓ **(4)**]	
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3	**D4**, D7	D5, D8	D6, D9, D10	**2**
	(1)	**D4** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**31**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☑

Worksheet 5-27. Vertical stability – degradation.

Stream: **Trail Creek Trib., D4a+ Poor Reach** Stream Type: **D4a**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **Rosgen *et al*.** Date: **8/16/2010**

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 5-22)**	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) (Worksheet 5-20)**	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 5-12)**	1.00 – 1.10 **[✓ (2)]**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **[✓ (2)]**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**2**
				Total Points	**16**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek Trib., D4a+ Poor Reach**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F)	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
2 **Lateral Stability (Worksheet 5-25)**	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	**4**
	(2)	[✓ **(4)**]	**(6)**	**(8)**	
				Total Points	**28**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☑

Worksheet 5-29. Overall sediment supply.

Stream: **Trail Creek Trib., D4a+ Poor Reach** Stream Type: **D4a**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **Rosgen *et al*.** Date: **8/16/2010**

	Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	Stability Rating	Points	Selected Points
1	Lateral Stability (Worksheet 5-25)	*Stable*	1	4
		Mod. Unstable	2	
		Unstable	3	
		Highly Unstable	[✓ 4]	
2	Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	1	4
		Mod. Deposition	2	
		Excess Deposition	3	
		Aggradation	[✓ 4]	
3	Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	1	2
		Slightly Incised	[✓ 2]	
		Mod. Incised	3	
		Degradation	4	
4	Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	4
		Slight Increase	2	
		Mod. Increase	3	
		Extensive	[✓ 4]	
5	Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	1	4
		Fair: Mod. Unstable	2	
		Poor: Unstable	[✓ 4]	
			Total Points	**18**

Overall Sediment Supply Rating (use total points and check stability rating)	Category Point Range			
	Low 5 ☐	*Moderate* 6 – 10 ☐	*High* 11 – 15 ☐	*Very High* 16 – 20 ☑

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek Trib., D4a+ Poor, Riffle XS 1+54.5**						Location: **Pike National Forest, Colorado**						
Observers:	**Rosgen *et al*.**			Date: **8/16/2010**			Stream Type: **D4a**			Valley Type: **VIII**			
Channel Dimension (Riffle XS 1+07.5)	Mean Bankfull Depth (ft):	**0.15**	Bankfull Width (ft):	**7.8**	Cross-Sectional Area (ft^2):	**1.18**	Width of Flood-Prone Area (ft):	**43.31**	Entrenchment Ratio:	**5.55**			
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**2.04** **1.93-2.16**	Sinuosity:	**1.03**		
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☑ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed								
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope				
									Valley:	**0.1267**	Water Surface:	**0.123**	
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:	Potential Composition/Density:	Remarks: Condition, Vigor & Usage of Existing Reach:									
		< 5% Annual Grass/Forb	**Willow/Alder/Grass/Aspen**	**Burnt, 5% Ponderosa Pine Aerial**									
	Flow Regime:	**E2,E8,** **S2,S8**	Stream Size & Order:	**S-3(2)**	Meander Patterns:	**N/A**	Depositional Patterns:	**B5, B6, B7**	Debris/Channel Blockages:	**D4**			
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**146 (Poor)**							
	Width/depth Ratio (W/d):	**52**	Reference W/d Ratio (W/d$_{ref}$):	**12.6**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**4.14**	W/d Ratio State Stability Rating:	**Highly Unstable**					
	Meander Width Ratio (MWR):	**2.04**	Reference MWR$_{ref}$:	**2.7**	Degree of confinement (MWR / MWR$_{ref}$):	**0.76**	MWR / MWR$_{ref}$ Stability Rating:	**Slight Departure from Reference**					
Bank Erosion Summary	Length of Reach Studied (ft):	**300**	Annual Streambank Erosion Rate:	**215.58** (tons/yr)	**0.7183** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:						
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity	Remarks: **> 21% Reduction in Transport Capacity**									
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	$\tau =$	**11.3**	$\tau^* =$	**N/A**	Existing Depth:	**0.15**	Required Depth:	**0.004-0.02**	Existing Slope:	**0.123**	Required Slope:	**.003-.019**
Successional Stage Shift	**B** → **G** → **F** → [✓ **D**] → **B** →	Existing Stream State (Type):	**D4a+**	Potential Stream State (Type):	**B4a**								
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☑ *Highly Unstable*	Remarks/causes:	**Fire and flood impacts**							
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☑ *Aggradation*	Remarks/causes:	**Fire and flood impacts**							
Vertical Stability (Degradation)	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Fire and flood impacts**							
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☑ *Extensive*	Remarks/causes:	**Fire and flood impacts**							
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☐ *High*	☑ *Very High*	Remarks/causes:	**Fire and flood impacts**							

Appendix C9

E4 Stream Type

Good Stability HWD Reach

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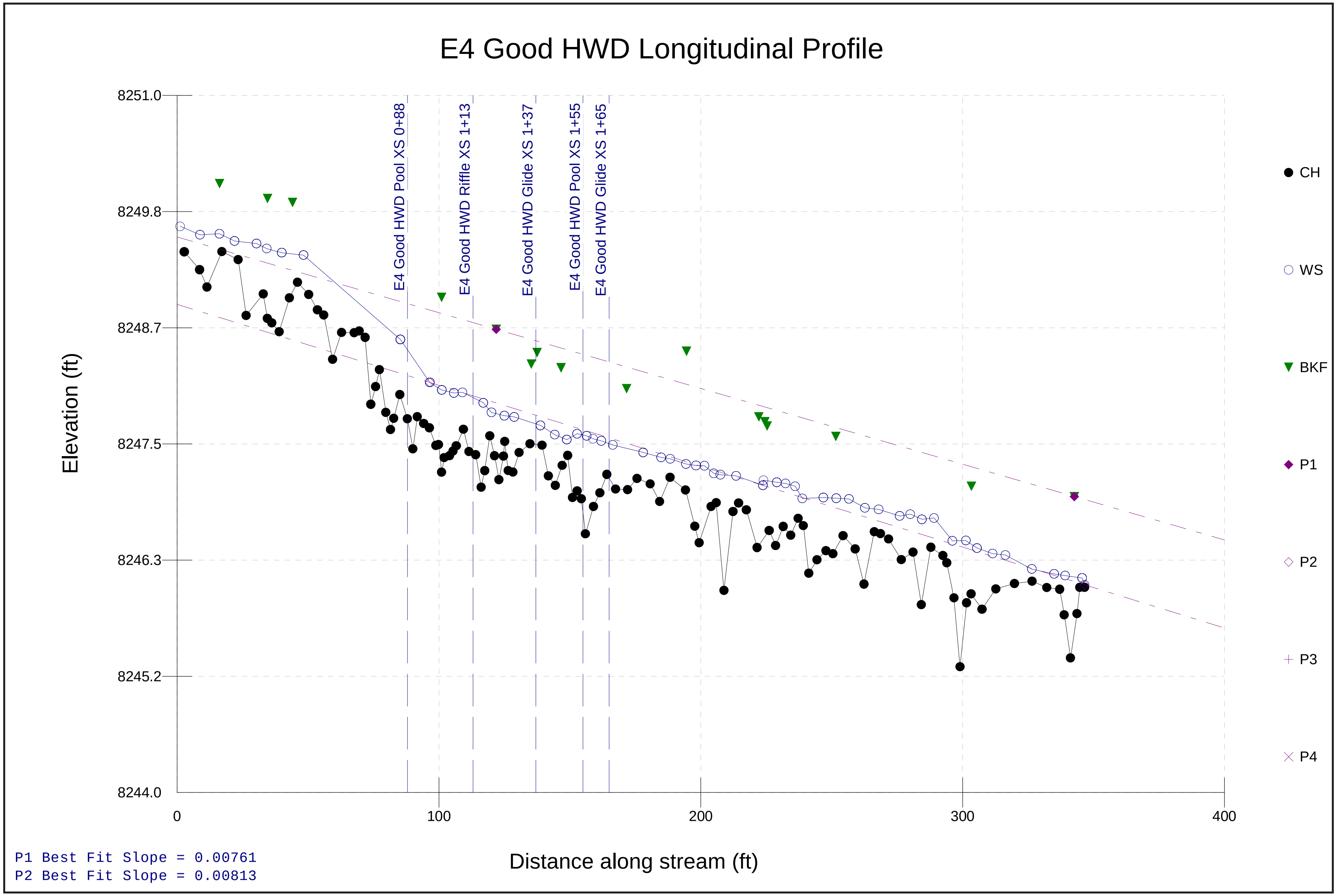
Appendix C9: E4 Good HWD Reach

E4 Good HWD Reach Location & Overview

The E4 Good HWD representative reach is a 3rd order, perennial, low gradient, meandering stream located in upper Trail Creek (see location map **Figure C-2**). The photograph depicts excellent riparian vegetation, although the stream is recovering from past impacts. The width/depth ratio of *9.72* is at the upper end of the range of values for an E4 stream type, but the reach has a very high recovery potential in the lacustrine, beaver meadow, Valley Type X. The stream is narrowing and deepening as it is becoming more stable and has fishery potential. The potential stable stream type in this valley type is E4; thus no POWERSED run was made as the stream has not departed from the reference stream type, shows no incision, and its width/depth ratio indicates no excess deposition. The stability rating is "Good" due to a Pfankuch stability rating of "Good" and the relatively low streambank erosion rate of *0.007 tons/yr/ft*. However, according to the WRENSS model, the water yield due to the fire increased from *1,377 acre-ft* to *2,700 acre-ft*, representing an increase of *1,324 acre-ft*, which is double the pre-fire condition. The FLOWSED model showed that bedload increased from *36 tons/yr* to *216 tons/yr* and the suspended sediment increased from *20 tons/yr* to *200 tons/yr*, representing a total increase in sediment of *350 tons/yr*. This sediment yield increase is the result of increased sediment transport capacity or efficient routing of sediment supplied from upstream sources due to the low width/depth ratio.

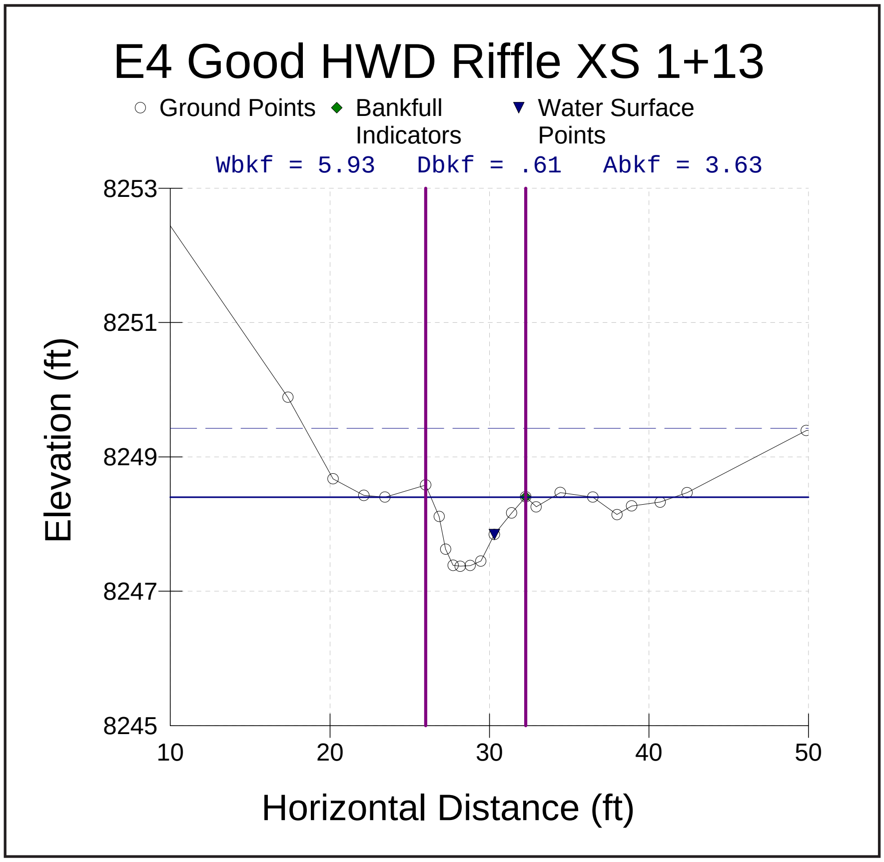
The photograph depicts the typical character of this representative E4 stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Good" rating.

Survey Summary

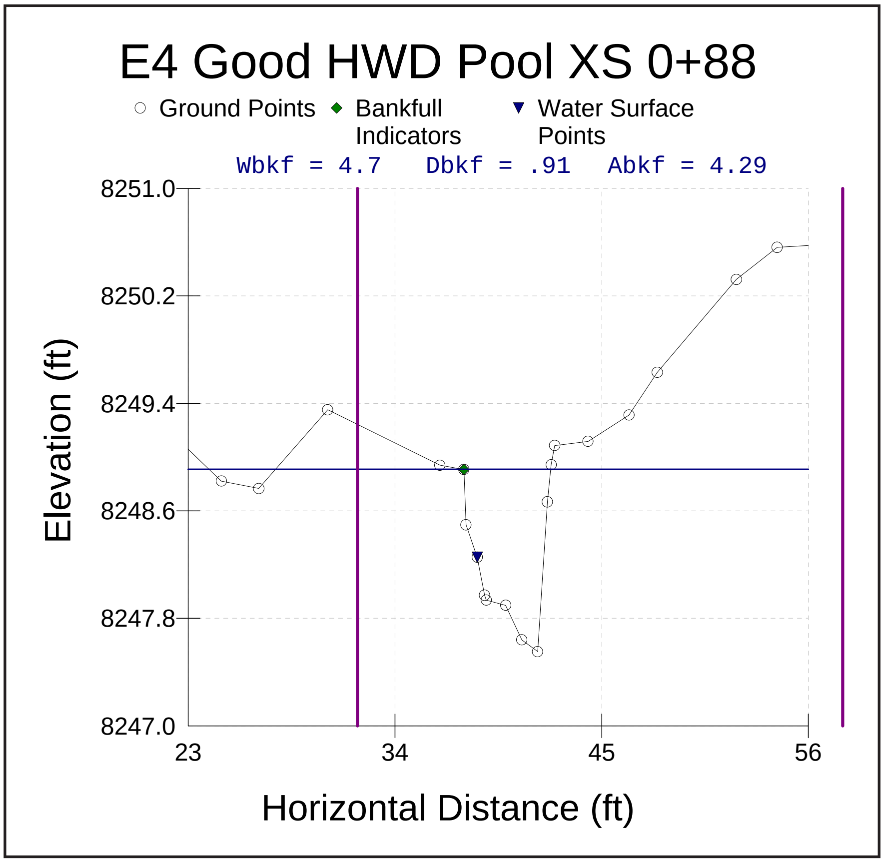


P1 Best Fit Slope = 0.00761
P2 Best Fit Slope = 0.00813

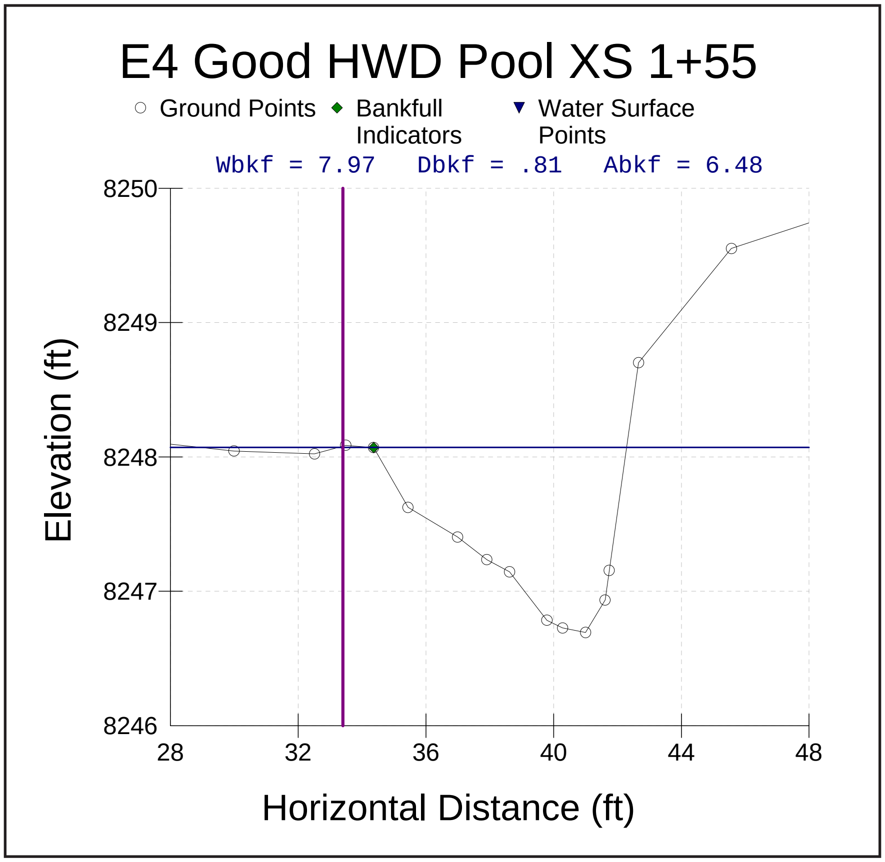
Longitudinal Profile (graph generated from RIVERMorph^{TM})



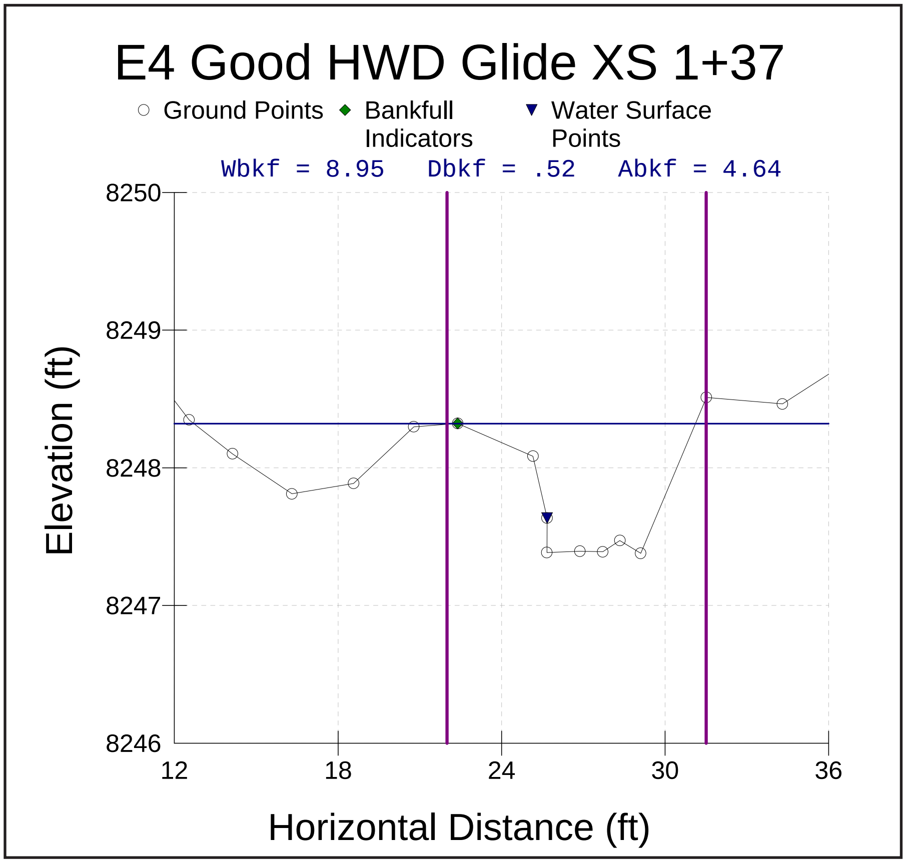
Representative Riffle Cross-section 1+13 (graph generated from RIVERMorph^{TM})



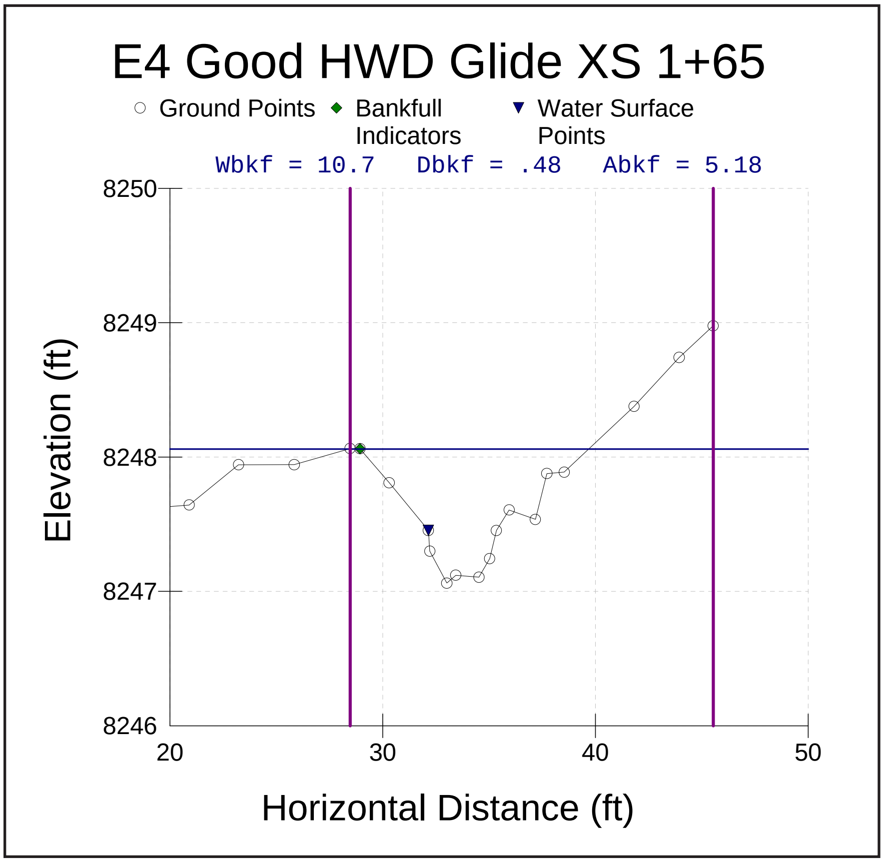
Pool Cross-section 0+88 (graph generated from RIVERMorph^{TM})



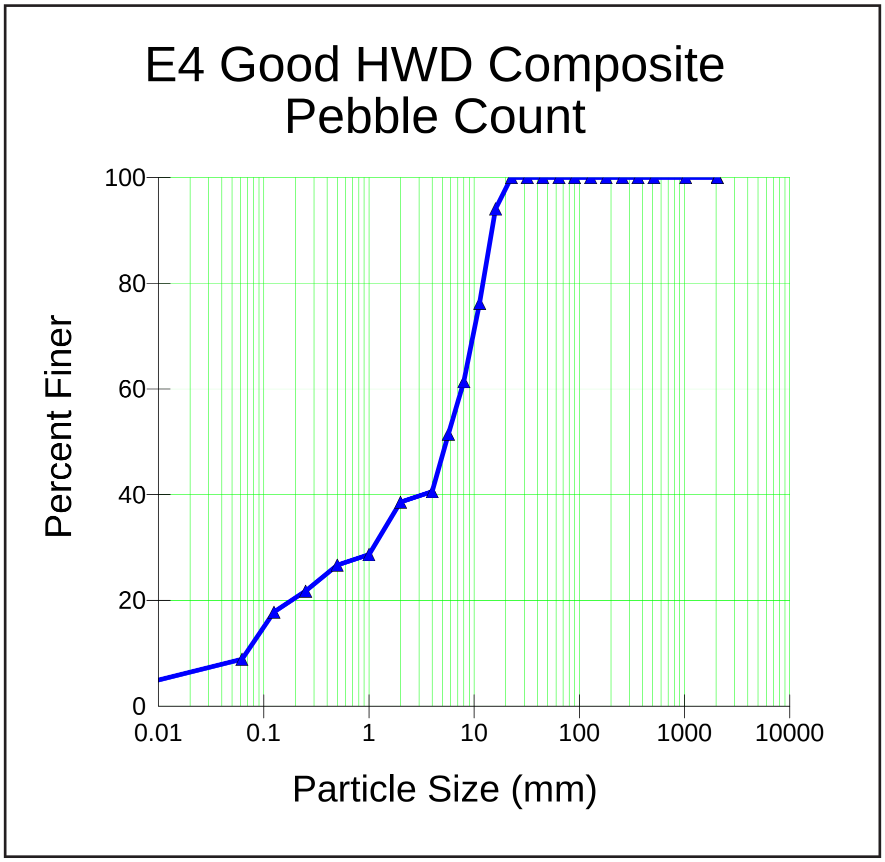
Pool Cross-section 0+50.8 (graph generated from RIVERMorph^{TM})



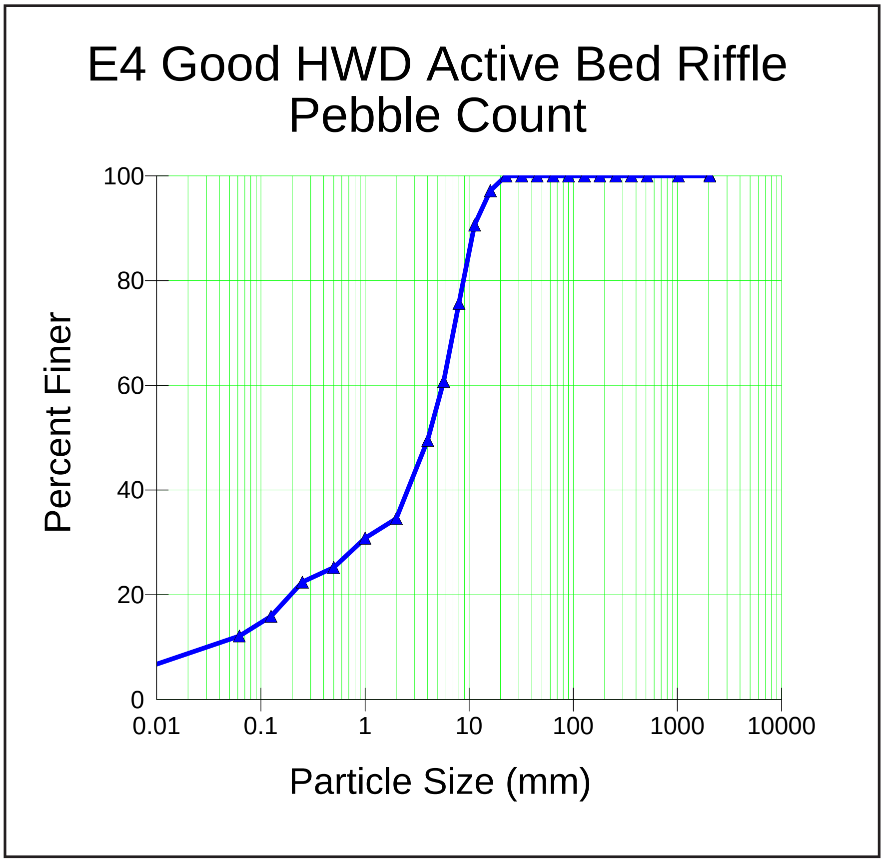
Glide Cross-section 1+37 (graph generated from RIVERMorph^{TM})



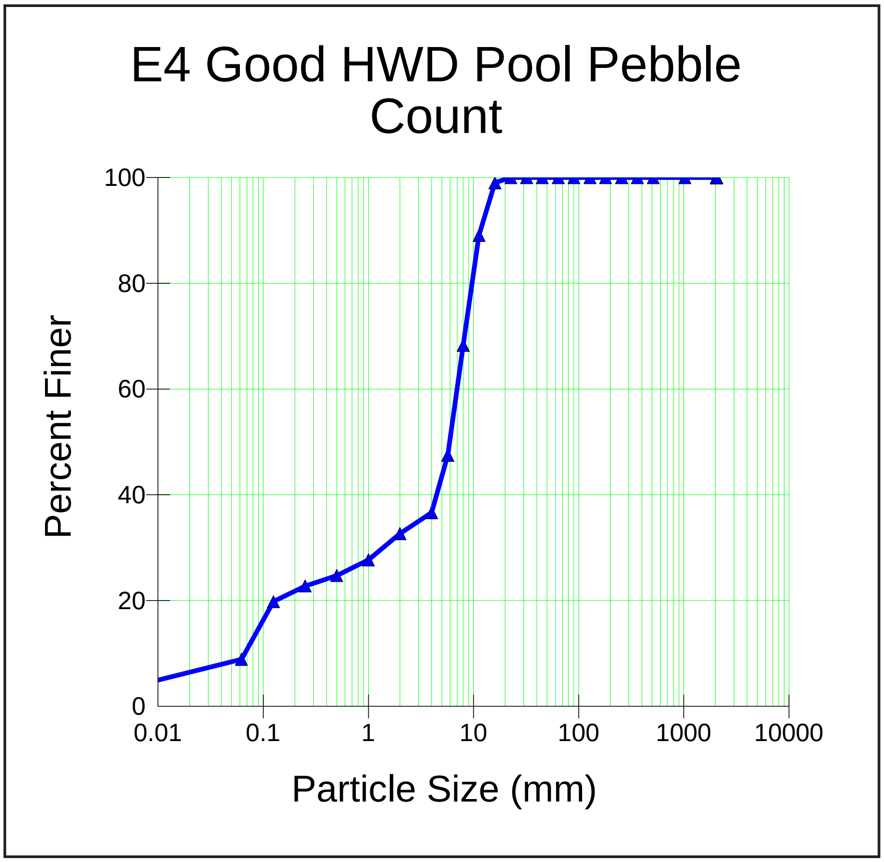
Glide Cross-section 1+65 (graph generated from RIVERMorph^{TM})



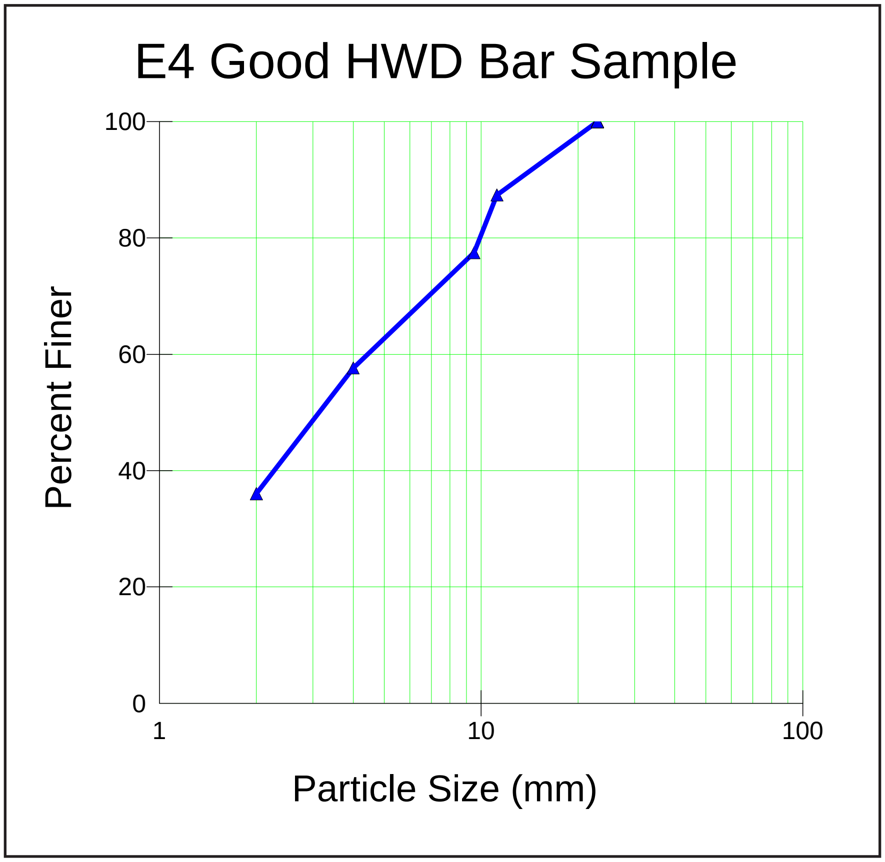
Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Pool Pebble Count (graph generated from RIVERMorph^TM^)



Bar Sample (graph generated from RIVERMorph^TM^)

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, E4 Good HWD Reach**			Location:	**Riffle XS 1+13, Pike N.F., Colorado**
Date:	**8/23/2010**	Stream Type:	**E4**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**			HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**3.63**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.61**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**5.93**	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**7.15**	W_p (ft)
D_{84} at Riffle	**9.8**	Dia. (mm)	D_{84} (mm) / 304.8	**0.03**	D_{84} (ft)
Bankfull SLOPE	**0.008**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.51**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**15.73**	R / D_{84}
Drainage Area	**7.7**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.362**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**3.47**	ft / sec	**12.60**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.027**	**3.14**	ft / sec	**11.40**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.032**	**2.65**	ft / sec	**9.62**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.069** **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	**1.22**	ft / sec	**4.43**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **u/u***	**3.48**	ft / sec	**12.6**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, E4 Good HWD Reach**

Basin: Drainage Area: acres **7.7** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 1+13** Date: **08/23/201**

Observers: **K. Wright & B. Kasun** Valley Type: **X**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**5.93**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.61**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**3.63**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.72**	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.	**1.03**	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.	**32.23**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**5.44**	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.	**5.47**	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.	**0.008**	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).	**1.46**	

Stream Type **E4** (See **Figure 2-14**)

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, E4 Good HWD Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010** Valley Type: **X** Stream Type: **E4**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	5.93			ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	3.63		
Mean Riffle Depth (d_{bkf})	0.61			ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	9.72		
Maximum Riffle Depth (d_{max})	1.03			ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.69		
Width of Flood-Prone Area (W_{fpa})	32.2			ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	5.44		
Riffle Inner Berm Width (W_{ib})	2.6			ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.438		
Riffle Inner Berm Depth (d_{ib})	0.19			ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.311		
Riffle Inner Berm Area (A_{ib})	0.51			ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.140		
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	14.2							

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	6.34	4.70	7.97	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.07	0.79	1.34
Mean Pool Depth (d_{bkfp})	0.86	0.81	0.91	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.41	1.33	1.49
Pool Cross-Sectional Area (A_{bkfp})	5.39	4.29	6.48	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.48	1.18	1.79
Maximum Pool Depth (d_{maxp})	1.37	1.36	1.38	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.25	2.23	2.26
Pool Inner Berm Width (W_{ibp})	3.16	3.07	3.24	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.498	0.484	0.511
Pool Inner Berm Depth (d_{ibp})	0.26	0.22	0.3	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.30	0.26	0.35
Pool Inner Berm Area (A_{ibp})	0.83	0.68	0.98	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.15	0.13	0.18
Point Bar Slope (S_{pb})	0.19	0.13	0.24	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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	9.85	8.95	10.74	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.66	1.51	1.81
Mean Glide Depth (d_{bkfg})	0.50	0.48	0.52	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.82	0.79	0.85
Glide Cross-Sectional Area (A_{bkfg})	4.91	4.64	5.18	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.35	1.28	1.43
Maximum Glide Depth (d_{maxg})	0.97	0.94	1.00	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.59	1.54	1.64
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	19.80	17.21	22.38	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	14.36	11.24	17.48
Glide Inner Berm Width (W_{ibg})	3.64	3.26	4.02	ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.370	0.331	0.408
Glide Inner Berm Depth (d_{ibg})	0.26	0.23	0.29	ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.520	0.460	0.580
Glide Inner Berm Area (A_{ibg})	0.93	0.92	0.94	ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.189	0.187	0.191

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, E4 Good HWD Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010** Valley Type: **X** Stream Type: **E4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.47**	ft/sec	Estimation Method	**FF/RR**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**12.60**	cfs	Drainage Area	**7.7**	mi^2

Channel Pattern

Geometry	**Mean**	**Min**	**Max**		**Dimensionless Geometry Ratios**	**Mean**	**Min**	**Max**
Linear Wavelength (λ)	**35.5**	**25.5**	**49**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**5.99**	**4.30**	**8.26**
Stream Meander Length (L_m)	**47.6**	**30.5**	**66.4**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**8.03**	**5.15**	**11.20**
Radius of Curvature (R_c)	**7.4**	**4.5**	**10.4**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**1.25**	**0.75**	**1.75**
Belt Width (W_{blt})	**22.9**	**16.3**	**31.6**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**3.86**	**2.75**	**5.33**
Arc Length (L_a)	**11.64**	**8.2**	**14.2**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**1.96**	**1.38**	**2.39**
Riffle Length (L_r)	**19.2**	**8.4**	**29.5**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**3.24**	**1.41**	**4.97**
Individual Pool Length (L_p)	**10.1**	**6.9**	**17.5**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.70**	**1.16**	**2.95**
Pool to Pool Spacing (P_s)	**21.1**	**7.0**	**43.2**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**3.56**	**1.19**	**7.28**

Channel Profile

Valley Slope (S_{val})	**0.0117**	ft/ft	Average Water Surface Slope (S)	**0.008**	ft/ft	Sinuosity (S_{val} / S)	**1.46**
Stream Length (SL)	**90.0**	ft	Valley Length (VL)	**61.6**	ft	Sinuosity (SL / VL)	**1.46**

Low Bank Height (LBH)	start	**0.89**	ft	Max Bankfull Depth (d_{max})	start	**1.00**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.0**
	end	**0.94**	ft		end	**1.00**	ft		end	**1.0**

Facet Slopes	**Mean**	**Min**	**Max**		**Dimensionless Facet Slope Ratios**	**Mean**	**Min**	**Max**
Riffle Slope (S_{rif})	**0.0130**	**0.0110**	**0.0150**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.6250**	**1.3750**	**1.8750**
Run Slope (S_{run})	**0.0320**	**0.0140**	**0.0480**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**4.0000**	**1.7500**	**6.0000**
Pool Slope (S_p)	**0.0050**	**0.0030**	**0.0070**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.6250**	**0.3750**	**0.8750**
Glide Slope (S_g)	**0.0060**	**0.0060**	**0.0080**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.7500**	**0.7500**	**1.0000**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	**Mean**	**Min**	**Max**		**Dimensionless Depth Ratios**	**Mean**	**Min**	**Max**
Max Riffle Depth (d_{max})	**1.100**			ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.803**		
Max Run Depth (d_{maxr})	**1.100**			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**1.803**		
Max Pool Depth (d_{maxp})	**1.490**			ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.443**		
Max Glide Depth (d_{maxg})	**1.000**			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.639**		
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	**Riffle**[c]	**Bar**		**Reach**[b]	**Riffle**[c]	**Bar**	**Protrusion Height**[d]	
% Silt/Clay	**8.91**	**12.15**	**0**	D_{16}	**0.1**	**0.1**	**0.0**		mm
% Sand	**29.7**	**22.43**	**36.04**	D_{35}	**1.6**	**2.1**	**0.0**		mm
% Gravel	**61.39**	**65.42**	**63.96**	D_{50}	**5.5**	**4.1**	**3.3**		mm
% Cobble				D_{84}	**13.4**	**9.8**	**10.6**		mm
% Boulder				D_{95}	**17.0**	**14.4**	**18.3**		mm
% Bedrock				D_{100}	**22.6**	**22.6**	**23.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, E4 Good HWD Reach**

Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/23/2010**

Existing species composition: **Willow, Thistle, Carex Juncus, Toad Flax, Grasses**

Potential species composition: **Same as Existing Composition**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**85%**	**30%**	**Willow**	**60%**
				Carex	**20%**
				Juncus	**20%**
					100%
2. Understory	Shrub layer	▨	**20%**	**Willow**	**60%**
				Carex	**18%**
				Juncus	**18%**
				Water Hemlock	**5%**
					100%
3. Ground level	Herbaceous	▨	**45%**	**Annual Grasses**	**50%**
				Brome	**40%**
				Thistle	**10%**
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**0%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Needs invasive weed control

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, E4 Good HWD** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, E4 Good HWD Reach**
Location: **Pike National Forest, Colorado**
Observers: **K. Wright & B. Kasun**
Date: **8/23/2010**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

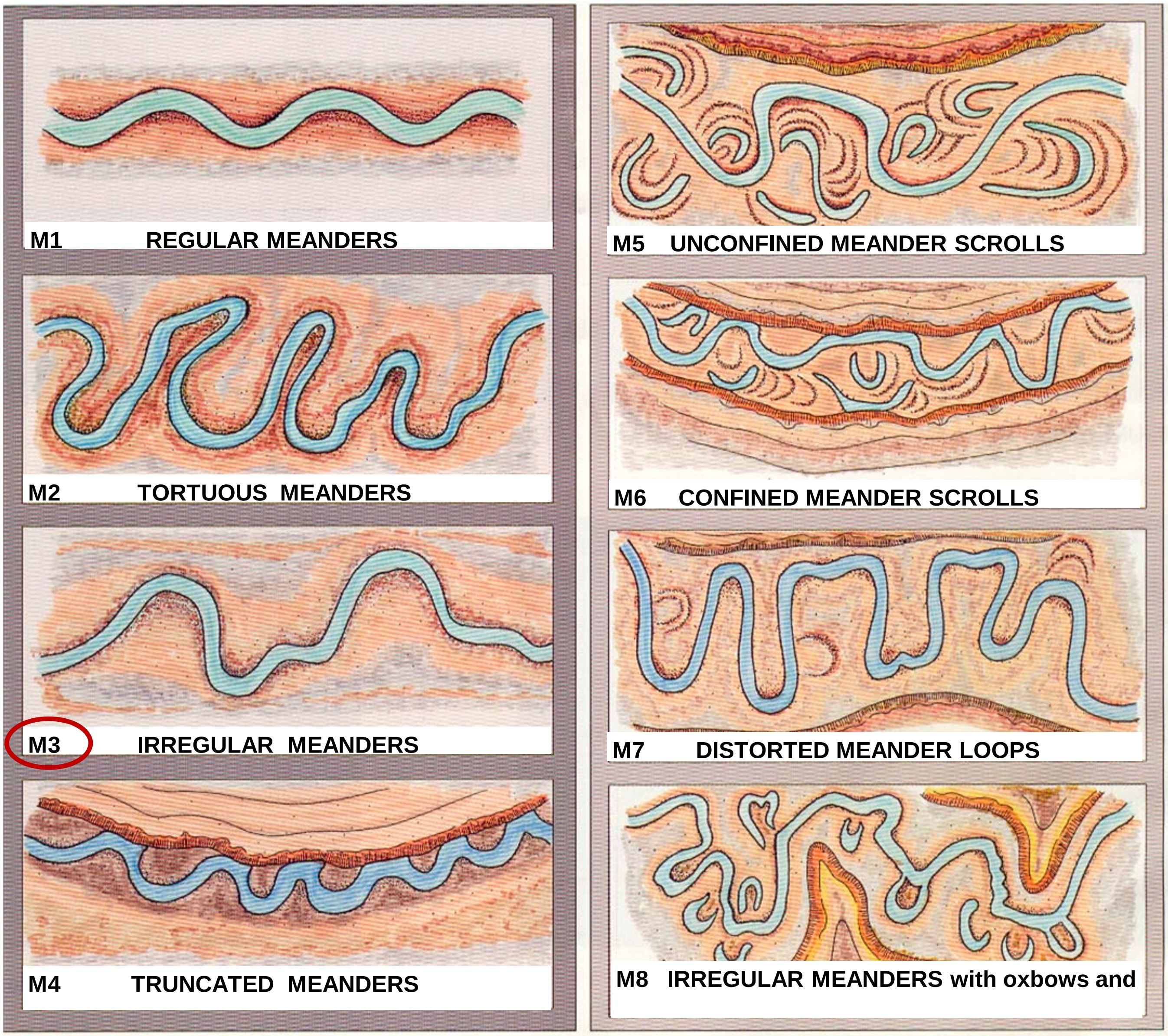
Meander Patterns

Stream: **Trail Creek, E4 Good HWD Reach** Location: **Pike National Forest, CO**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

List ALL CATEGORIES that APPLY ☞	M3				

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



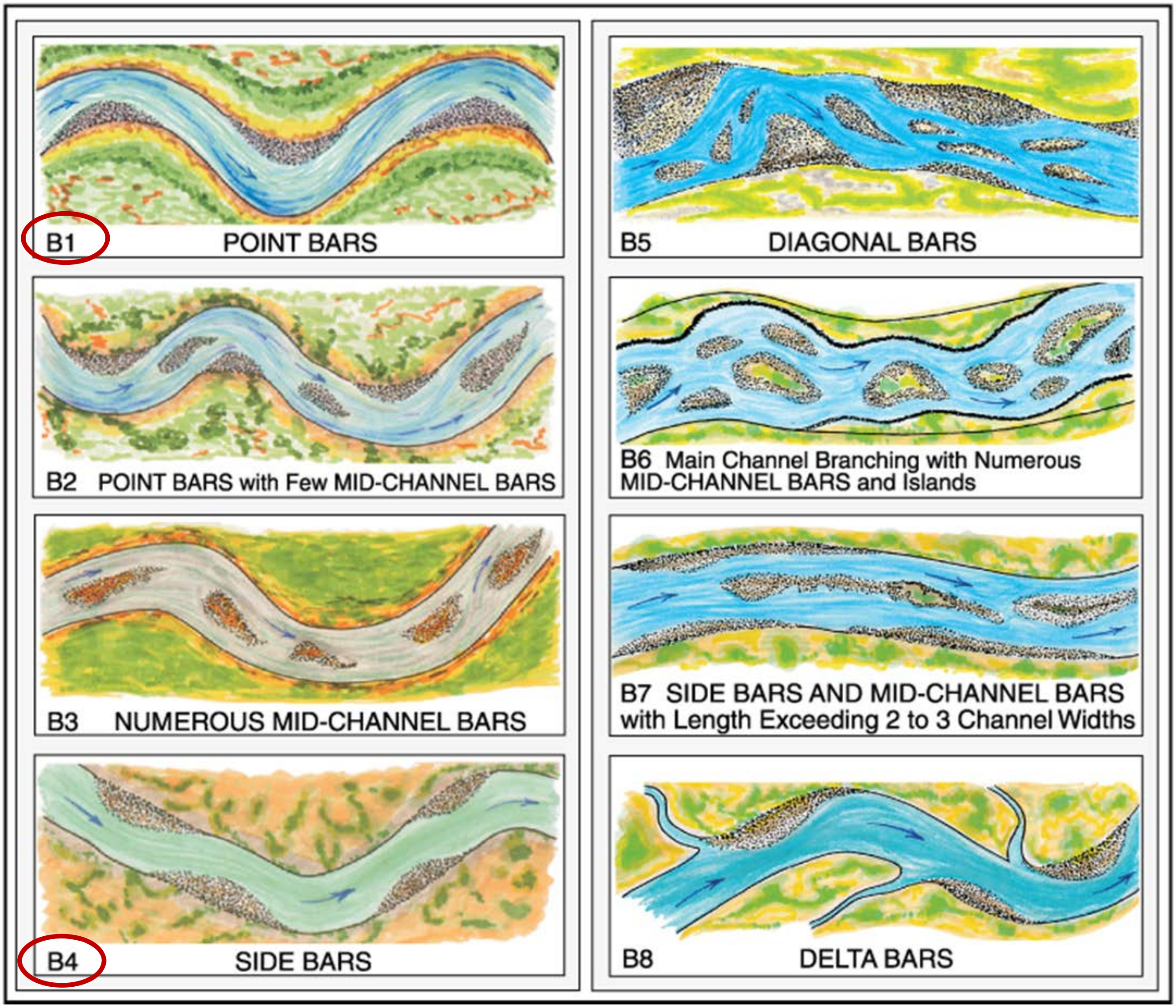
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**Trail Creek, E4 Good HWD Reach**	Location:	**Pike National Forest, Colorado**
Observers:	**K. Wright & B. Kasun**	Date:	**8/23/2010**

List ALL CATEGORIES that APPLY ☞	**B1**	**B4**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, E4 Good HWD Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

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 5-12. Degree of channel incision.

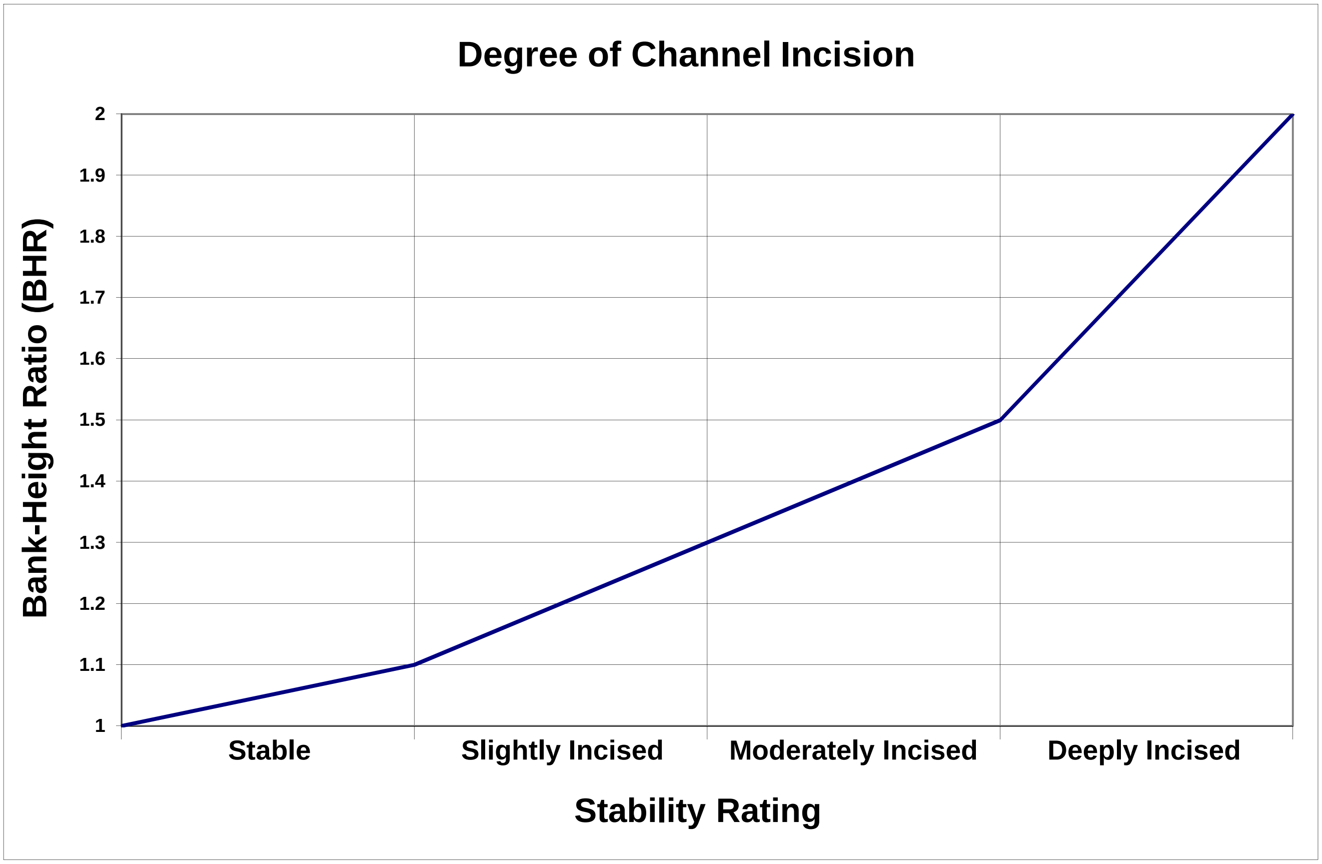
Degree of Channel Incision

Low Bank Height: **1.1**

Max Bankfull Depth: **1.1**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

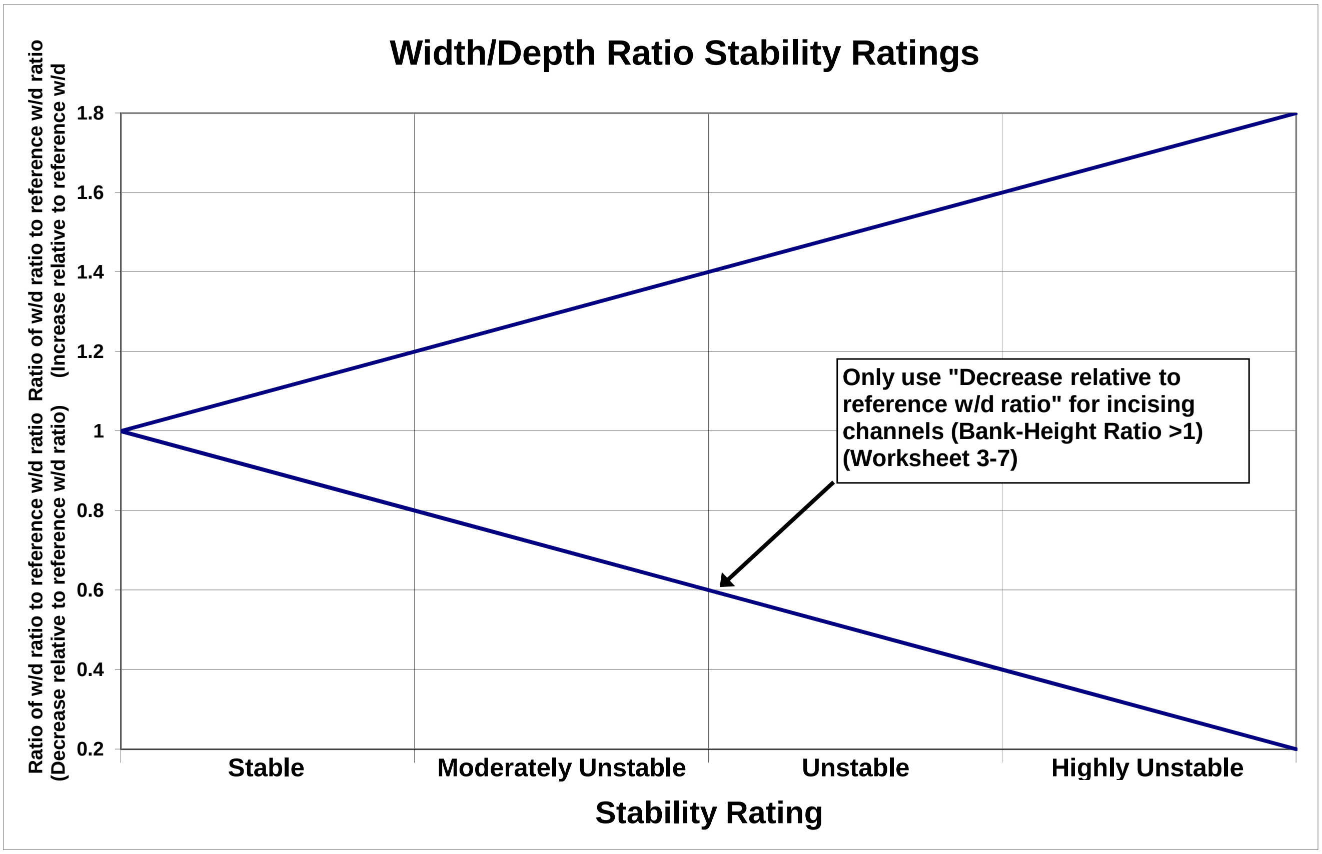
Width/Depth Ratio State

Existing Width/Depth Ratio: **9.72**

Reference Width/Depth Ratio: **7.8**

Ratio of existing W/d to reference W/d: **1.25**

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



Width/Depth Ratio Stability Ratings

Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

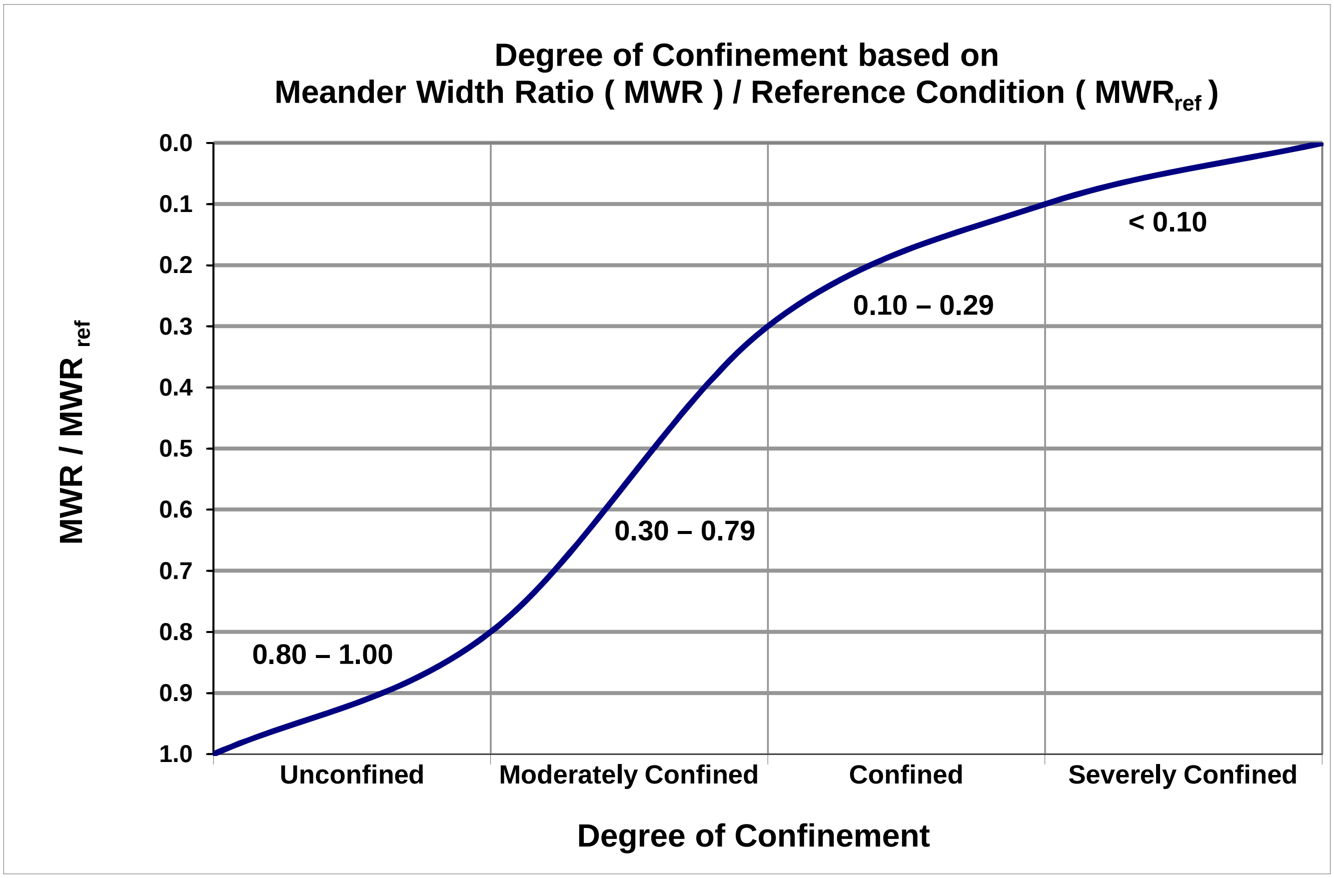
Degree of Confinement

Existing Meander Width Ratio (MWR): **3.86**

Reference Meander Width Ratio (MWR_{ref}): **3.33**

Ratio of MWR to MWR_{ref}: **1.16**

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, E4 Good HWD Reach **Location: Pike National Forest, CO** **Valley Type: X** **Observers: K. Wright & B. Kasun** **Date: 8/23/2010**

Location	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	[✓ 2]	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	[✓ 3]	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	[✓ 3]	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 2]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	[✓ 5]	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	[✓ 4]	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	[✓ 7]	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	[✓ 4]	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	[✓ 6]	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	[✓ 3]	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	**32**	**Good total =**	**2**	**Fair total =**	**10**	**Poor total =**	**12**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	[✓ **E4**]	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**56**
Existing stream type =	**E4**
***Potential stream type =**	**E4**
Modified channel stability rating =	**Good**

*Rating is adjusted to potential stream type, not existing.

BANCS Model − Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, E4 Good HWD Reach** Location: **Pike National Forest, Colorado**

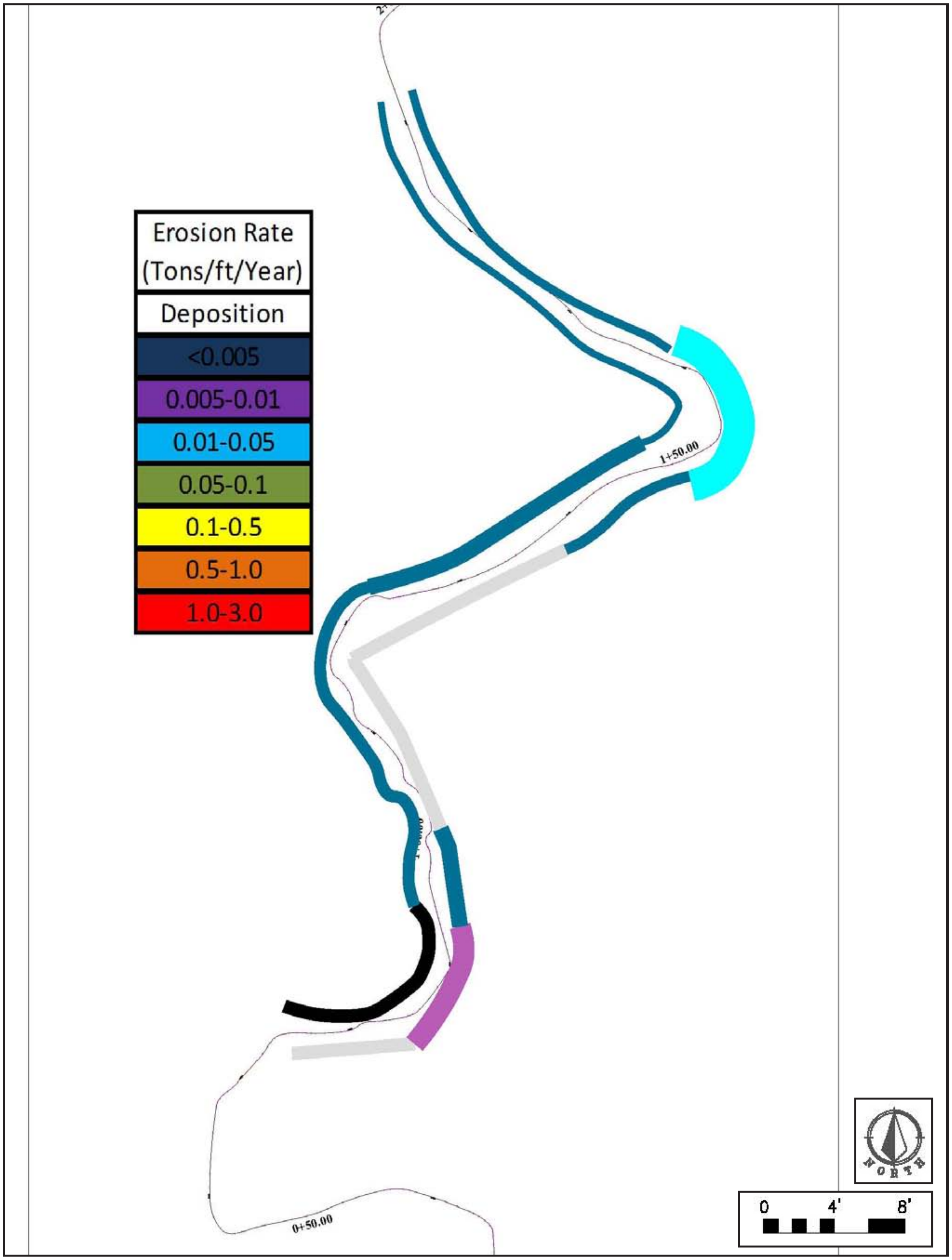
Graph Used: **Colorado** Total Stream Length (ft): **90** Date: **8/23/2010**

Observers: **K. Wright & B. Kasun** Valley Type: **X** Stream Type: **E4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **O+08 - 0+16 RB**	**Low**	**High**	**0.15505**	**8.0**	**1.6**	**1.98**	**0.01194**
2. **0+16 - 0+26 RB**	**Low**	**Moderate**	**0.07435**	**10.0**	**1.2**	**0.89**	**0.00430**
3. **0+17-0+35 LB**	**Low**	**Low**	**0.03566**	**18.0**	**0.9**	**0.58**	**0.00155**
4. **0+35-0+45 LB**	**Low**	**Moderate**	**0.07435**	**10.0**	**0.9**	**0.67**	**0.00322**
5. **0+62-0+69 RB**	**Low**	**Low**	**0.03566**	**7.0**	**0.8**	**0.20**	**0.00137**
6. **0+45 - 0+69 LB**	**Very Low**	**High**	**0.02130**	**1.0**	**1.2**	**0.03**	**0.00123**
7. **0+69 - 0+77 RB**	**Moderate**	**High**	**0.42031**	**8.0**	**2.4**	**8.07**	**0.04857**
8 **0+69 - 0+90 LB**	**Low**	**Low**	**0.03566**	**21.0**	**0.5**	**0.37**	**0.00086**
9 **0+77 - 0+90 RB**	**Low**	**Low**	**0.03566**	**13.0**	**0.6**	**0.28**	**0.00103**
10							
11							
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	**Total Erosion (ft^3/yr)**	**13.07**
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	**Total Erosion (yds^3/yr)**	**0.48**
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	**Total Erosion (tons/yr)**	**0.63**
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	**Total Erosion (tons/yr/ft)**	**0.0070**

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	12.6	0.0148	16.998
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	32.0													
0.10%	27.5	0.05%	0.09%	0.34	29.8	2.363	7.461	10.19	6.670	9.40	10.2	3.50	3.22	6.72
0.25%	23.8	0.08%	0.15%	0.55	25.7	2.036	5.232	6.16	4.809	6.78	14.0	3.37	3.71	7.08
0.50%	20.6	0.13%	0.25%	0.91	22.2	1.761	3.706	3.77	3.494	4.92	20.2	3.44	4.49	7.93
0.75%	17.6	0.13%	0.25%	0.91	19.1	1.513	2.592	2.27	2.502	3.53	17.4	2.07	3.22	5.29
1%	15.2	0.13%	0.25%	0.91	16.4	1.300	1.817	1.37	1.790	2.52	14.9	1.25	2.30	3.55
1.5%	13.0	0.25%	0.50%	1.83	14.1	1.120	1.289	0.84	1.289	1.82	25.8	1.52	3.31	4.84
2%	10.9	0.25%	0.50%	1.83	12.0	0.949	0.886	0.49	0.893	1.26	21.8	0.89	2.30	3.18
3%	9.2	0.50%	1.00%	3.65	10.0	0.795	0.600	0.28	0.602	0.85	36.6	1.01	3.09	4.10
4%	7.8	0.50%	1.00%	3.65	8.5	0.674	0.424	0.17	0.415	0.59	31.0	0.60	2.14	2.74
5%	7.0	0.50%	1.00%	3.65	7.4	0.587	0.322	0.11	0.304	0.43	27.0	0.40	1.56	1.96
10%	4.4	2.50%	5.00%	18.25	5.7	0.450	0.200	0.05	0.165	0.23	103.5	0.95	4.24	5.19
20%	2.4	5.00%	10.00%	36.50	3.4	0.269	0.103	0.02	0.045	0.06	123.5	0.58	2.34	2.92
30%	1.6	5.00%	10.00%	36.50	2.0	0.158	0.075	0.01	0.006	0.01	72.6	0.25	0.33	0.58
40%	1.1	5.00%	10.00%	36.50	1.4	0.108	0.068	0.00	0.000	0.00	49.6	0.15	0.00	0.15
50%	0.9	5.00%	10.00%	36.50	1.0	0.079	0.066	0.00	0.000	0.00	36.3	0.11	0.00	0.11
60%	0.7	5.00%	10.00%	36.50	0.8	0.061	0.065	0.00	0.000	0.00	27.8	0.08	0.00	0.08
70%	0.5	5.00%	10.00%	36.50	0.6	0.047	0.064	0.00	0.000	0.00	21.8	0.06	0.00	0.06
80%	0.5	5.00%	10.00%	36.50	0.5	0.039	0.064	0.00	0.000	0.00	18.2	0.05	0.00	0.05
90%	0.3	5.00%	10.00%	36.50	0.4	0.032	0.064	0.00	0.000	0.00	14.5	0.04	0.00	0.04
100%	0.1	5.00%	10.00%	36.50	0.2	0.016	0.064	0.00	0.000	0.00	7.3	0.02	0.00	0.02
									Annual Totals:		694.2 (cfs) 1,376.9 (acre-ft)	20.4 (tons/yr)	36.3 (tons/yr)	56.6 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**12.6**	**0.0148**	**16.998**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**48.3**													
0.10%	**43.8**	**0.05%**	**0.09%**	**0.34**	**46.0**	**3.654**	**21.209**	**44.82**	**17.374**	**24.48**	**15.8**	**15.38**	**8.40**	**23.78**
0.25%	**40.1**	**0.08%**	**0.15%**	**0.55**	**41.9**	**3.327**	**16.937**	**32.59**	**14.144**	**19.93**	**23.0**	**17.84**	**10.91**	**28.75**
0.50%	**36.8**	**0.13%**	**0.25%**	**0.91**	**38.5**	**3.052**	**13.769**	**24.30**	**11.702**	**16.49**	**35.1**	**22.17**	**15.04**	**37.22**
0.75%	**33.8**	**0.13%**	**0.25%**	**0.91**	**35.3**	**2.804**	**11.241**	**18.23**	**9.718**	**13.69**	**32.2**	**16.63**	**12.49**	**29.13**
1%	**31.5**	**0.13%**	**0.25%**	**0.91**	**32.6**	**2.591**	**9.303**	**13.94**	**8.169**	**11.51**	**29.8**	**12.72**	**10.50**	**23.22**
1.5%	**29.1**	**0.25%**	**0.50%**	**1.83**	**30.3**	**2.403**	**7.764**	**10.79**	**6.919**	**9.75**	**55.2**	**19.69**	**17.79**	**37.48**
2%	**26.7**	**0.25%**	**0.50%**	**1.83**	**27.9**	**2.213**	**6.383**	**8.17**	**5.777**	**8.14**	**50.9**	**14.91**	**14.86**	**29.76**
3%	**25.0**	**0.50%**	**1.00%**	**3.65**	**25.8**	**2.050**	**5.319**	**6.31**	**4.883**	**6.88**	**94.3**	**23.01**	**25.11**	**48.12**
4%	**22.4**	**0.50%**	**1.00%**	**3.65**	**23.7**	**1.878**	**4.318**	**4.69**	**4.026**	**5.67**	**86.4**	**17.11**	**20.71**	**37.82**
5%	**19.7**	**0.50%**	**1.00%**	**3.65**	**21.0**	**1.671**	**3.274**	**3.16**	**3.113**	**4.39**	**76.8**	**11.54**	**16.01**	**27.55**
10%	**12.3**	**2.50%**	**5.00%**	**18.25**	**16.0**	**1.271**	**1.725**	**1.27**	**1.704**	**2.40**	**292.3**	**23.14**	**43.82**	**66.96**
20%	**3.8**	**5.00%**	**10.00%**	**36.50**	**8.0**	**0.637**	**0.378**	**0.14**	**0.366**	**0.52**	**293.0**	**5.09**	**18.81**	**23.90**
30%	**1.7**	**5.00%**	**10.00%**	**36.50**	**2.7**	**0.216**	**0.087**	**0.01**	**0.024**	**0.03**	**99.5**	**0.40**	**1.23**	**1.63**
40%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.4**	**0.112**	**0.068**	**0.00**	**0.000**	**0.00**	**51.3**	**0.16**	**0.00**	**0.16**
50%	**0.9**	**5.00%**	**10.00%**	**36.50**	**1.0**	**0.079**	**0.066**	**0.00**	**0.000**	**0.00**	**36.3**	**0.11**	**0.00**	**0.11**
60%	**0.7**	**5.00%**	**10.00%**	**36.50**	**0.8**	**0.061**	**0.065**	**0.00**	**0.000**	**0.00**	**27.8**	**0.08**	**0.00**	**0.08**
70%	**0.5**	**5.00%**	**10.00%**	**36.50**	**0.6**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**21.8**	**0.06**	**0.00**	**0.06**
80%	**0.5**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**18.2**	**0.05**	**0.00**	**0.05**
90%	**0.3**	**5.00%**	**10.00%**	**36.50**	**0.4**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**14.5**	**0.04**	**0.00**	**0.04**
100%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.2**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**7.3**	**0.02**	**0.00**	**0.02**
									Annual Totals:		**1,361.4** (cfs) **2,700.4** (acre-ft)	**200.2** (tons/yr)	**215.7** (tons/yr)	**415.9** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, E4 Good HWD Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8-23-2010**

Enter Required Information for Existing Condition

4.1	D_{50}	Riffle bed material D_{50} (mm)			
3.3	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.08	D_{max}	Largest particle from bar sample (ft)	**23**	**(mm)**	304.8 mm/ft
0.008	S	Existing bankfull water surface slope (ft/ft)			
0.52	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.24	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
5.65	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

0.260		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 **18**	CO **58**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **0.32**	CO **0.08**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.64**	CO **0.16**	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 **0.0099**	CO **0.0025**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, E4 Good HWD** Stream Type: **E4**

Location: **Pike National Forest, CO** Valley Type: **X**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**Stability Rating (Check Appropriate Rating)**
Stream Type at Potential, (C→E) E-C-Gc-F-C-E	☑ Stable
(E→C), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **Trail Creek, E4 Good HWD Reach** Stream Type: **E4**
Location: **Pike National Forest, Colorado** Valley Type: **X**
Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**4**
		(2)	**1.25** [✓ **(4)**]	**(6)**	**(8)**	
2	**Depositional Patterns (Worksheet 5-10)**	**B1**, B2	**B4**, B8	B3	B5, B6, B7	**2**
		(1)	**B1, B4** [✓ **(2)**]	**(3)**	**(4)**	
3	**Meander Patterns (Worksheet 5-9)**	M1, **M3**, M4		M2, M5, M6, M7, M8		**1**
		M3 [✓ **(1)**]		**(3)**		
4	**Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, **L/L**, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
		L/L [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5	**Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
		0.88 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
					Total Points	**10**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☑	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, E4 Good HWD Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/23/2010**

	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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope- slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
		[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2	**Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
		[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3	**W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**4**
		(2)	**1.3** [✓ **(4)**]	**(6)**	**(8)**	
4	**Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
		at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5	**Depositional Patterns (Worksheet 5-10)**	**B1**	B2, **B4**	B3, B5	B6, B7, B8	**2**
		(1)	**B1, B4** [✓ **(2)**]	**(3)**	**(4)**	
6	**Debris / Blockages (Worksheet 5-11)**	**D1**, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
		D1 [✓ **(1)**]	**(2)**	**(3)**	**(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 **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, E4 Good HWD Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/23/2010**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.16 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, E4 Good HWD Reach** Stream Type: **E4**
Location: **Pike National Forest, Colorado** Valley Type: **X**
Observers: **K. Wright & B. Kasun** Date: **8/23/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F)	2
	at potential [✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Lateral Stability (Worksheet 5-25)**	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	4
	(2)	**[✓ (4)]**	**(6)**	**(8)**	
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	2
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	2
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
				Total Points	**10**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, E4 Good HWD Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/23/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	1	2
	Mod. Unstable	[✓ 2]	
	Unstable	3	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	[✓ 1]	1
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	[✓ 1]	1
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	6

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	*Low* 5 ☐	*Moderate* 6 – 10 ☑	*High* 11 – 15 ☐	*Very High* 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, E4 Good HWD Reach**						Location:	**Pike National Forest, Colorado**				
Observers:	**K. Wright & B. Kasun**		Date:	**8/23/2010**			Stream Type:	**E4**		Valley Type:	**X**	
Channel Dimension (Riffle XS 1+13)	Mean Bankfull Depth (ft):	**0.61**	Bankfull Width (ft):	**5.93**	Cross-Sectional Area (ft^2):	**3.63**	Width of Flood-Prone Area (ft):	**32.23**	Entrenchment Ratio:	**5.44**		
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**5.99** **4.3-8.26**	L_m/W_{bkf}:	**8.03** **5.15-11.2**	R_c/W_{bkf}:	**1.25** **.75-1.75**	MWR:	**3.86** **2.75-5.33**	Sinuosity:	**1.46**	
River Profile & Bed Features	Check: ☑ Riffle/Pool		☐ Step/Pool		☐ Plane Bed		☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed			
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope			
		1.1	**1.49**		**1.8**	**2.4**		**3.56**	Valley:	**0.0117**	Water Surface:	**0.008**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:		Remarks: Condition, Vigor & Usage of Existing Reach:						
		Willow/Carex/Thistle/Grass		**Same but w/o invasives**		**Exc. Veg but needs invasvive weed control**						
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(3)**	Meander Patterns:	**M3**	Depositional Patterns:	**B1, B4**	Debris/Channel Blockages:	**D1**		
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**56 (Good)**						
	Width/depth Ratio (W/d):	**9.72**	Reference W/d Ratio (W/d$_{ref}$):	**7.8**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**1.25**	W/d Ratio State Stability Rating:	**Mod. Unstable**				
	Meander Width Ratio (MWR):	**3.86**	Reference MWR$_{ref}$:	**3.33**	Degree of confinement (MWR / MWR$_{ref}$):	**1.2**	MWR / MWR$_{ref}$ Stability Rating:	**Unconfined**				
Bank Erosion Summary	Length of Reach Studied (ft):	**90**	Annual Streambank Erosion Rate:			Curve Used:	Remarks:	**Excellent Riparian Vegetation**				
			0.63 (tons/yr)	**0.007** (tons/yr/ft)		**Colorado**						
Sediment Capacity (POWERSED)	☑ Sufficient Capacity		☐ Insufficient Capacity		☐ Excess Capacity		Remarks:					
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**23**	$\tau =$	**0.26**	$\tau^* =$	**N/A**	Existing Depth:	**0.55**	Required Depth:	**0.16-0.64**	Existing Slope: **0.008**	Required Slope: **.003-0.01**
Successional Stage Shift	**E** → **C** → **Gc** → **F** → **C** → [✓ **E**]						Existing Stream State (Type):	**E4**	Potential Stream State (Type):	**E4**		
Lateral Stability	☐ *Stable*	☑ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**High Width/Depth Ratio**						
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:							
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:							
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:							
Sediment Supply (Channel Source)	☐ *Low*	☑ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:	**Mod. b/c of High W/d, but has excellent vegetation & trending toward low W/d E**						

Appendix C10

F4 Stream Type

Fair Stability Reach

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Appendix C10: F4 Fair Stability Reach

F4 Fair Reach Location & Overview

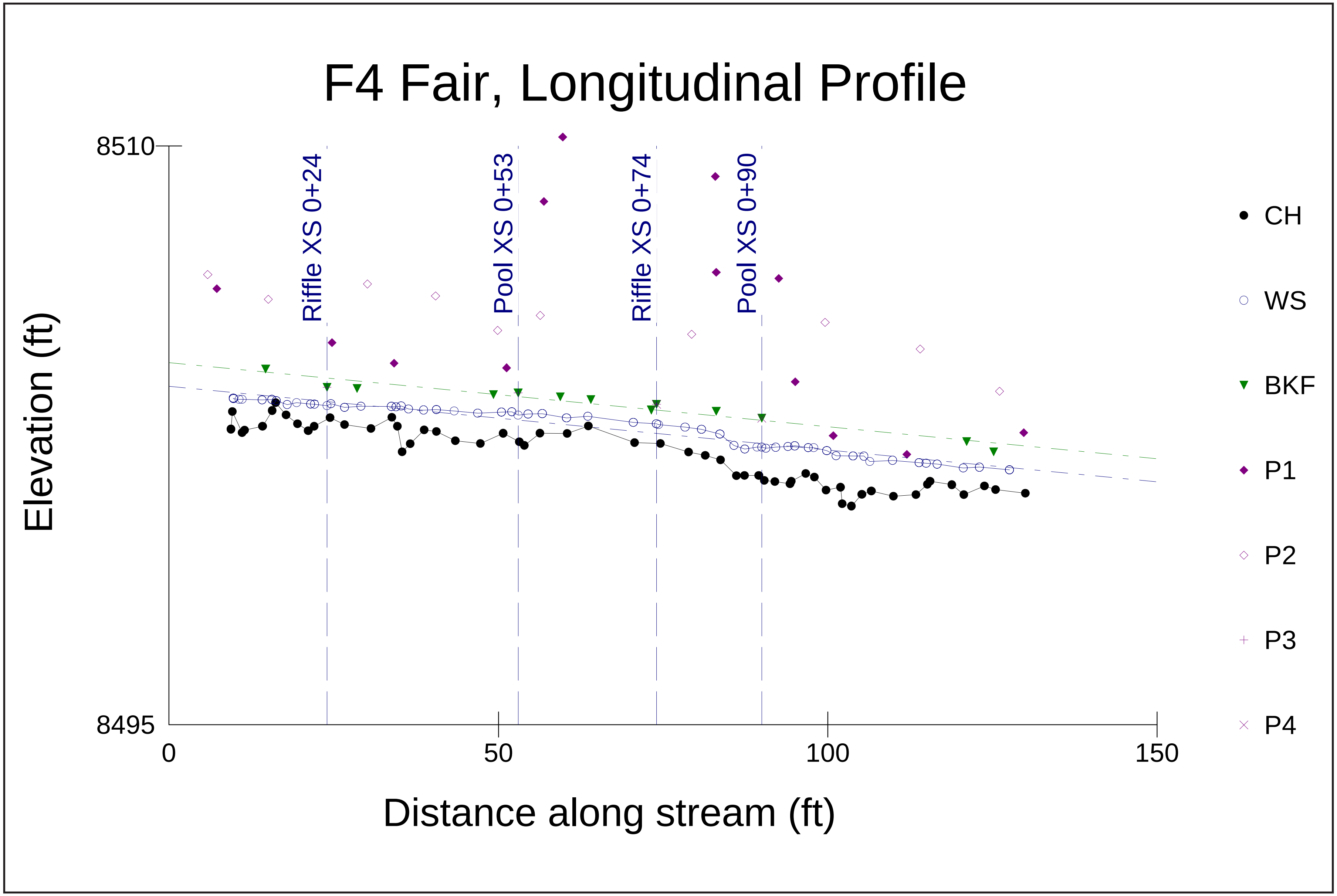
The F4 Fair representative reach is a recovering, perennial, entrenched stream located in the mainstem of West Monument Creek (**Figure C-1**). This reach is in a terraced alluvial Valley Type VIIIb, on a 4th order stream. The width/depth ratio of *14* is relatively low for an F4 stream type. The reach is near a road, which is influencing streambank erosion. The streamflow is seasonal by snowmelt and stormflow runoff. Flow is regulated by an upstream dam and will experience increased peak flows due to Waldo Canyon Fire.

A POWERSED run was made to determine streambed stability, which predicted deposition. The channel has a predicted *Moderate Increase* in channel enlargement, and a *High* overall sediment supply. The reach has a unit erosion rate of *0.0589 tons/yr/ft*.

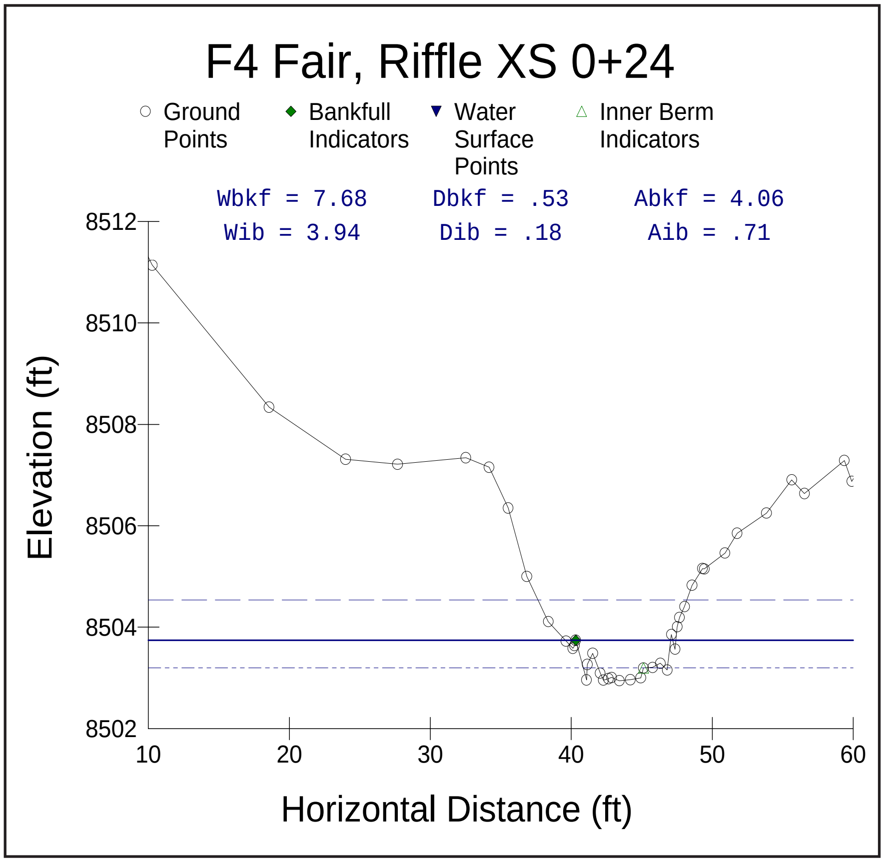
The WRENSS model indicated that the water yield due to the fire increased from *2,460 acre-ft to 3,283.5 acre-ft*, representing a total increase of *823.5 acre-ft per year*. The corresponding bedload increased from *9.1 tons/year to 19.3 tons/yr*, and suspended sediment increased from *39.9 tons/yr to 78.0 tons/yr*, representing a total increase in sediment of *48.3 tons/yr*. This sediment yield reflects increases due to the increased flows, even in a moderately unstable reach.

The photograph depicts the typical character of this representative F4 Fair stream type. The following graphs and summary worksheets provide the details of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall “Fair” rating.

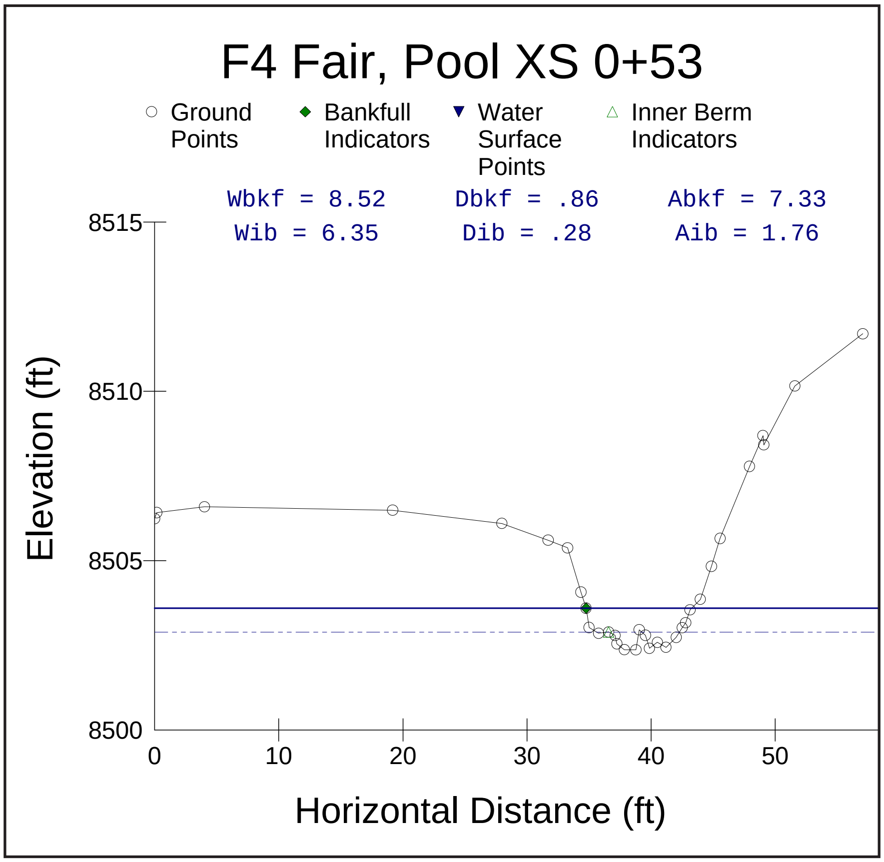
Survey Summary



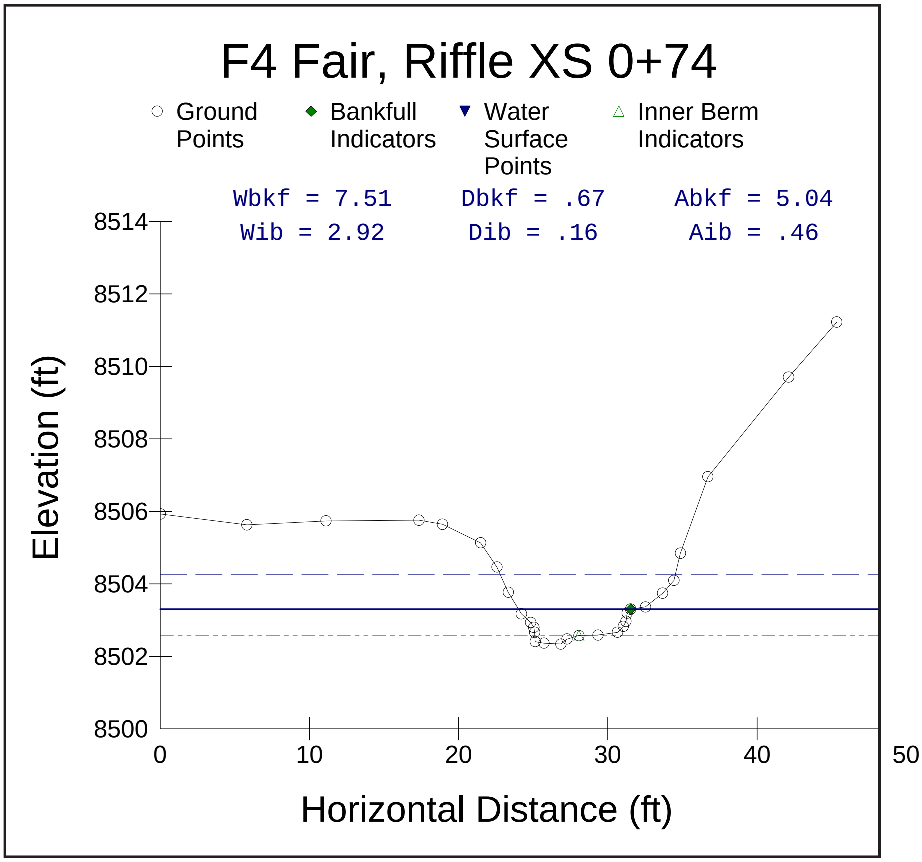
Longitudinal Profile (graph generated from RIVERMorph^{TM})



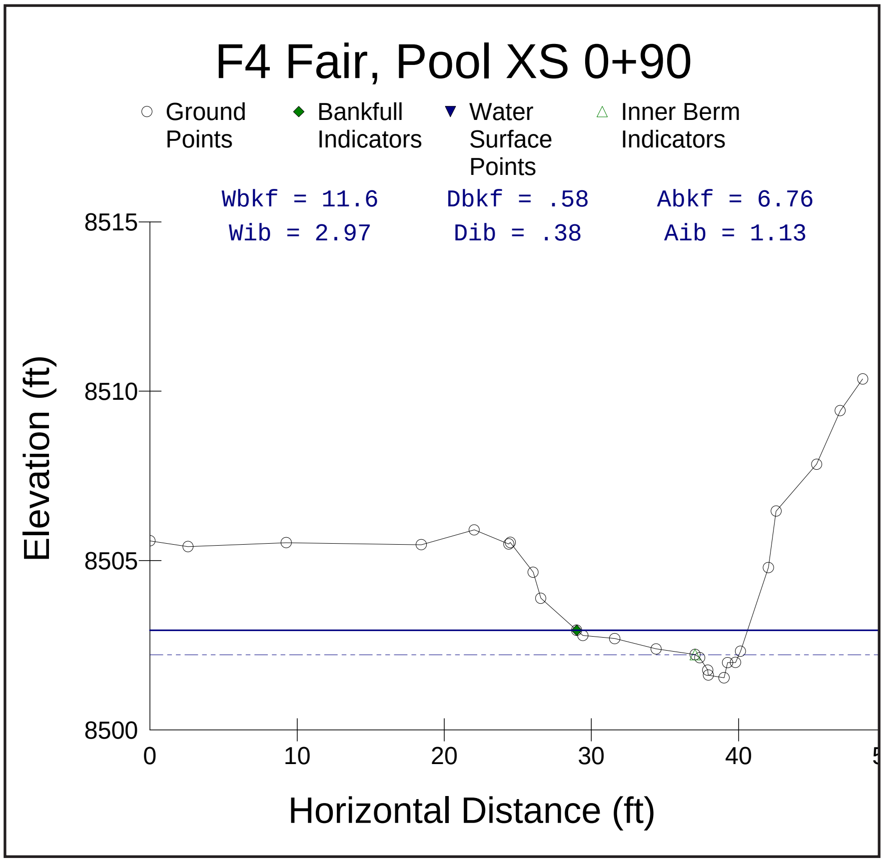
Representative Cross-section 0+24 (graph generated from RIVERMorph^{TM})



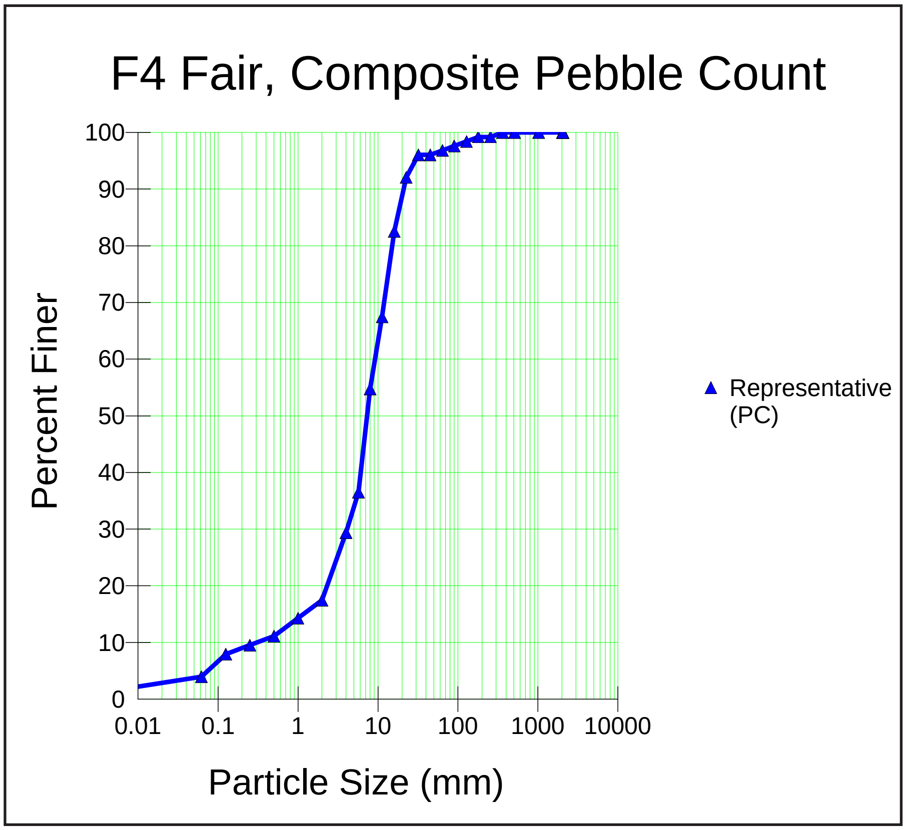
Cross-section 0+53 (graph generated from RIVERMorph^{TM})



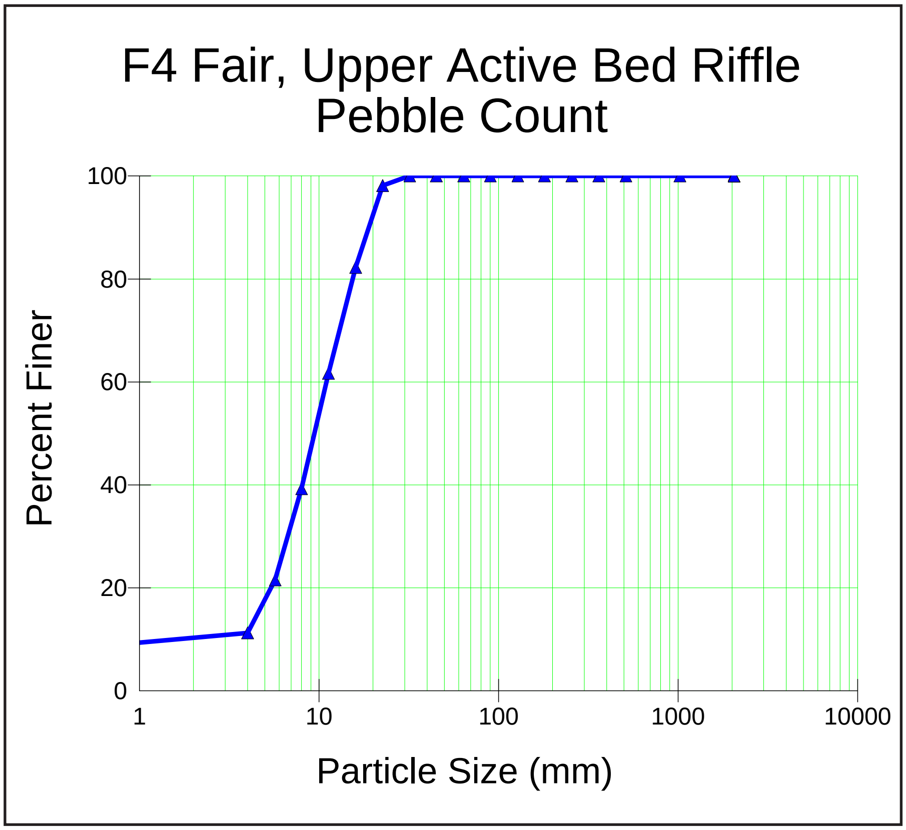
Cross-section 0+74 (graph generated from RIVERMorph^{TM})



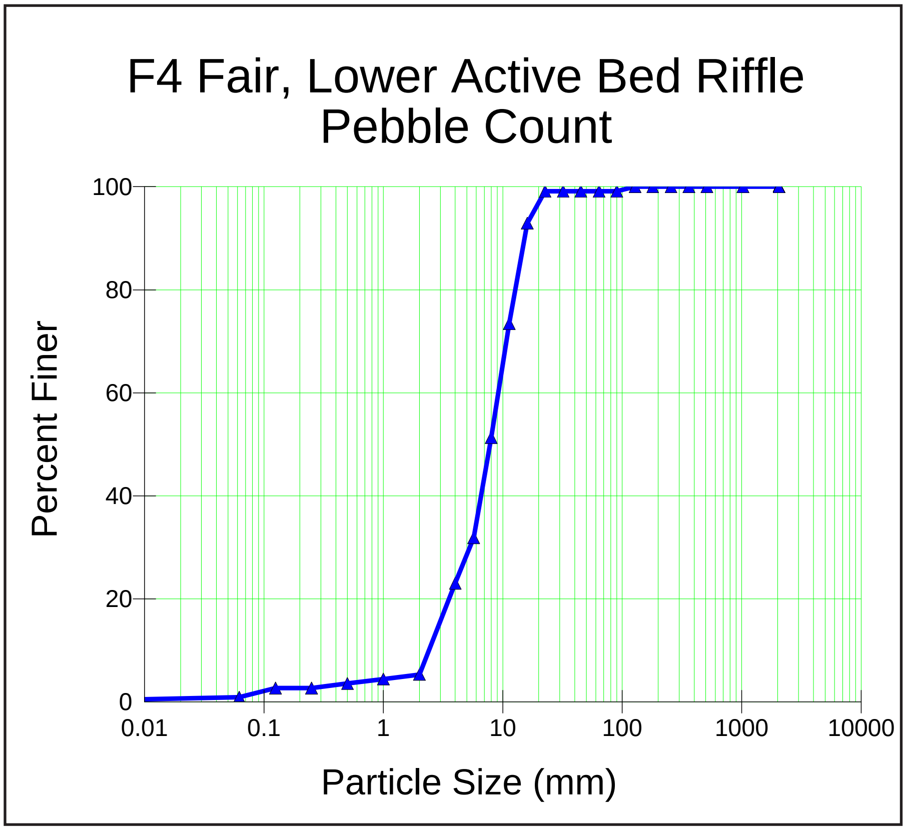
Cross-section 0+90 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph™)



Upper Active Bed Riffle Pebble Count (graph generated from RIVERMorph™)



Lower Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**West Monument F4 Fair**	Location:	**Pike National Forest, Colorado**
Date:	**11/5/2012** Stream Type: **F4**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	HUC:	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	4.06	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.53	d_{bkf} (ft)
Bankfull Riffle WIDTH	7.7	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	8.74	W_p (ft)
D_{84} at Riffle	13.9	Dia. (mm)	D_{84} (mm) / 304.8	0.05	D_{84} (ft)
Bankfull SLOPE	0.009	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.46	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	10.22	R / D_{84}
Drainage Area	10.88	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	0.365	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * \text{Log}\{R / D_{84}\}] u^*$	2.97	ft / sec	12.06	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ 0.037	2.18	ft / sec	8.85	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ 0.05	1.62	ft / sec	6.58	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ 0.074	1.09	ft / sec	4.43	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	3.49	ft / sec	14.2	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **West Monument F4 Fair**

Basin: Drainage Area: **6963** acres **10.88** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+24** Date: **11/05/2012**

Observers: **Rosgen et. al.** Valley Type: **VIIIb**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**7.68**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.53**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**4.06**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**14.49**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.8**	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.	**10.56**	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 median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**7.4**	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.	**0.0165**	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 (S_{val} / S).	**1.09**	

Stream Type **F4** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument F4 Fair** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/05/12** Valley Type: **VIIIb** Stream Type: **F4**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**7.7**	**7.5**	**7.7**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**4.1**	**4.1**	**5.0**
Mean Riffle Depth (d_{bkf})	**0.53**	**0.53**	**0.67**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**12.9**	**11.2**	**14.5**
Maximum Riffle Depth (d_{max})	**0.88**	**0.80**	**0.96**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.660**	**1.509**	**1.811**
Width of Flood-Prone Area (W_{fpa})	**11.2**	**10.6**	**11.9**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.5**	**1.4**	**1.6**
Riffle Inner Berm Width (W_{ib})	**3.4**	**2.9**	**3.9**	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	**0.447**	**0.380**	**0.513**
Riffle Inner Berm Depth (d_{ib})	**0.17**	**0.16**	**0.18**	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	**0.321**	**0.302**	**0.340**
Riffle Inner Berm Area (A_{ib})	**0.6**	**0.5**	**0.7**	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	**0.133**	**0.092**	**0.174**
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	**20.2**	**18.5**	**21.9**					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	**10.1**	**8.5**	**11.6**	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	**1.315**	**1.109**	**1.510**
Mean Pool Depth (d_{bkfp})	**0.72**	**0.58**	**0.86**	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	**1.358**	**1.094**	**1.623**
Pool Cross-Sectional Area (A_{bkfp})	**7.1**	**6.8**	**7.3**	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	**1.736**	**1.665**	**1.805**
Maximum Pool Depth (d_{maxp})	**1.32**	**1.23**	**1.40**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.491**	**2.321**	**2.642**
Pool Inner Berm Width (W_{ibp})	**4.7**	**3.0**	**6.4**	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	**0.461**	**0.294**	**0.629**
Pool Inner Berm Depth (d_{ibp})	**0.33**	**0.28**	**0.38**	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	**0.458**	**0.389**	**0.528**
Pool Inner Berm Area (A_{ibp})	**1.5**	**1.1**	**1.8**	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	**0.206**	**0.160**	**0.250**
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument F4 Fair** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/5/2012** Valley Type: **VIIIb** Stream Type: **F4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**2.18**	ft/sec	Estimation Method	**Roughness Coefficient**
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**8.85**	cfs	Drainage Area	**10.88** mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**53.1**	**50.9**	**55.2**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**6.91**	**6.63**	**7.19**
Stream Meander Length (L_m)	**60.5**	**56.0**	**65.0**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**7.88**	**7.29**	**8.46**
Radius of Curvature (R_c)	**12.3**	**8.8**	**25.0**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**1.60**	**1.15**	**3.26**
Belt Width (W_{blt})	**26.4**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**3.44**		
Arc Length (L_a)	**12.8**	**6.2**	**15.0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**1.67**	**0.81**	**1.95**
Riffle Length (L_r)	**3.4**	**0.8**	**6.5**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.45**	**0.11**	**0.85**
Individual Pool Length (L_p)	**8.8**	**4.3**	**20.2**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.15**	**0.55**	**2.63**
Pool to Pool Spacing (P_s)	**18.6**	**9.3**	**47.1**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**2.42**	**1.21**	**6.13**

Channel Profile

Valley Slope (S_{val})	**0.0180**	ft/ft	Average Water Surface Slope (S)	**0.0165**	ft/ft	Sinuosity (S_{val} / S)	**1.09**
Stream Length (SL)	**131.0**	ft	Valley Length (VL)	**120.6**	ft	Sinuosity (SL / VL)	**1.09**

Low Bank Height (LBH)	start	**2.00** ft	Max Bankfull Depth (d_{max})	start	**0.90** ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**2.2**
	end	**3.00** ft		end	**1.12** ft		end	**2.7**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0240**	**0.0120**	**0.0460**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.4545**	**0.7273**	**2.7879**
Run Slope (S_{run})	**0.0910**	**0.0640**	**0.1380**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**5.515**	**3.8788**	**8.364**
Pool Slope (S_p)	**0.0040**	**0.0010**	**0.0060**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.2424**	**0.0606**	**0.3636**
Glide Slope (S_g)	**0.0120**	**0.0090**	**0.0190**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.7273**	**0.5455**	**1.1515**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.08**	**0.89**	**1.31**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.038**	**1.679**	**2.472**
Max Run Depth (d_{maxr})	**1.10**	**0.67**	**1.49**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**2.075**	**1.264**	**2.811**
Max Pool Depth (d_{maxp})	**1.43**	**1.04**	**1.92**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.698**	**1.962**	**3.623**
Max Glide Depth (d_{maxg})	**0.87**	**0.51**	**1.28**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.642**	**0.962**	**2.415**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**3.97**	**0.00**		D_{16}	**1.54**	**4.79**			mm
% Sand	**13.49**	**0.00**		D_{35}	**2.34**	**7.45**			mm
% Gravel	**79.37**	**100.00**		D_{50}	**7.40**	**9.58**			mm
% Cobble	**2.38**	**0.00**		D_{84}	**17.01**	**16.73**			mm
% Boulder	**0.79**	**0.00**		D_{95}	**29.56**	**21.30**			mm
% Bedrock	**0.00**	**0.00**		D_{100}	**361.99**	**32.00**			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **West Monument F4 Fair**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen et. al.**
Reference reach ☐
Disturbed (impacted reach) ☒
Date: **11/05/2012**
Existing species composition: **Willow/Aspen dominated**
Potential species composition: **At potential**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**3%**	**10%**	**Ponderosa**	**3%**
				Blue Spruce	**3%**
				Aspen	**94%**
					0%
					0%
					0%
					100%
2. Understory	Shrub layer	▨	**80%**	**Willows**	**90%**
				Chokecherry	**3%**
				Rocky Mountain Maple	**2%**
				Rose	**5%**
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	**2%**	**Grass**	**70%**
				Forbs	**30%**
					0%
					0%
					0%
					0%
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**3%**		
			Column Total = 100%		

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

Remarks:
Condition, vigor and/or usage of existing reach:
Bare ground under shaded canopy

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **West Monument F4 Fair** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/5/2012**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P7**	**P8**				

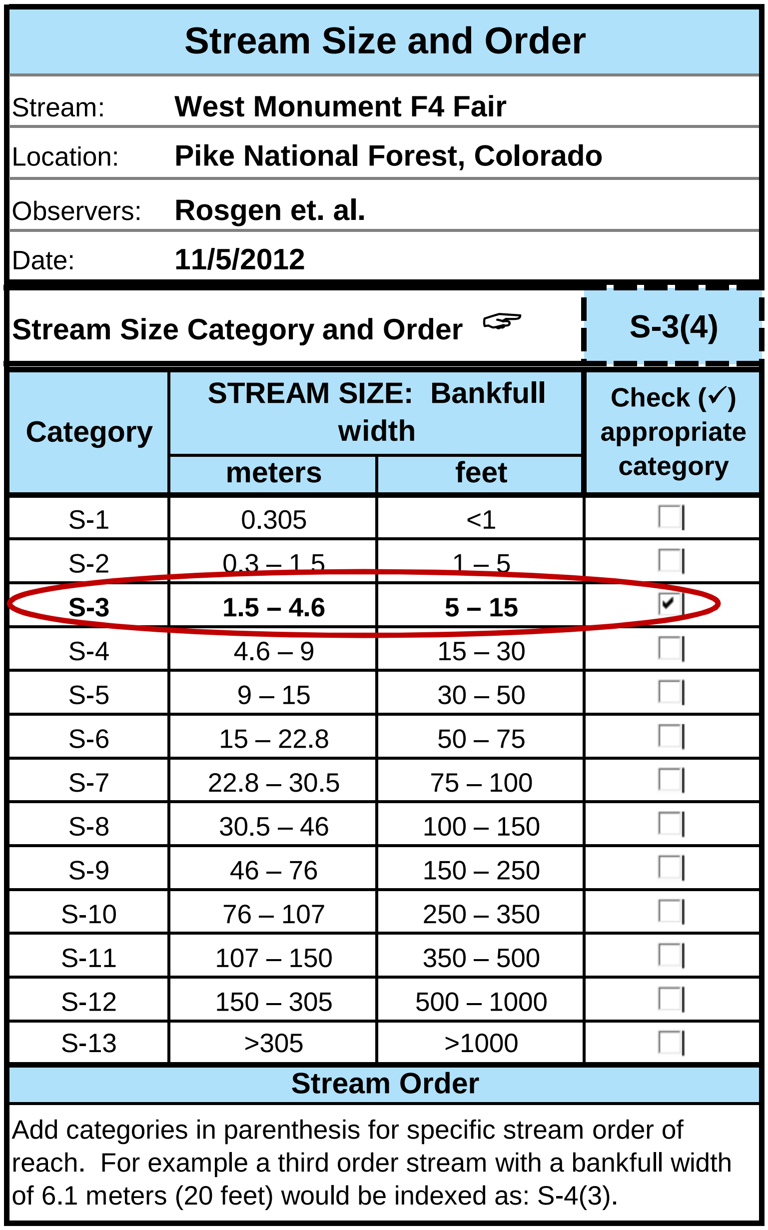
General Category

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 5-8. Stream order & stream size.



Stream Size and Order

Stream: **West Monument F4 Fair**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen et. al.**
Date: **11/5/2012**

Stream Size Category and Order ☞ **S-3(4)**

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 5-9. Meander patterns.

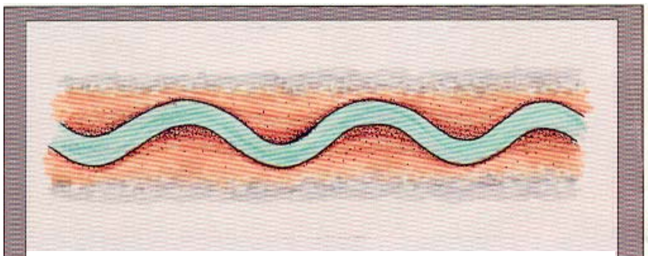
Meander Patterns

Stream: **West Monument F4 Fair** Location: **Pike National Forest, CO**

Observers: **Rosgen et. al.** Date: **11/5/2012**

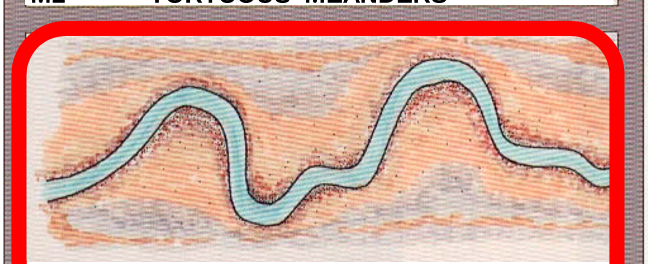
List ALL CATEGORIES that APPLY ☞	**M3**				

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

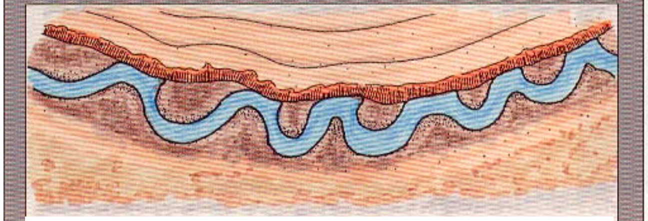


M1 REGULAR MEANDERS

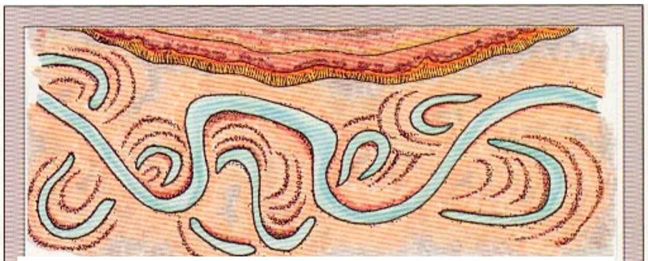
M2 TORTUOUS MEANDERS



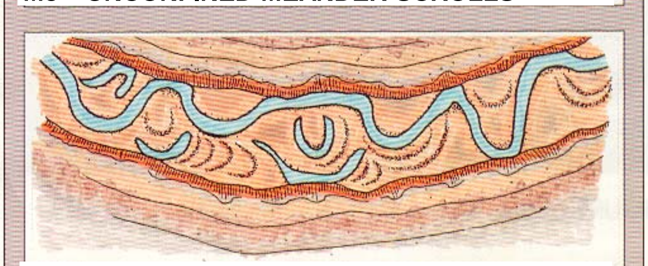
M3 IRREGULAR MEANDERS



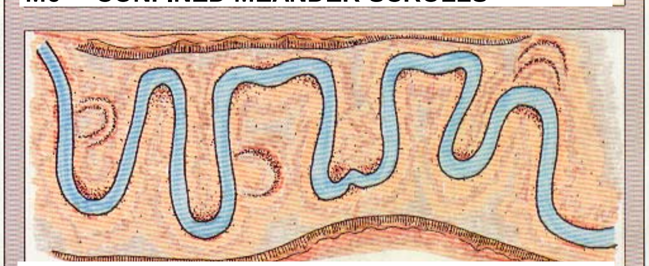
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and oxbow cutoffs

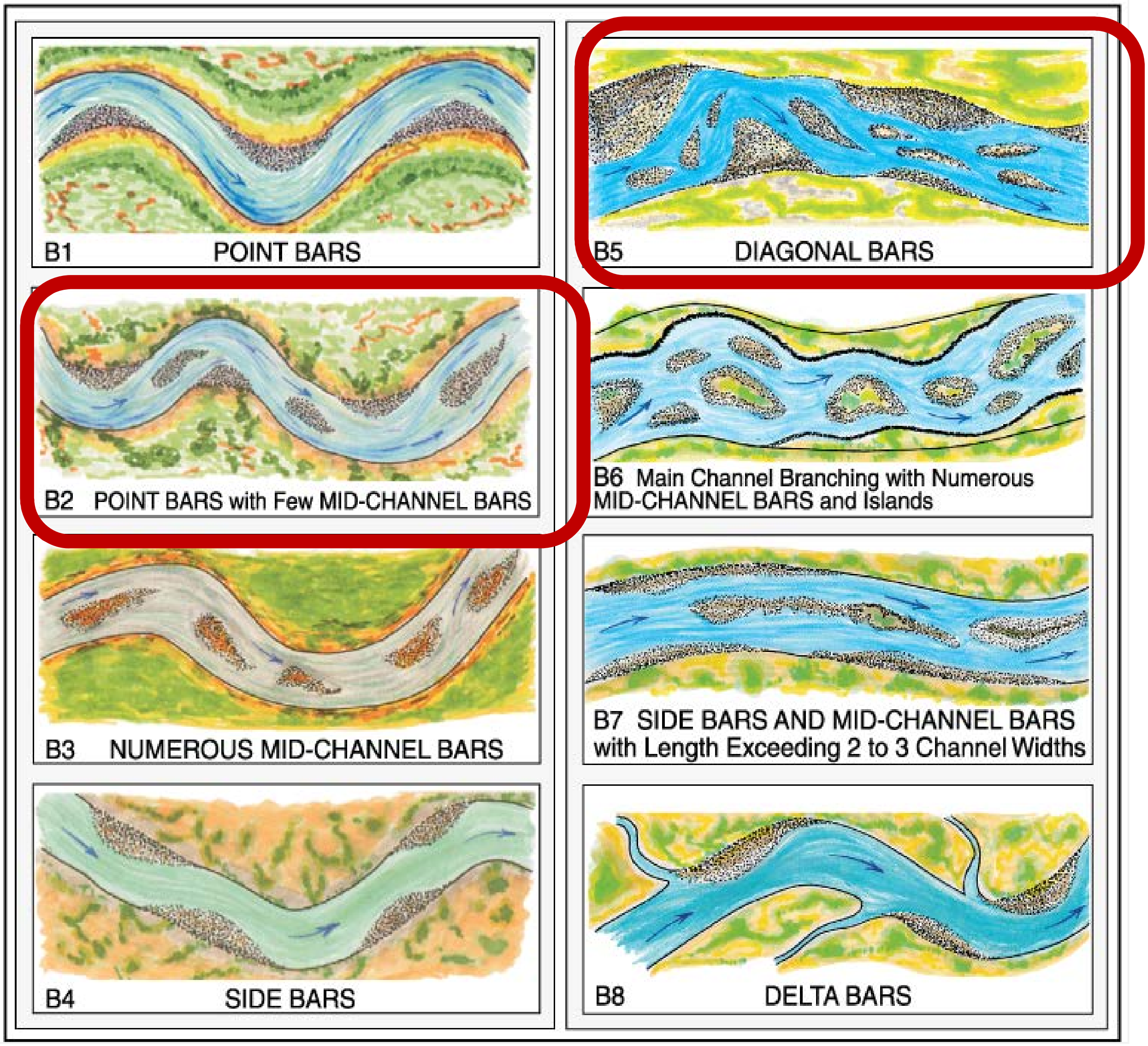
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**West Monument F4 Fair**	Location:	**Pike National Forest, Colorado**
Observers:	**Rosgen et. al.**	Date:	**11/5/2012**

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

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



Worksheet 5-11. Channel blockages.

Channel Blockages		
Stream: **West Monument F4 Fair**	Location: **Pike National Forest, Colorado**	
Observers: **Rosgen et. al.**	Date: **11/5/2012**	
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 5-12. Degree of channel incision.

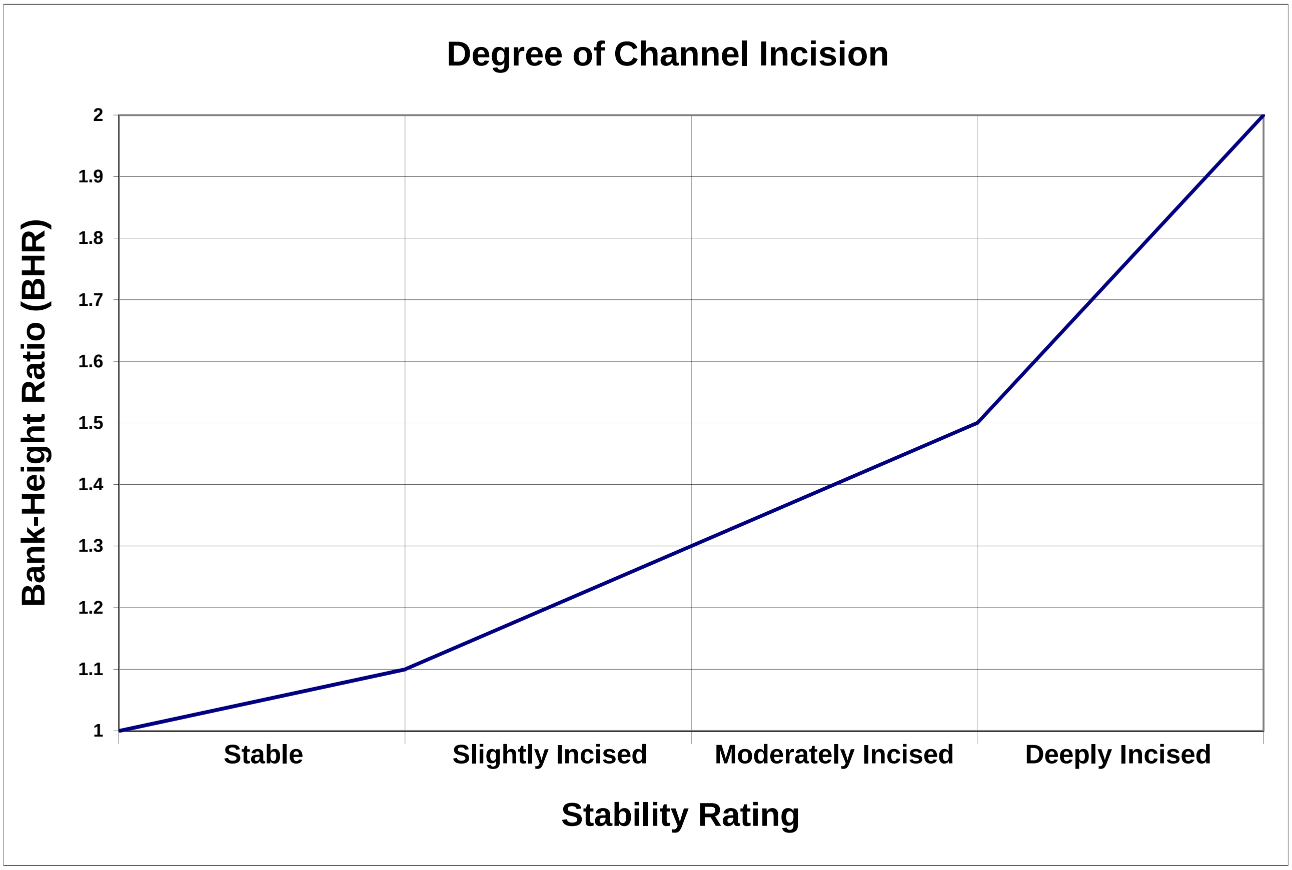
Degree of Channel Incision

Low Bank Height: **2**

Max Bankfull Depth: **0.9**

Bank-Height Ratio: **2.2**

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



Worksheet 5-13. Width/depth ratio state.

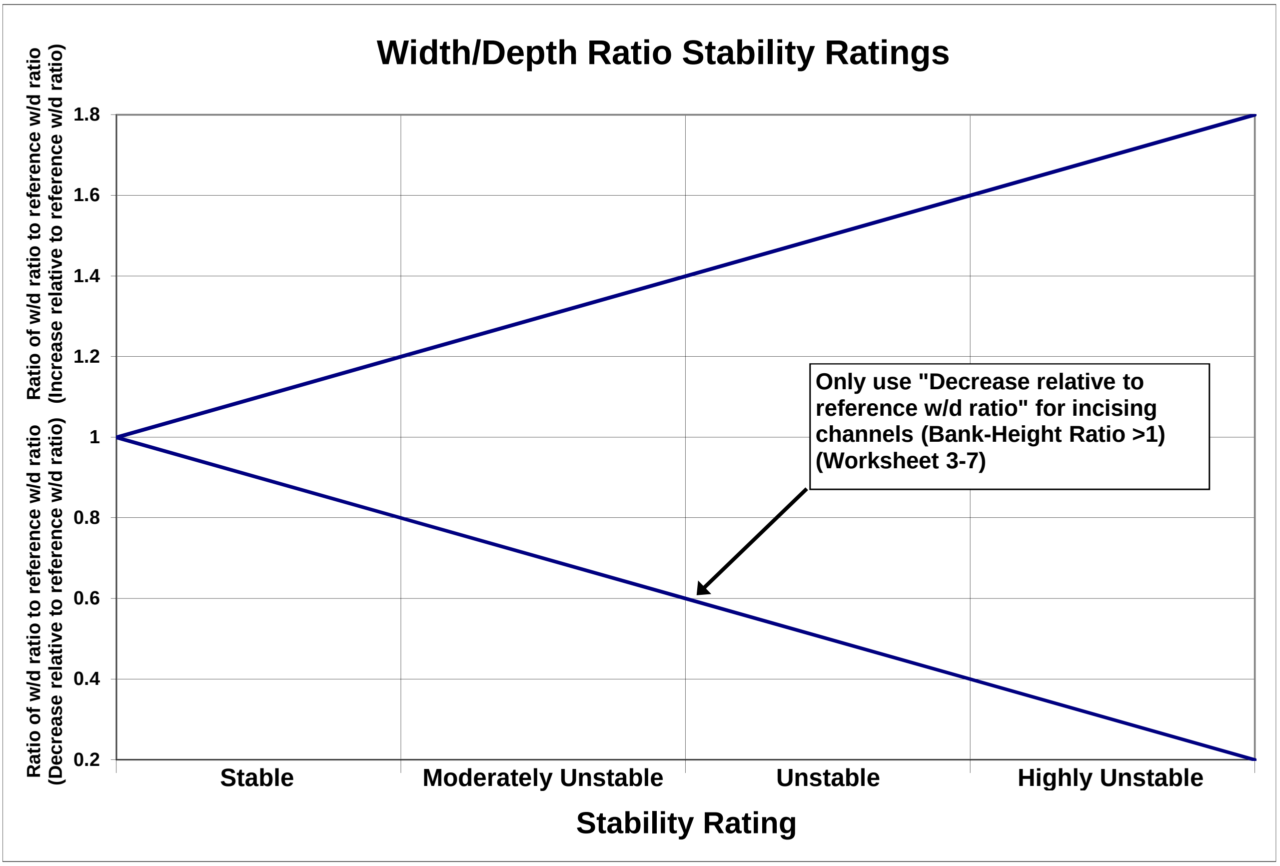
Width/Depth Ratio State

Existing Width/Depth Ratio: **14.5**

Reference Width/Depth Ratio: **16**

Ratio of existing W/d to reference W/d: **0.91**

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

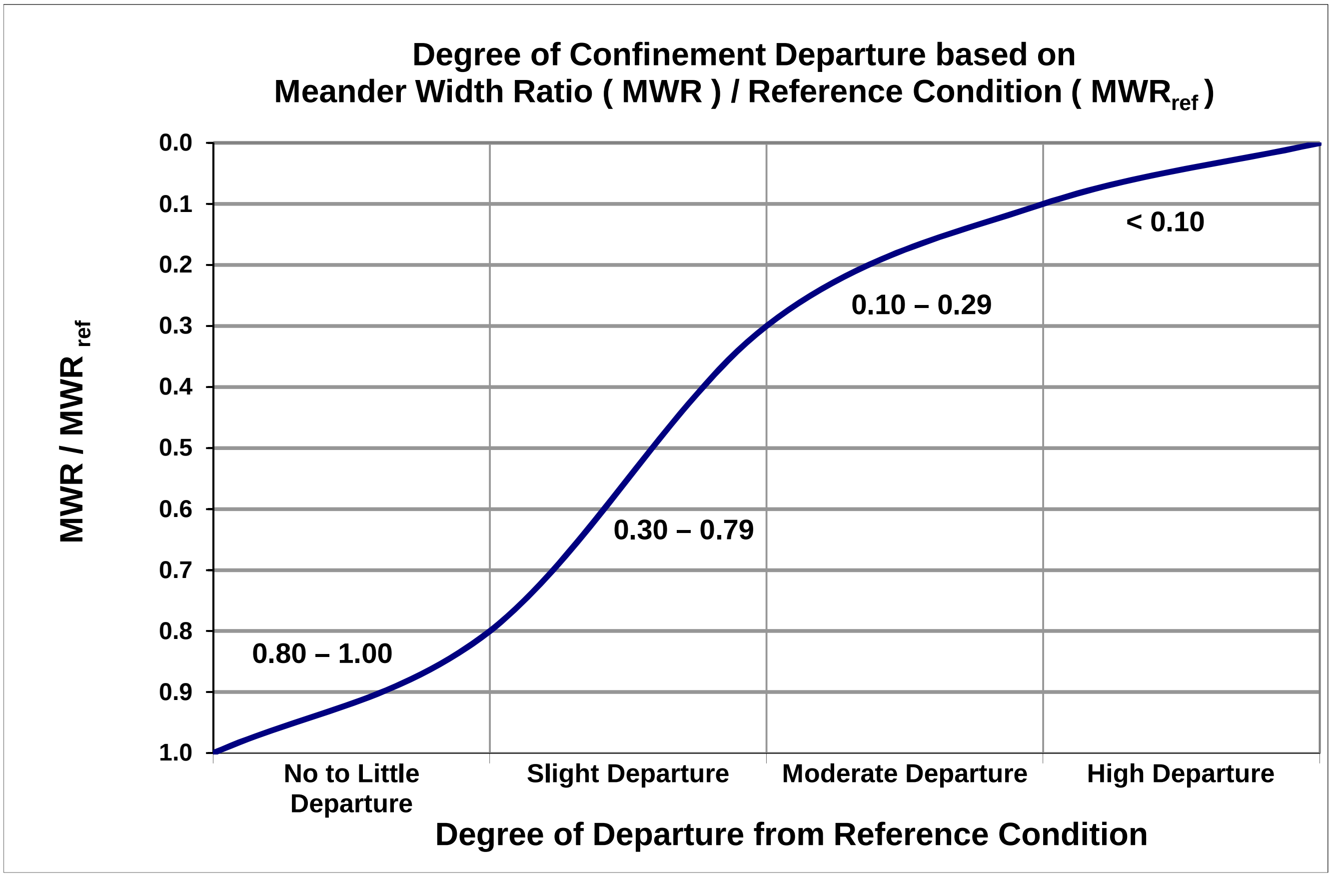
Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	3.44
Reference Meander Width Ratio (MWR_{ref}):	3.7

Ratio of MWR to MWR_{ref}: **0.93**

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: West Monument F4 Fair **Location: Pike National Forest, CO** **Valley Type: VIIIb** **Observers: Reosgen et. al.** **Date: 11/5/2012**

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	5	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	7	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	5	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	5	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	5	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	5	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	16	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	5	Good total =	48	Fair total =	20	Poor total =	24

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	97
Existing stream type =	F4
*Potential stream type =	B4
Modified channel stability rating =	Poor

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **West Monument F4 Fair** Location:

Graph Used: **Colorado** Total Stream Length (ft): **120** Date: **11/5/2012**

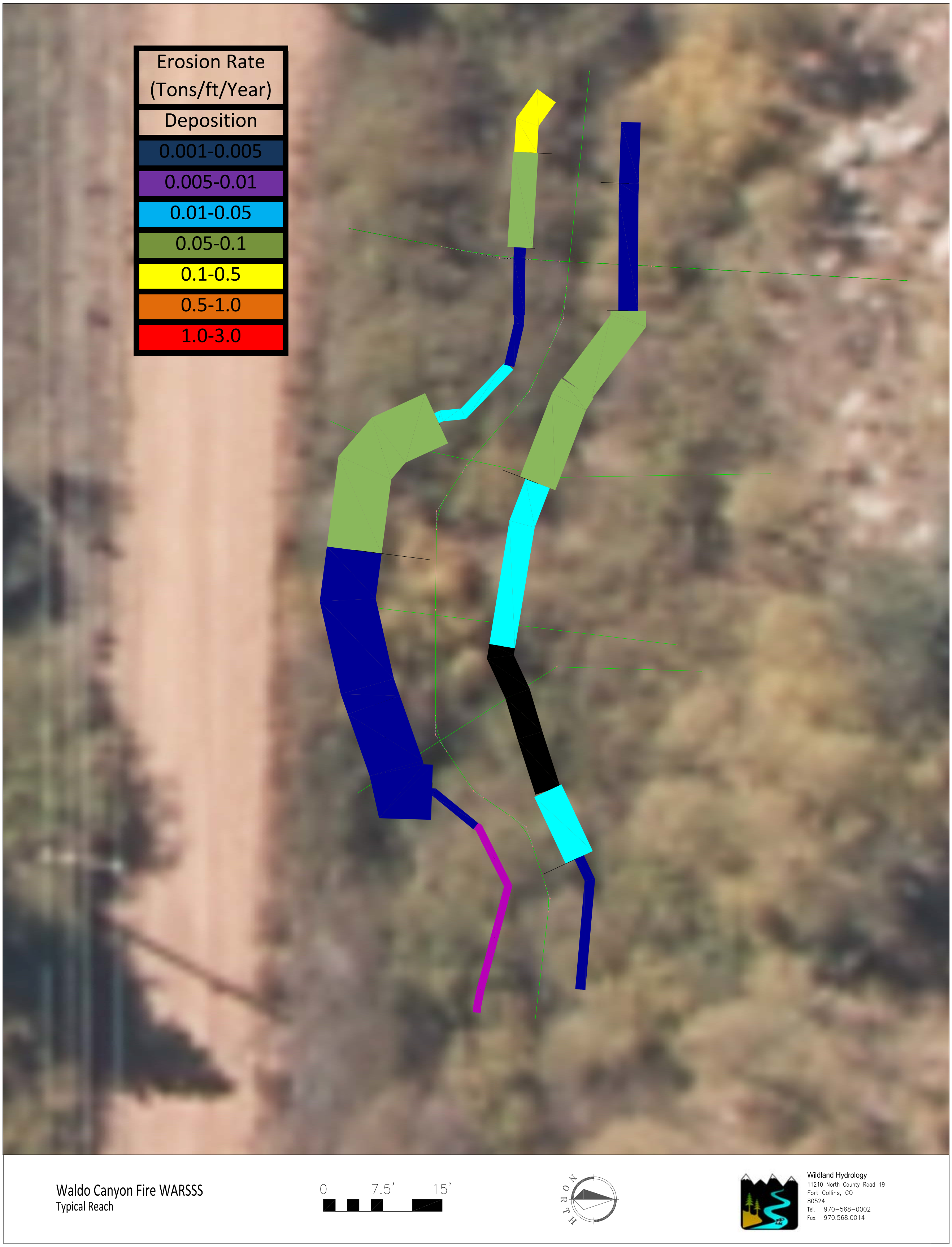
Observers: **Rosgen et. al.** Valley Type: **VIIIb** Stream Type: **F4**

(1) Station (ft)	(2) BEHI rating (Worksheet 3-11) (adjective)	(3) NBS rating (Worksheet 3-12) (adjective)	(4) Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. LB 0+09 to 0+17	Very Low	Low	0.003	8.0	2.5	0.06	0.00036
2. LB 0+26 to 0+31	Moderate	High	0.420	5.0	4.5	9.45	0.09100
3. LB 0+00 to 0+09	Very Low	Very Low	0.0017	9.0	2.5	0.04	0.00020
4. LB 0+17 to 0+26	Moderate	Very Low	0.092	9.0	3.3	2.74	0.01460
5. LB 0+31 to 0+48	High	Moderate	0.380	17.0	4.8	31.01	0.08780
6. LB 0+48 to 0+71	Moderate	Low	0.153	23.0	3.3	11.61	0.02430
7. LB 0+97 to 1+09	Low	High	0.151	12.0	3.8	6.89	0.02760
8. LB 1+09 to 1+20	Low	Low	0.036	11.0	1.3	0.51	0.00220
9. RB 0+87 to 0+95	Very Low	Very Low	0.0017	8.0	1.0	0.01	0.00008
10. RB 0+80 to 0+87	High	Very High	0.810	7.0	4.0	22.68	0.15600
11. RB 0+60 to 0+80	Low	Moderate	0.073	20.0	1.0	1.45	0.00350
12. RB 0+46 to 0+60	Moderate	Moderate	0.282	14.0	7.0	27.64	0.09500
13. RB 0+38 to 0+46	Moderate	Low	0.153	8.0	1.4	1.71	0.01030
14. RB 0+29 to 0+38	Low	Moderate	0.073	9.0	1.3	0.85	0.00450
15. RB 0+17 to 0+29	Low	Low	0.036	12.0	1.5	0.64	0.00260
16 RB 0+05 to 0+17	Moderate	High	0.420	12.0	3.2	16.13	0.06470
17 RB 0+00 to 0+05	Very High	Very High	0.872	5.0	2.9	12.64	0.12180
18 RB 0+95 to 1+18	Low	Low	0.021	18.0	1.0	0.37	0.00100
19 RB 1+18 to 1+20	Moderate	Moderate	0.179	2.0	1.0	0.34	0.00820
20							
21							

Worksheet 5-18, con't. Annual streambank erosion estimates.

Stream:	**West Monument F4 Fair**			Location:			
Graph Used:	**Colorado**	Total Stream Length (ft): **120**				Date: **11/5/2012**	
Observers:	**Rosgen et. al.**		Valley Type: **VIIIb**			Stream Type: **F4**	
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**146.77**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**5.44**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**7.07**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.0589**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

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	**0.1**													
90.000	**0.2**	**95.00**	**10.00**	**36.50**	**0.1**	**0.02**	**0.1**	**0.0**	**0.0000**	**0.00**	**1.40**	**0.00**	**0.00**	**0.00**
80.000	**0.3**	**85.00**	**10.00**	**36.50**	**0.3**	**0.04**	**0.1**	**0.0**	**0.0000**	**0.00**	**2.80**	**0.00**	**0.00**	**0.00**
70.000	**0.4**	**75.00**	**10.00**	**36.50**	**0.3**	**0.05**	**0.1**	**0.0**	**0.0000**	**0.00**	**3.40**	**0.00**	**0.00**	**0.00**
60.000	**0.5**	**65.00**	**10.00**	**36.50**	**0.4**	**0.06**	**0.1**	**0.0**	**0.0000**	**0.00**	**4.20**	**0.00**	**0.00**	**0.00**
50.000	**0.6**	**55.00**	**10.00**	**36.50**	**0.5**	**0.08**	**0.1**	**0.0**	**0.0000**	**0.00**	**5.30**	**0.00**	**0.00**	**0.00**
40.000	**0.8**	**45.00**	**10.00**	**36.50**	**0.7**	**0.10**	**0.1**	**0.0**	**0.0000**	**0.00**	**7.00**	**0.00**	**0.00**	**0.00**
30.000	**1.1**	**35.00**	**10.00**	**36.50**	**1.0**	**0.14**	**0.1**	**0.0**	**0.0000**	**0.00**	**9.50**	**0.00**	**0.00**	**0.00**
20.000	**1.7**	**25.00**	**10.00**	**36.50**	**1.4**	**0.20**	**0.1**	**0.0**	**0.0001**	**0.00**	**13.90**	**0.00**	**0.00**	**0.00**
10.000	**3.1**	**15.00**	**10.00**	**36.50**	**2.4**	**0.34**	**0.1**	**0.0**	**0.0006**	**0.09**	**23.70**	**0.36**	**3.28**	**3.64**
5.000	**4.9**	**7.50**	**5.00**	**18.25**	**4.0**	**0.57**	**0.2**	**0.0**	**0.0021**	**0.26**	**19.80**	**0.36**	**4.75**	**5.11**
4.000	**5.5**	**4.50**	**1.00**	**3.65**	**5.2**	**0.74**	**0.3**	**0.1**	**0.0039**	**0.48**	**5.16**	**0.18**	**1.75**	**1.93**
3.000	**6.4**	**3.50**	**1.00**	**3.65**	**5.9**	**0.85**	**0.5**	**0.1**	**0.0053**	**0.65**	**5.92**	**0.29**	**2.37**	**2.66**
2.000	**7.6**	**2.50**	**1.00**	**3.65**	**7.0**	**1.00**	**0.6**	**0.1**	**0.0077**	**0.91**	**6.99**	**0.47**	**3.32**	**3.79**
1.500	**8.7**	**1.75**	**0.50**	**1.83**	**8.1**	**1.16**	**0.9**	**0.2**	**0.0107**	**1.30**	**4.07**	**0.38**	**2.37**	**2.75**
1.000	**10.6**	**1.25**	**0.50**	**1.83**	**9.7**	**1.38**	**1.3**	**0.4**	**0.0157**	**1.90**	**4.83**	**0.66**	**3.47**	**4.13**
0.900	**11.3**	**0.95**	**0.10**	**0.37**	**11.0**	**1.57**	**1.6**	**0.6**	**0.0194**	**2.51**	**1.09**	**0.20**	**0.92**	**1.12**
0.800	**11.9**	**0.85**	**0.10**	**0.37**	**11.6**	**1.66**	**1.6**	**0.7**	**0.0194**	**2.85**	**1.16**	**0.24**	**1.04**	**1.28**
0.700	**12.6**	**0.75**	**0.10**	**0.37**	**12.3**	**1.76**	**1.6**	**0.8**	**0.0194**	**3.20**	**1.23**	**0.29**	**1.17**	**1.46**
0.600	**13.4**	**0.65**	**0.10**	**0.37**	**13.0**	**1.86**	**1.6**	**1.0**	**0.0194**	**3.63**	**1.30**	**0.35**	**1.32**	**1.67**
0.500	**14.4**	**0.55**	**0.10**	**0.37**	**13.9**	**1.99**	**1.6**	**1.2**	**0.0194**	**4.19**	**1.39**	**0.44**	**1.53**	**1.97**
0.250	**16.6**	**0.38**	**0.25**	**0.91**	**15.5**	**2.21**	**1.6**	**1.8**	**0.0194**	**5.36**	**3.87**	**1.60**	**4.89**	**6.49**
0.100	**19.2**	**0.18**	**0.15**	**0.55**	**17.9**	**2.56**	**1.6**	**2.9**	**0.0194**	**7.39**	**2.69**	**1.56**	**4.05**	**5.61**
0.050	**20.6**	**0.08**	**0.05**	**0.18**	**19.9**	**2.84**	**1.6**	**4.1**	**0.0194**	**9.29**	**0.99**	**0.74**	**1.70**	**2.44**
0.010	**22.4**	**0.03**	**0.04**	**0.15**	**21.5**	**3.07**	**1.6**	**5.3**	**0.0194**	**10.97**	**0.86**	**0.77**	**1.60**	**2.37**
0.005	**22.4**	**0.01**	**0.01**	**0.02**	**22.4**	**3.20**	**1.6**	**6.1**	**0.0194**	**12.01**	**0.11**	**0.11**	**0.22**	**0.33**
0.001	**22.4**	**0.00**	**0.00**	**0.01**	**22.4**	**3.20**	**1.6**	**6.1**	**0.0194**	**12.01**	**0.09**	**0.09**	**0.18**	**0.27**
										Annual totals:		**9.1** (tons/yr)	**39.9** (tons/yr)	**49.0** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

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	**0.1**													
90.000	**0.2**	**95.00**	**10.00**	**36.50**	**0.1**	**0.02**	**0.1**	**0.0**	**0.0000**	**0.00**	**1.40**	**0.00**	**0.00**	**0.00**
80.000	**0.3**	**85.00**	**10.00**	**36.50**	**0.3**	**0.04**	**0.1**	**0.0**	**0.0000**	**0.00**	**2.80**	**0.00**	**0.00**	**0.00**
70.000	**0.4**	**75.00**	**10.00**	**36.50**	**0.3**	**0.05**	**0.1**	**0.0**	**0.0000**	**0.00**	**3.40**	**0.00**	**0.00**	**0.00**
60.000	**0.5**	**65.00**	**10.00**	**36.50**	**0.4**	**0.06**	**0.1**	**0.0**	**0.0000**	**0.00**	**4.20**	**0.00**	**0.00**	**0.00**
50.000	**0.6**	**55.00**	**10.00**	**36.50**	**0.5**	**0.08**	**0.1**	**0.0**	**0.0000**	**0.00**	**5.30**	**0.00**	**0.00**	**0.00**
40.000	**0.8**	**45.00**	**10.00**	**36.50**	**0.7**	**0.10**	**0.1**	**0.0**	**0.0000**	**0.00**	**7.00**	**0.00**	**0.00**	**0.00**
30.000	**1.2**	**35.00**	**10.00**	**36.50**	**1.0**	**0.14**	**0.1**	**0.0**	**0.0000**	**0.00**	**10.00**	**0.00**	**0.00**	**0.00**
20.000	**2.5**	**25.00**	**10.00**	**36.50**	**1.8**	**0.26**	**0.1**	**0.0**	**0.0002**	**0.04**	**18.30**	**0.00**	**1.46**	**1.46**
10.000	**5.0**	**15.00**	**10.00**	**36.50**	**3.7**	**0.53**	**0.2**	**0.0**	**0.0018**	**0.22**	**37.30**	**0.73**	**8.03**	**8.76**
5.000	**7.5**	**7.50**	**5.00**	**18.25**	**6.2**	**0.89**	**0.5**	**0.1**	**0.0059**	**0.73**	**31.20**	**1.64**	**13.32**	**14.96**
4.000	**8.2**	**4.50**	**1.00**	**3.65**	**7.8**	**1.12**	**0.8**	**0.2**	**0.0098**	**1.17**	**7.81**	**0.66**	**4.27**	**4.93**
3.000	**9.3**	**3.50**	**1.00**	**3.65**	**8.7**	**1.25**	**1.0**	**0.3**	**0.0125**	**1.51**	**8.71**	**0.95**	**5.51**	**6.46**
2.000	**10.5**	**2.50**	**1.00**	**3.65**	**9.9**	**1.41**	**1.4**	**0.4**	**0.0165**	**1.99**	**9.87**	**1.42**	**7.26**	**8.68**
1.500	**11.7**	**1.75**	**0.50**	**1.83**	**11.1**	**1.58**	**1.6**	**0.6**	**0.0194**	**2.55**	**5.54**	**1.04**	**4.65**	**5.69**
1.000	**13.6**	**1.25**	**0.50**	**1.83**	**12.6**	**1.80**	**1.6**	**0.9**	**0.0194**	**3.41**	**6.30**	**1.59**	**6.22**	**7.81**
0.900	**14.2**	**0.95**	**0.10**	**0.37**	**13.9**	**1.99**	**1.6**	**1.2**	**0.0194**	**4.23**	**1.39**	**0.44**	**1.54**	**1.98**
0.800	**14.9**	**0.85**	**0.10**	**0.37**	**14.6**	**2.08**	**1.6**	**1.4**	**0.0194**	**4.67**	**1.46**	**0.52**	**1.70**	**2.22**
0.700	**15.5**	**0.75**	**0.10**	**0.37**	**15.2**	**2.18**	**1.6**	**1.6**	**0.0194**	**5.14**	**1.52**	**0.60**	**1.88**	**2.48**
0.600	**16.4**	**0.65**	**0.10**	**0.37**	**16.0**	**2.28**	**1.6**	**1.9**	**0.0194**	**5.70**	**1.60**	**0.70**	**2.08**	**2.78**
0.500	**17.3**	**0.55**	**0.10**	**0.37**	**16.8**	**2.41**	**1.6**	**2.3**	**0.0194**	**6.44**	**1.68**	**0.85**	**2.35**	**3.20**
0.250	**19.6**	**0.38**	**0.25**	**0.91**	**18.4**	**2.64**	**1.6**	**3.2**	**0.0194**	**7.86**	**4.61**	**2.87**	**7.17**	**10.04**
0.100	**22.2**	**0.18**	**0.15**	**0.55**	**20.9**	**2.99**	**1.6**	**4.8**	**0.0194**	**10.32**	**3.13**	**2.62**	**5.65**	**8.27**
0.050	**23.5**	**0.08**	**0.05**	**0.18**	**22.8**	**3.27**	**1.6**	**6.5**	**0.0194**	**12.57**	**1.14**	**1.18**	**2.29**	**3.47**
0.010	**25.3**	**0.03**	**0.04**	**0.15**	**24.4**	**3.49**	**1.6**	**8.1**	**0.0194**	**14.56**	**0.98**	**1.19**	**2.13**	**3.32**
0.005	**25.3**	**0.01**	**0.01**	**0.02**	**25.3**	**3.62**	**1.6**	**9.2**	**0.0194**	**15.77**	**0.13**	**0.17**	**0.29**	**0.46**
0.001	**25.3**	**0.00**	**0.00**	**0.01**	**25.3**	**3.62**	**1.6**	**9.2**	**0.0194**	**15.77**	**0.10**	**0.13**	**0.23**	**0.36**
										Annual totals:		**19.3** (tons/yr)	**78.0** (tons/yr)	**97.3** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

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	**0.05**									**0.00**					**0.00**	**0.00**	**0.00**
90.000	**0.23**	**0.14**	**0.23**	**3.31**	**0.07**	**0.49**	**0.0090**	**0.04**	**0.08**	**0.02**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.000	**0.32**	**0.28**	**0.38**	**3.95**	**0.10**	**0.64**	**0.0090**	**0.05**	**0.16**	**0.04**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.000	**0.37**	**0.34**	**0.45**	**4.22**	**0.11**	**0.71**	**0.0090**	**0.06**	**0.19**	**0.05**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.000	**0.46**	**0.42**	**0.53**	**4.47**	**0.12**	**0.78**	**0.0090**	**0.07**	**0.24**	**0.05**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.000	**0.60**	**0.53**	**0.61**	**4.57**	**0.13**	**0.83**	**0.0090**	**0.07**	**0.30**	**0.07**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
40.000	**0.79**	**0.70**	**0.73**	**4.72**	**0.15**	**0.91**	**0.0090**	**0.09**	**0.39**	**0.08**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
30.000	**1.11**	**0.95**	**0.90**	**4.95**	**0.18**	**1.03**	**0.0090**	**0.10**	**0.53**	**0.11**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
20.000	**1.67**	**1.39**	**1.16**	**5.22**	**0.22**	**1.17**	**0.0090**	**0.12**	**0.78**	**0.15**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
10.000	**3.06**	**2.37**	**1.66**	**5.65**	**0.29**	**1.41**	**0.0090**	**0.16**	**1.33**	**0.24**	**10.000**	**36.50**	**0.09**	**0.01**	**3.00**	**0.00**	**4.00**
5.000	**4.86**	**3.96**	**2.33**	**6.03**	**0.39**	**1.69**	**0.0090**	**0.21**	**2.22**	**0.37**	**5.000**	**18.25**	**0.26**	**0.02**	**5.00**	**0.00**	**5.00**
4.000	**5.46**	**5.16**	**2.78**	**6.20**	**0.45**	**1.85**	**0.0090**	**0.24**	**2.90**	**0.47**	**1.000**	**3.65**	**0.48**	**0.05**	**2.00**	**0.00**	**2.00**
3.000	**6.39**	**5.92**	**3.04**	**6.32**	**0.48**	**1.94**	**0.0090**	**0.26**	**3.32**	**0.53**	**1.000**	**3.65**	**0.65**	**0.08**	**2.00**	**0.00**	**3.00**
2.000	**7.59**	**6.99**	**3.41**	**6.52**	**0.52**	**2.05**	**0.0090**	**0.28**	**3.93**	**0.60**	**1.000**	**3.65**	**0.91**	**0.13**	**3.00**	**0.00**	**4.00**
1.500	**8.70**	**8.14**	**3.83**	**6.92**	**0.55**	**2.12**	**0.0090**	**0.30**	**4.57**	**0.66**	**0.500**	**1.83**	**1.25**	**0.19**	**2.00**	**0.00**	**3.00**
1.000	**10.60**	**9.65**															
0.900	**11.30**	**10.95**															
0.800	**11.94**	**11.62**															
0.700	**12.59**	**12.27**															
0.600	**13.42**	**13.00**															
0.500	**14.35**	**13.88**															
0.250	**16.62**	**15.48**															
0.100	**19.21**	**17.91**															
0.050	**20.55**	**19.88**															
0.010	**22.36**	**21.45**															
0.005	**22.36**	**22.36**															
0.001	**22.36**	**22.36**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**17.9**	**2.1**	**19.7**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

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	**0.05**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**0.23**	**0.14**	**0.21**	**2.95**	**0.07**	**0.63**	**0.0090**	**0.04**	**0.08**	**0.03**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.000	**0.32**	**0.28**	**0.32**	**3.08**	**0.10**	**0.77**	**0.0090**	**0.05**	**0.16**	**0.05**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.000	**0.37**	**0.34**	**0.37**	**3.13**	**0.12**	**0.83**	**0.0090**	**0.06**	**0.19**	**0.06**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.000	**0.46**	**0.42**	**0.43**	**3.21**	**0.13**	**0.91**	**0.0090**	**0.07**	**0.24**	**0.07**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
50.000	**0.60**	**0.53**	**0.52**	**3.31**	**0.16**	**1.03**	**0.0090**	**0.08**	**0.30**	**0.09**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
40.000	**0.79**	**0.70**	**0.65**	**3.83**	**0.17**	**1.06**	**0.0090**	**0.09**	**0.39**	**0.10**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
30.000	**1.11**	**0.95**	**0.84**	**4.60**	**0.18**	**1.12**	**0.0090**	**0.09**	**0.53**	**0.12**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
20.000	**1.67**	**1.39**	**1.10**	**5.19**	**0.21**	**1.23**	**0.0090**	**0.11**	**0.78**	**0.15**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
10.000	**3.06**	**2.37**	**1.61**	**5.87**	**0.27**	**1.46**	**0.0090**	**0.13**	**1.33**	**0.23**	**10.000**	**36.50**	**0.09**	**0.01**	**3.00**	**0.00**	**4.00**
5.000	**4.86**	**3.96**	**2.27**	**6.29**	**0.36**	**1.73**	**0.0090**	**0.17**	**2.22**	**0.35**	**5.000**	**18.25**	**0.22**	**0.02**	**4.00**	**0.00**	**4.00**
4.000	**5.46**	**5.16**	**2.71**	**6.47**	**0.42**	**1.91**	**0.0090**	**0.20**	**2.90**	**0.45**	**1.000**	**3.65**	**0.43**	**0.05**	**2.00**	**0.00**	**2.00**
3.000	**6.39**	**5.92**	**2.99**	**6.71**	**0.45**	**1.97**	**0.0090**	**0.21**	**3.32**	**0.49**	**1.000**	**3.65**	**0.52**	**0.06**	**2.00**	**0.00**	**2.00**
2.000	**7.59**	**6.99**	**3.38**	**7.05**	**0.48**	**2.07**	**0.0090**	**0.23**	**3.93**	**0.56**	**1.000**	**3.65**	**0.78**	**0.11**	**3.00**	**0.00**	**3.00**
1.500	**8.70**	**8.14**	**3.80**	**7.44**	**0.51**	**2.14**	**0.0090**	**0.24**	**4.57**	**0.61**	**0.500**	**1.83**	**0.95**	**0.16**	**2.00**	**0.00**	**2.00**
1.000	**10.60**	**9.65**															
0.900	**11.30**	**10.95**															
0.800	**11.94**	**11.62**															
0.700	**12.59**	**12.27**															
0.600	**13.42**	**13.00**															
0.500	**14.35**	**13.88**															
0.250	**16.62**	**15.48**															
0.100	**19.21**	**17.91**															
0.050	**20.55**	**19.88**															
0.010	**22.36**	**21.45**															
0.005	**22.36**	**22.36**															
0.001	**22.36**	**22.36**															
Notes:										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**15.4**	**1.9**	**17.2**
										Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):					**17.8**	**2.0**	**19.8**
										Difference in sediment transport capacity (tons/yr) (+ or -):					**-2.4**	**-0.1**	**-2.6**
										Stability evaluation: Aggradation, Degradation or Stable:					**Aggradation**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**West Monument F4 Fair**	Stream Type:	**F4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	Date:	**11/05/2012**

Enter Required Information for Existing Condition

9.6	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.197	D_{max}	Largest particle from **Bed Material** (ft)	**60**	**(mm)**	304.8 mm/ft
0.01650	S	Existing bankfull water surface slope (ft/ft)			
0.53	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	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:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
6.26	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**2**

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

N/A	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

N/A	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

0.294		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 **21.8**	CO **61.84**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **0.779**	CO **0.283**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **1.40**	CO **0.51**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \dfrac{\tau}{\gamma S}$
Shields **0.0235**	CO **0.0085**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \dfrac{\tau}{\gamma d}$

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **West Monument F4 Fair** Stream Type: **F4**

Location: **Pike National Forest, CO** Valley Type: **VIIIb**

Observers: **Rosgen et. al.** Date: **11/05/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**West Monument F4 Fair**	Stream Type:	**F4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	Date:	**11/05/2012**

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 5-13)**	< 1.2 **(2)**	1.2 – 1.4 [✓ **(4)**]	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**4**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL [✓ **(6)**]	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**6**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**14**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **West Monument F4 Fair** Stream Type: **F4 Fair**

Location: **Pike National Forest, Colorado** Valley Type: **VIIIb**

Observers: **Rosgen et. al.** Date: **11/05/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 (7)	**2**
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2 (2)	1.2 – 1.4 [✓ (4)]	1.4 – 1.6 (6)	>1.6 (8)	**4**
4 **Stream Succession States (Worksheet 5-24)**	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) [✓ (6)]	(C→D), (F→D) (8)	**6**
5 **Depositional Patterns (Worksheet 5-10)**	B1 (1)	B2, B4 (2)	B3, B5 (3)	B6, B7, B8 [✓ (4)]	**NA**
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3 [✓ (1)]	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	**1**
				Total Points	**15**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☑	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**West Monument F4 Fair**	Stream Type:	**F4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	Date:	**11/05/2012**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	[✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**15**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Mest Monument F4 Fair**	Stream Type:	**F4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	Date:	**11/05/2012**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) [✓ **(6)**]	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**6**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* [✓ **(4)**]	*Unstable* **(6)**	*Highly Unstable* **(8)**	**4**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* [✓ **(4)**]	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**4**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* [✓ **(4)**]	*Moderately Incised* **(6)**	*Degradation* **(8)**	**4**
				Total Points	**18**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**West Monument F4 Fair**	Stream Type:	**F4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Rosgen et. al.**	Date:	**11/05/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	1	2
	Mod. Unstable	[✓ 2]	
	Unstable	3	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	1	2
	Mod. Deposition	[✓ 2]	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	1	2
	Slightly Incised	[✓ 2]	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	1	2
	Slight Increase	[✓ 2]	
	Mod. Increase	3	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	1	4
	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*** 5 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☑	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**West Monument F4 Fair**					Location:	**Pike National Forest, Colorado**			
Observers:	**Rosgen et. al.**		Date:	**11/5/2012**		Stream Type:	**F4**	Valley Type:	**VIIIb**	
Channel Dimension	Mean Bankfull Depth (ft):	**0.53**	Bankfull Width (ft):	**7.68**	Cross-Sectional Area (ft^2):	**4.06**	Width of Flood-Prone Area (ft):	**14.49**	Entrenchment Ratio:	**1.38**
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**6.91** **6.63-7.19**	L_m/W_{bkf}:	**7.88** **7.29-8.46**	R_c/W_{bkf}:	**1.6** **1.15-3.26**	MWR:	**3.44**	Sinuosity: **1.09**
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
	Max Bankfull Depth (ft):	Riffle **0.8**	Pool **1.32**	Depth Ratio (max to mean):	Riffle **1.51**	Pool **1.83**	Pool-to-Pool Spacing:	Ratio **18.55**	Slope Valley: **0.018**	Water Surface: **0.0165**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Willow/Aspen Dominated**		Potential Composition/Density: **At Potential**		Remarks: Condition, Vigor & Usage of Existing Reach: **Bare Ground Under Shaded Canopy**				
	Flow Regime:	**P1, P2, P7, P8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**M3**	Depositional Patterns:	**B2, B5**	Debris/Channel Blockages:	**D3**
	Degree of Incision (Bank-Height Ratio):	**2.2**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**97 (Poor)**				
	Width/depth Ratio (W/d):	**14.49**	Reference W/d Ratio (W/d$_{ref}$):	**16**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**0.91**	W/d Ratio State Stability Rating:	**Stable**		
	Meander Width Ratio (MWR):	**3.44**	Reference MWR$_{ref}$:	**3.7**	Degree of confinement (MWR / MWR$_{ref}$):	**0.93**	MWR / MWR$_{ref}$ Stability Rating:	**Stable**		
Bank Erosion Summary	Length of Reach Studied (ft):	**120**	Annual Streambank Erosion Rate: **7.06** (tons/yr)	**0.0588** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:	**Used Yellowstone curve for very low BEHI**			
Sediment Capacity (POWERSED)	☑ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks:						
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**60**	$\tau =$ **0.283**	$\tau^* =$ **N/A**	Existing Depth:	**0.53**	Required Depth:	**0.51**	Existing Slope: **0.017**	Required Slope: **0.01**
Successional Stage Shift	**Bc** → **G** → **F** → **Bc** → →				Existing Stream State (Type):	**F4**	Potential Stream State (Type):	**B4c**		
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Moderatly high banks**				
Vertical Stability (Aggradation)	☐ *No Deposition*	☑ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:					
Vertical Stability (Degradation)	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:					
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**One large raw bank**				
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:	**Contribution from near by road.**				

Appendix C11

F4b Stream Type

Fair-Poor Stability Reach

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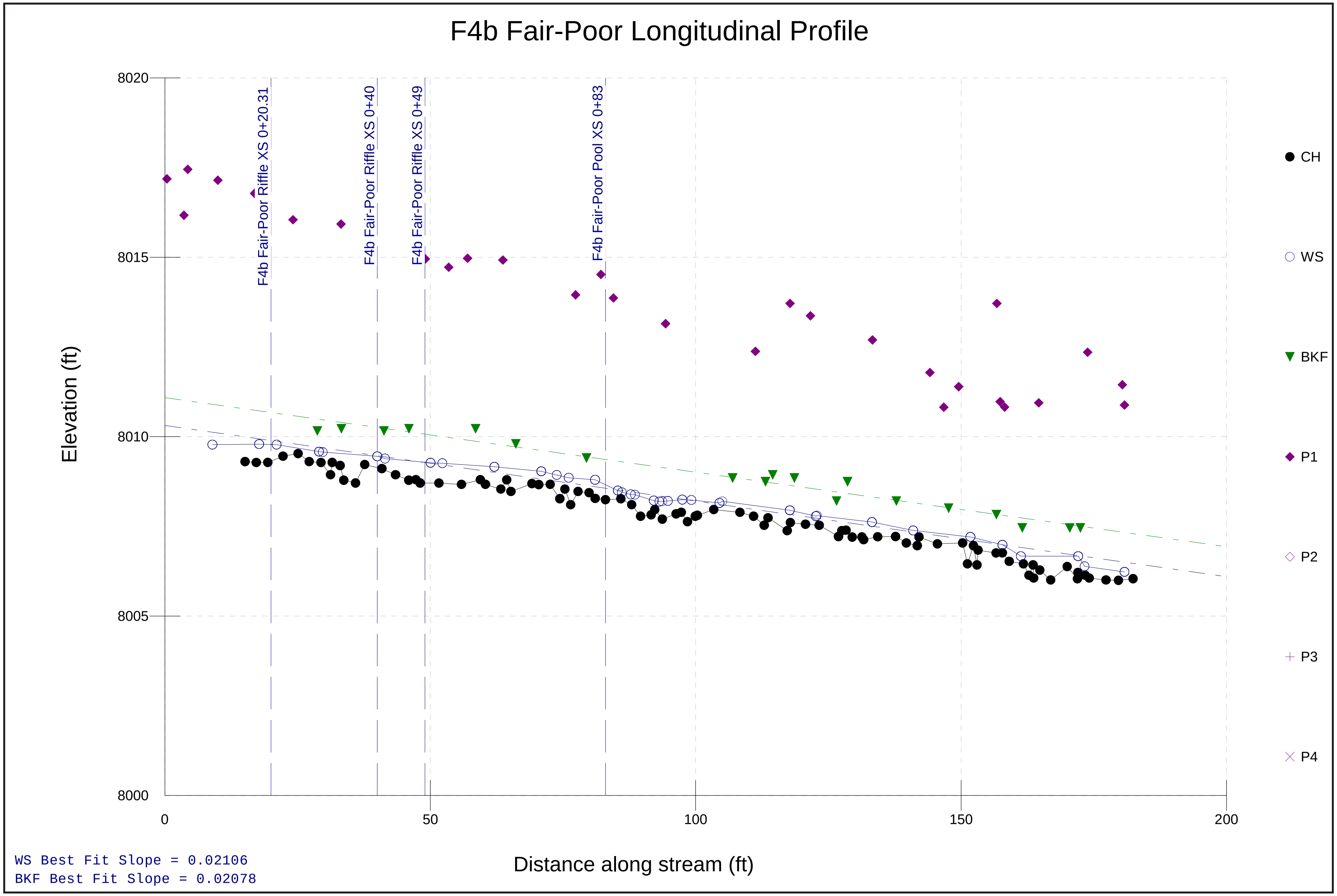
Appendix C11: F4b Fair-Poor Reach

F4b Fair-Poor Reach Location & Overview

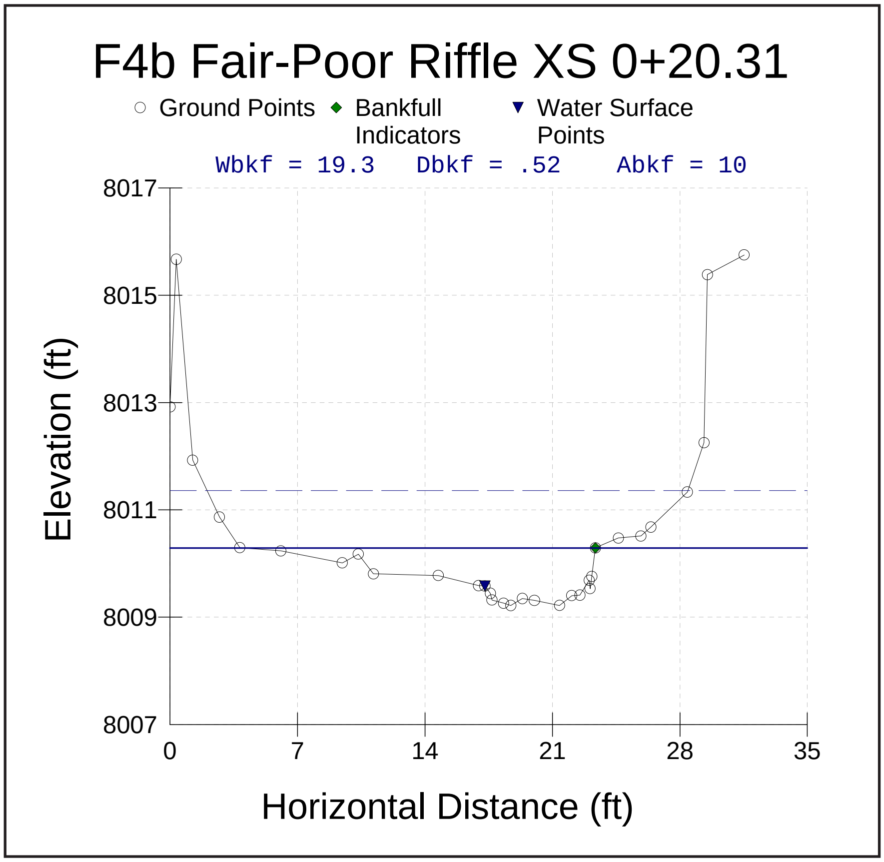
The F4b Fair-Poor representative reach is a 4th order, perennial, relatively steep gradient, entrenched stream located in lower Trail Creek (see location map **Figure C-2**). The photograph depicts an entrenched channel with evident bank erosion, yet colonization of riparian vegetation indicating a potential shift from an F4b to B4 stream type. The stream is apparently trying to recover from past flood and high sediment supply impacts. The width/depth ratio of *38* is still very high and will continue to promote excess deposition in this gulch-fill, alluvial Valley Type VIIIa. The stream is still enlarging due to the high peak flows following the fire. The potential stable stream type in this valley type is a B4; thus a POWERSED run was made to determine streambed stability, which indicated approximately *78 tons/yr* of deposition. The streambank erosion rate of *0.024 tons/yr/ft* is an order of magnitude larger than the B4 reference rate of *0.0048 tons/yr/ft*. The sediment supply rating is *High*, typical of an F4 stream type, due to the high banks on both sides and the sediment deposition in the bed. The "Fair-Poor" rating indicates a higher potential accelerated increase in flow-related sediment compared to the same-sized, B4 reference stream type. The WRENSS model indicated that the water yield due to the fire increased from *3,213 acre-ft* to *5,052 acre-ft*, representing an increase of *1,839 acre-ft*. The FLOWSED model indicated that bedload increased from *40 tons/yr* to *257 tons/yr* and suspended sediment increased from *63 tons/yr* to *549 tons/yr*, representing a total increase in sediment of *702 tons/yr*. This increase is the result of increased sediment supply due to the unstable banks and high width/depth ratio that encourages increased sediment deposition in the streambed.

The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Fair-Poor" rating.

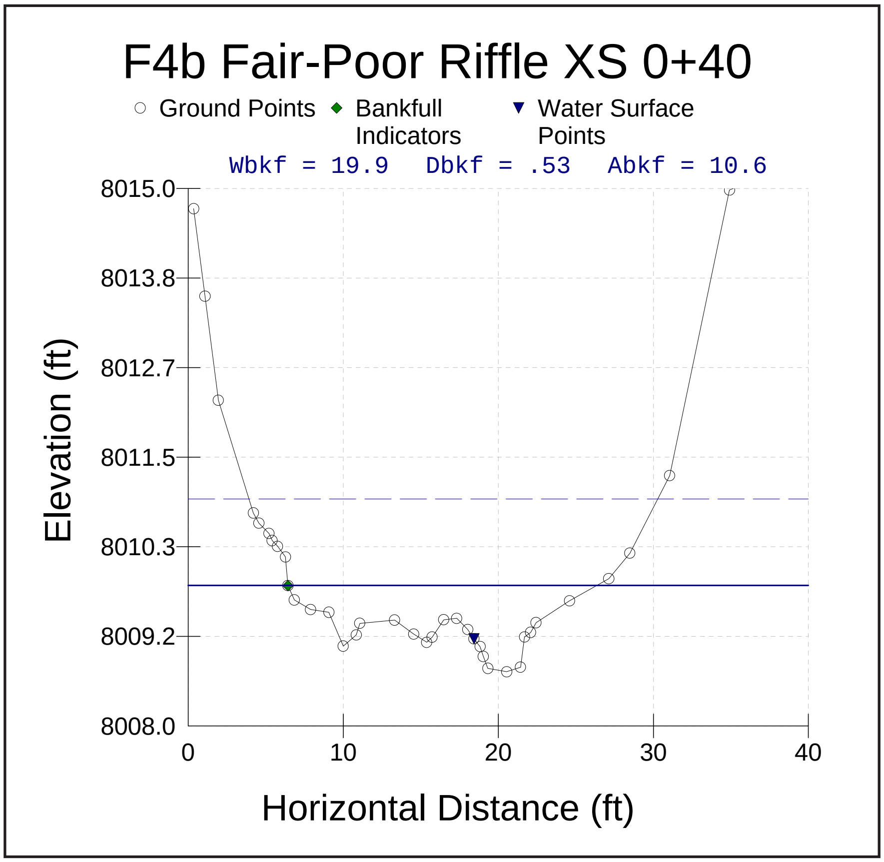
Survey Summary



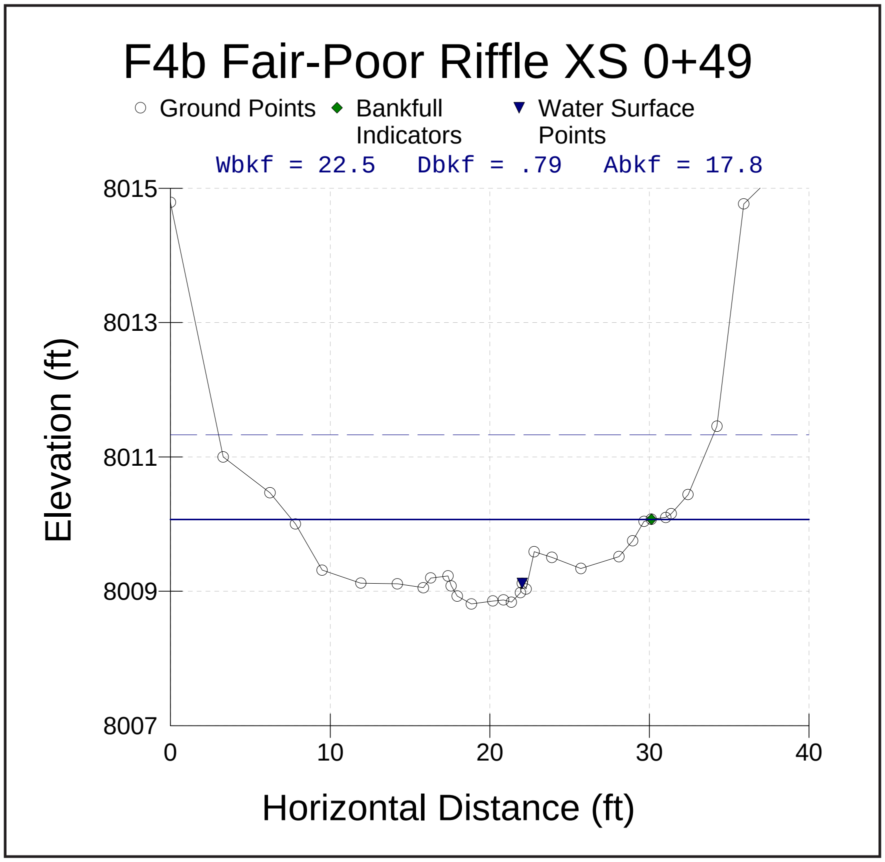
Longitudinal Profile (graph generated from RIVERMorph^{TM})



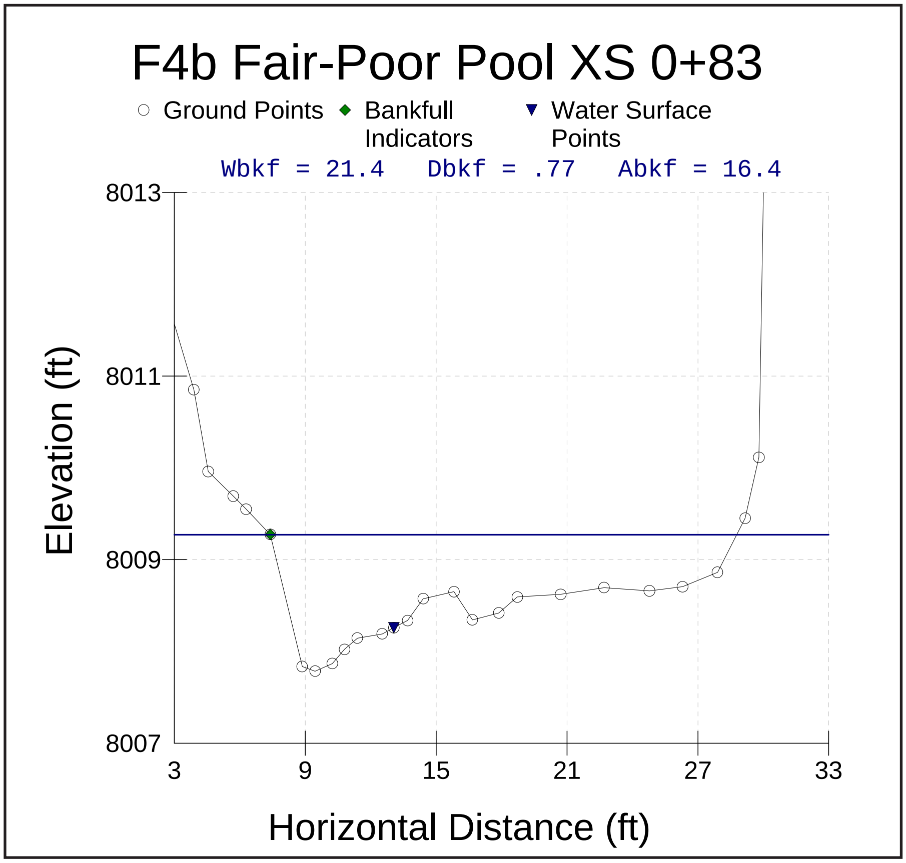
Riffle Cross-section 0+20.31 (graph generated from RIVERMorph^{TM})



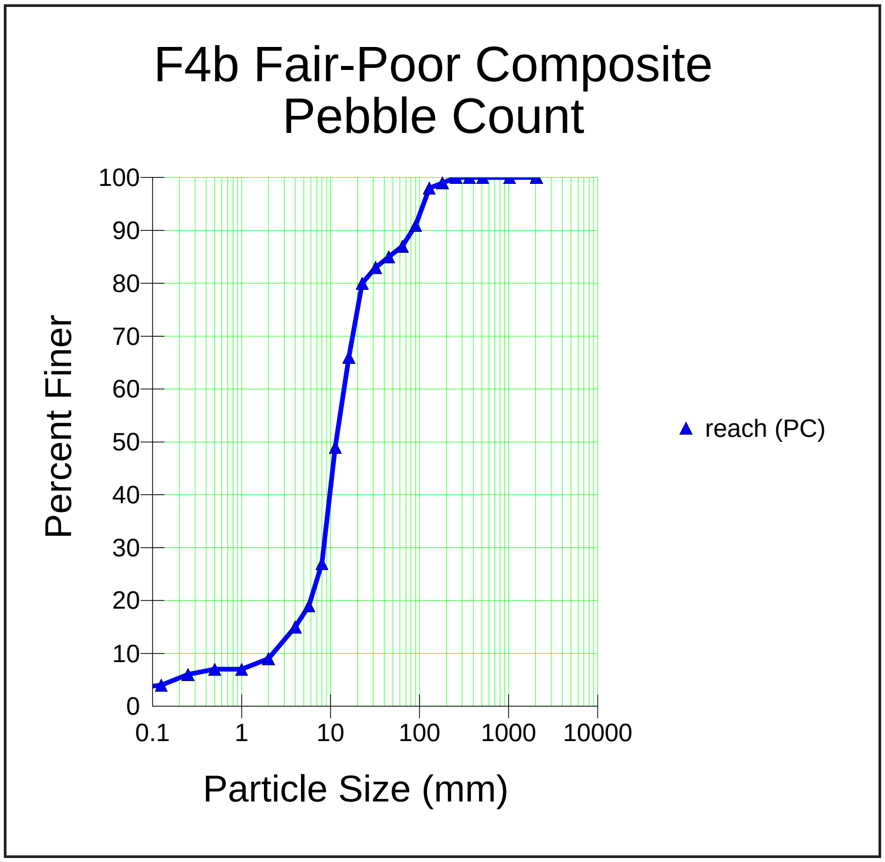
Representative Riffle Cross-section 0+40 (graph generated from RIVERMorph^{TM})



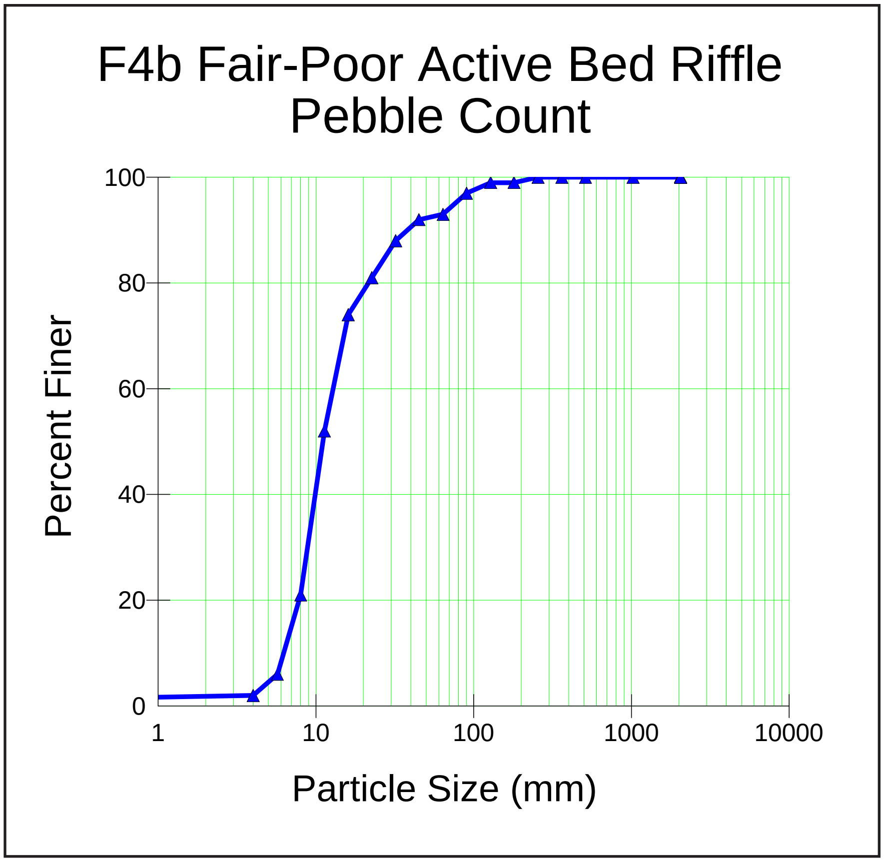
Riffle Cross-section 0+49 (graph generated from RIVERMorph^{TM})



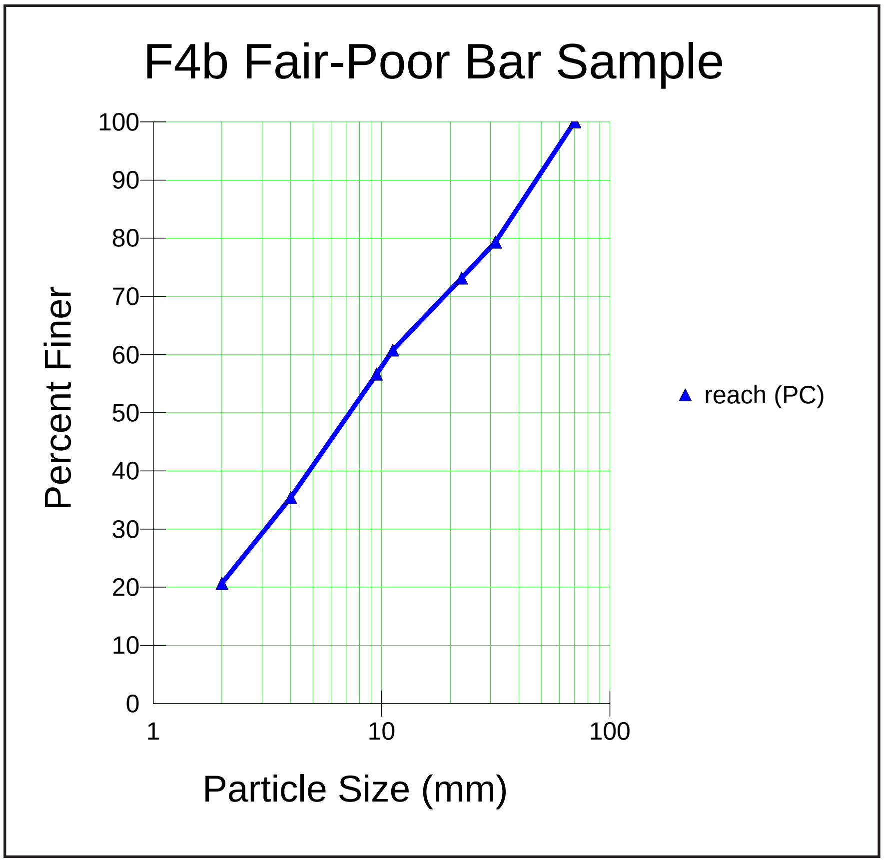
Pool Cross-Section 0+83 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

***WARSSS* Worksheets**

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, F4b Fair-Poor Reach**			Location:	**Riffle XS 0+40, Pike N.F., Colorado**
Date:	**8/26/2010**	Stream Type:	**F4b**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez *et al*.**			HUC:	

INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	**10.6**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.53**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**19.9**	**W_{bkf}** (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**20.59**	**W_p** (ft)
D_{84} at Riffle	**26.6**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.09**	**D_{84}** (ft)
Bankfull SLOPE	**0.021**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.51**	**R** (ft)
Gravitational Acceleration	**32.2**	**g** (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**5.89**	**R / D_{84}**
Drainage Area	**10.7**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.590**	**u*** (ft/sec)

ESTIMATION METHODS	**Bankfull VELOCITY**		**Bankfull DISCHARGE**	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**4.24**	ft / sec	**44.97**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.038**	**3.65**	ft / sec	**38.69**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.05**	**2.77**	ft / sec	**29.40**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.100**	**1.39**	ft / sec	**14.71**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** **Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, F4b Fair-Poor Reach**

Basin: Drainage Area: acres **10.7** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 0+40** Date: **8/26/10**

Observers: **K. Wright, L. Chavez, D. Butler & D. Bohon** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**19.9**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.53**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**10.6**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**37.6**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.13**	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.	**26.36**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.32**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**12**	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.	**0.021**	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 (S_{val} / S).	**1.03**	

Stream Type **F4b** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, F4b Fair-Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez *et al*.** Date: **8/26/2010** Valley Type: **VIII** Stream Type: **F4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Riffle Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Riffle Width (W_{bkf})	**20.4**	**19.3**	**22.0**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**12.6**	**10.0**	**17.2**
Mean Riffle Depth (d_{bkf})	**0.61**	**0.52**	**0.78**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**34.3**	**28.2**	**37.1**
Maximum Riffle Depth (d_{max})	**1.35**	**1.26**	**1.50**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.213**	**2.066**	**2.459**
Width of Flood-Prone Area (W_{fpa})	**27.9**	**26.4**	**31.0**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.3**	**1.3**	**1.4**
Riffle Inner Berm Width (W_{ib})	**7.9**			ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	**0.386**		
Riffle Inner Berm Depth (d_{ib})	**0.31**			ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	**0.508**		
Riffle Inner Berm Area (A_{ib})	**2.5**			ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	**0.195**		
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	**25.4**							

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})	**21.4**			ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	**1.048**		
Mean Pool Depth (d_{bkfp})	**0.77**			ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	**1.262**		
Pool Cross-Sectional Area (A_{bkfp})	**16.4**			ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	**1.304**		
Maximum Pool Depth (d_{maxp})	**1.49**			ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.443**		
Pool Inner Berm Width (W_{ibp})	**13.0**			ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	**0.608**		
Pool Inner Berm Depth (d_{ibp})	**0.30**			ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	**0.390**		
Pool Inner Berm Area (A_{ibp})	**4.0**			ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	**0.240**		
Point Bar Slope (S_{pb})	**0.370**			ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	**43.3**		

Run Dimensions*

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

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Location:	**Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez *et al*.**	Date: **8/26/2010**	Valley Type: **VIII**	Stream Type: **F4b**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**2.77**	ft/sec	Estimation Method	**"n" by Stream Type**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**29.4**	cfs	Drainage Area	**10.3**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**24.0**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.18**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)	**1.7**	**0.1**	**5.5**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.08**	**0.004**	**0.27**
Individual Pool Length (L_p)	**2.1**	**0.7**	**4.3**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.10**	**0.03**	**0.21**
Pool to Pool Spacing (P_s)	**3.9**	**0.4**	**11.9**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**0.19**	**0.02**	**0.58**

Channel Profile

Valley Slope (S_{val})	**0.0215**	ft/ft	Average Water Surface Slope (S)	**0.021**	ft/ft	Sinuosity (S_{val} / S)	**1.03**
Stream Length (SL)	**202.0**	ft	Valley Length (VL)	**197.0**	ft	Sinuosity (SL / VL)	**1.03**

Low Bank Height (LBH)	start	**1.45**	ft	Max Bankfull Depth (d_{max})	start	**1.36**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start **1.1**
	end	**2.25**	ft		end	**1.20**	ft		end **1.9**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0310**	**0.0040**	**0.0700**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.4762**	**0.1905**	**3.3333**
Run Slope (S_{run})	**0.0600**	**0.0190**	**0.2280**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**2.8571**	**0.9048**	**10.857**
Pool Slope (S_p)	**0.0210**	**0.0000**	**0.0560**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**1.0000**	**0.0001**	**2.6667**
Glide Slope (S_g)	**0.0250**	**0.0060**	**0.0730**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**1.1905**	**0.2857**	**3.4762**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.35**	**1.26**	**1.50**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.213**	**2.066**	**2.459**
Max Run Depth (d_{maxr})	**1.22**	**1.00**	**1.41**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**2.000**	**1.639**	**2.311**
Max Pool Depth (d_{maxp})	**1.40**	**1.12**	**1.65**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.295**	**1.836**	**2.705**
Max Glide Depth (d_{maxg})	**1.07**	**0.89**	**1.35**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.754**	**1.459**	**2.213**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**	**0**	**0**	D_{16}	**4.4**	**7.2**	**0.0**		mm
% Sand	**9**	**0**	**21**	D_{35}	**9.2**	**9.5**	**4.0**		mm
% Gravel	**78**	**93**	**7**	D_{50}	**11.6**	**11.1**	**7.8**		mm
% Cobble	**13**	**7**	**2**	D_{84}	**38.5**	**26.6**	**40.2**		mm
% Boulder				D_{95}	**111.7**	**77.0**	**60.7**		mm
% Bedrock				D_{100}	**256.0**	**256.0**	**70.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, F4b Fair-Poor Reach**

Location: **Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez, D. Butler & D. Bohon**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/26/2010**

Existing species composition: **Willow, Aspen, Grass/Forb**

Potential species composition: **Mature Willow, Aspen, Grass/Forb**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**15%**	**5%**	**Aspen**	**9%**
				Salix Spp.	**90%**
				Water birch	**1%**
					100%
2. Understory	Shrub layer	▨	**49%**	**Willow**	**100%**
					100%
3. Ground level	Herbaceous	▨	**40%**	**Grass (Poa, Agrostis, wheat**	**60%**
				forbs-Veronica, yarrow,	**36%**
				Epilobium)	
				Weeds (thistle, smartweed)	**4%**
					100%
	Leaf or needle litter	▨	**3%**		
	Bare ground	▨	**3%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, F4b Fair-Poor** Location: **Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez, D. Butler & D. Bohon** Date: **8/26/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, F4b Fair-Poor Reach**
Location: **Pike National Forest, Colorado**
Observers: **K. Wright, L. Chavez *et al* .**
Date: **8/26/2010**

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

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).

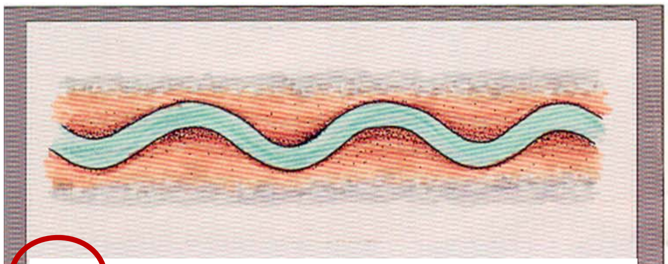
Worksheet 5-9. Meander patterns.

Meander Patterns

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Location:	**Pike National Forest, CO**
Observers:	**K. Wright, L. Chavez *et al*.**	Date:	**8/26/2010**

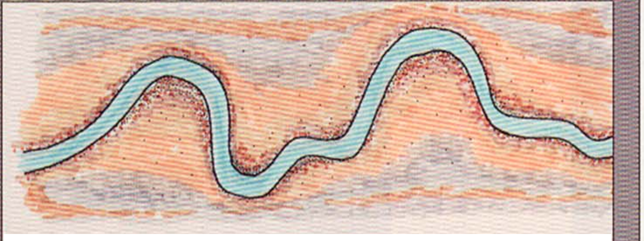
List ALL CATEGORIES that APPLY ☞	**M1**				

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

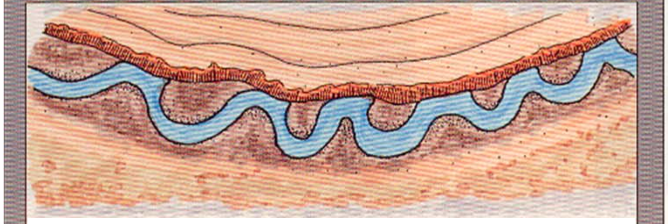


[✓ M1] REGULAR MEANDERS

M2 TORTUOUS MEANDERS

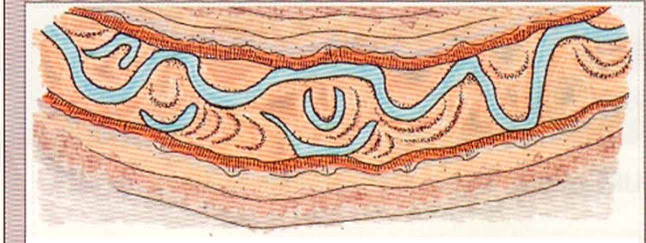


M3 IRREGULAR MEANDERS

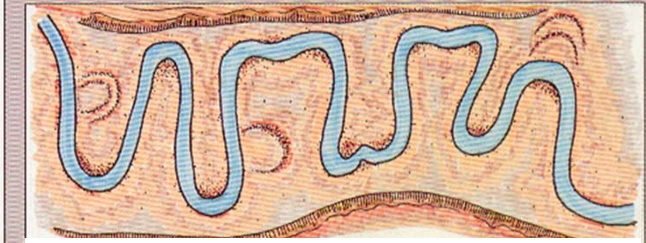


M4 TRUNCATED MEANDERS

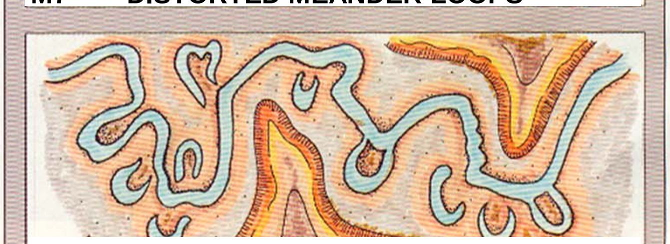
M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS



M8 IRREGULAR MEANDERS with oxbows and

Worksheet 5-10. Depositional patterns.

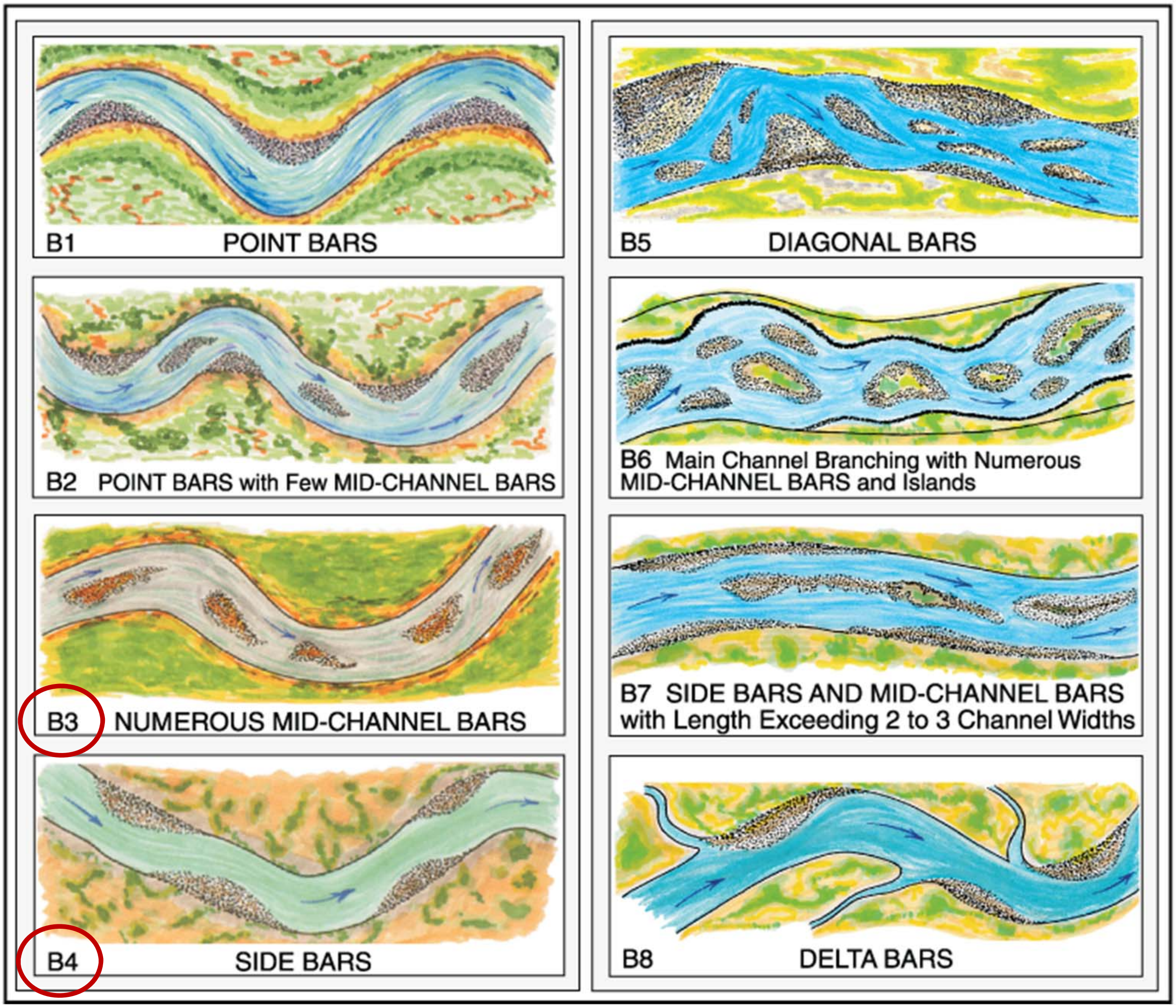
Depositional Patterns

Stream: **Trail Creek, F4b Fair-Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez *et al*.** Date: **8/26/2010**

List ALL CATEGORIES that APPLY ☞	**B3**	**B4**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, F4b Fair-Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright, L. Chavez *et al*.** Date: **8/26/2010**

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.	☐

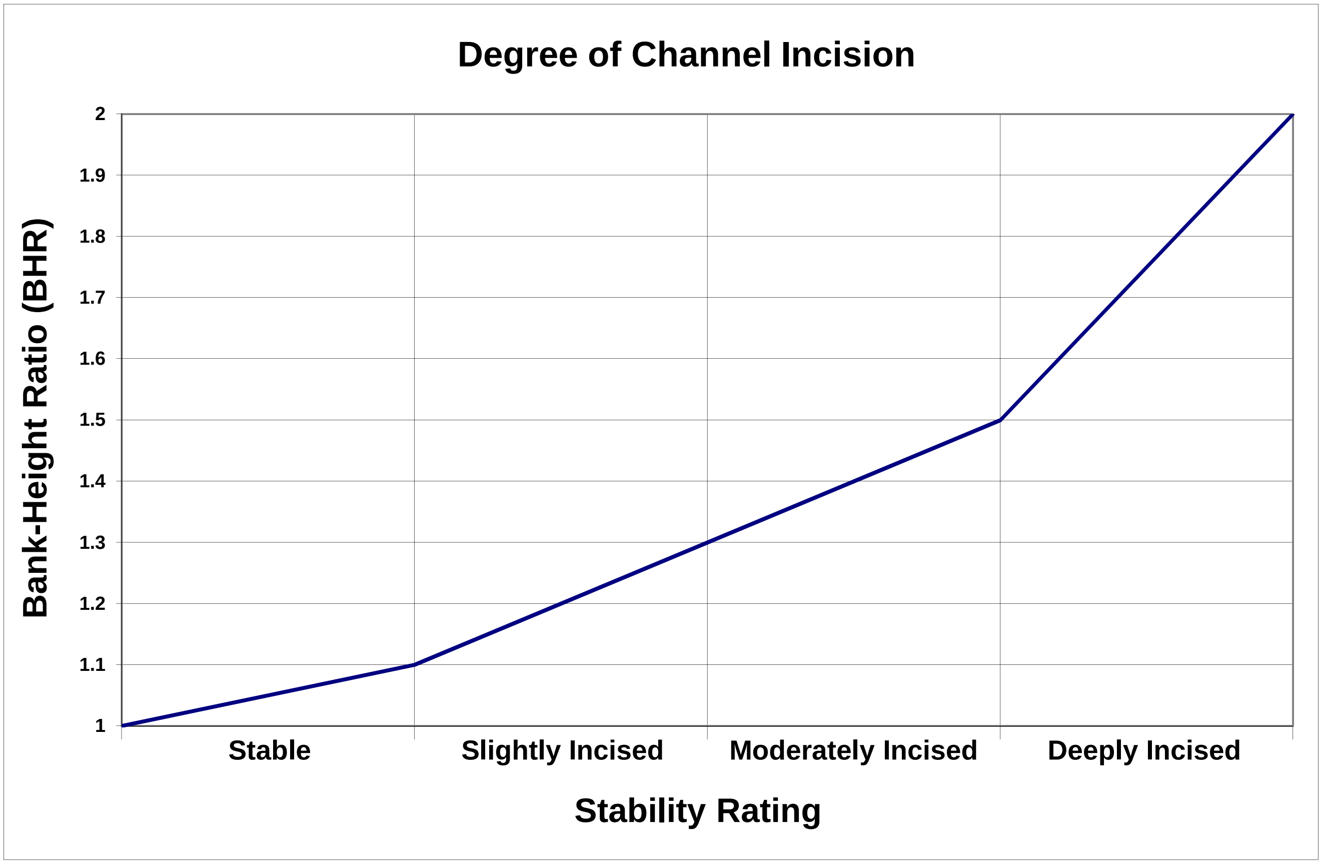
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**1.1**
Max Bankfull Depth:	**1.1**

Bank-Height Ratio:	**1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**

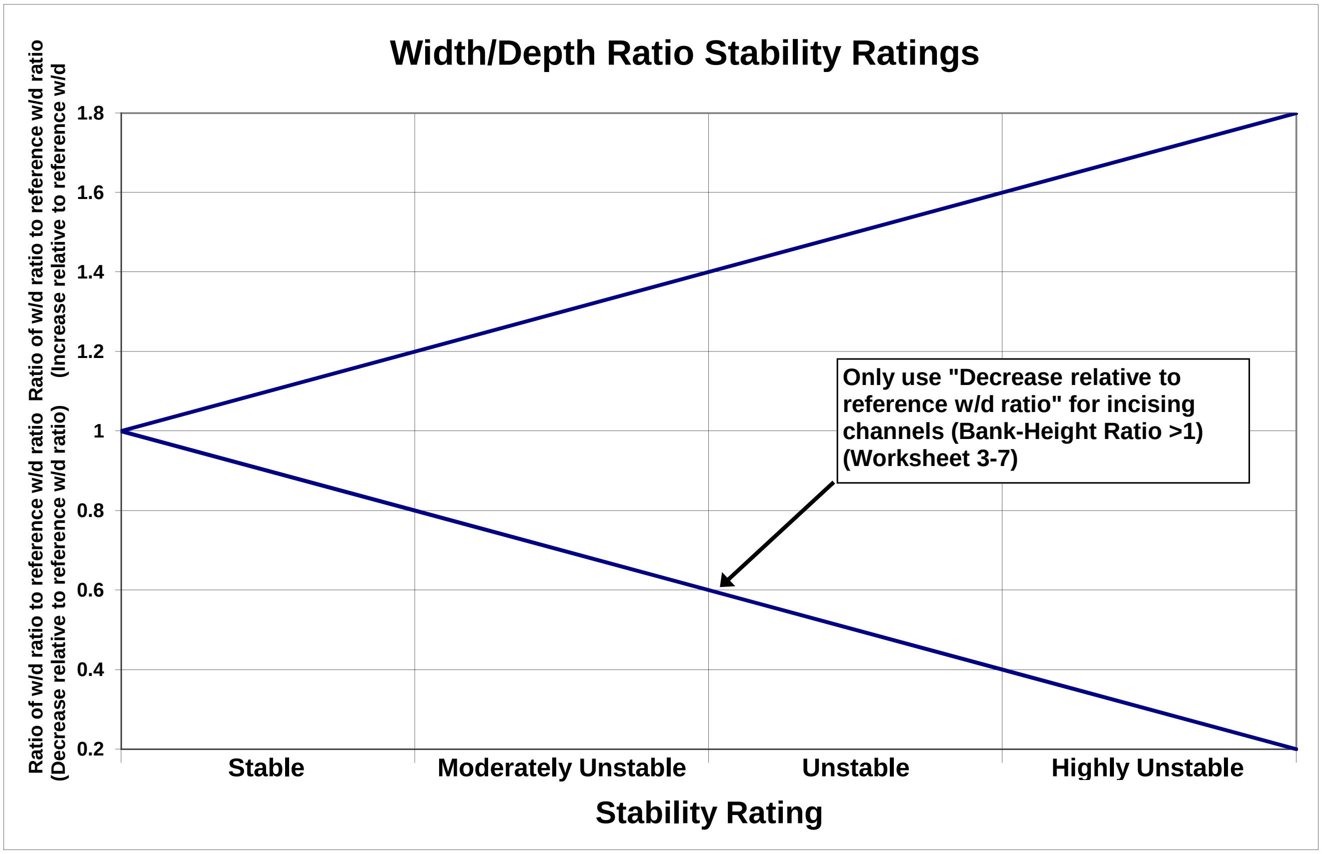


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**37.6**	Ratio of existing W/d to reference W/d:	**2.99**
Reference Width/Depth Ratio:	**12.57**		

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

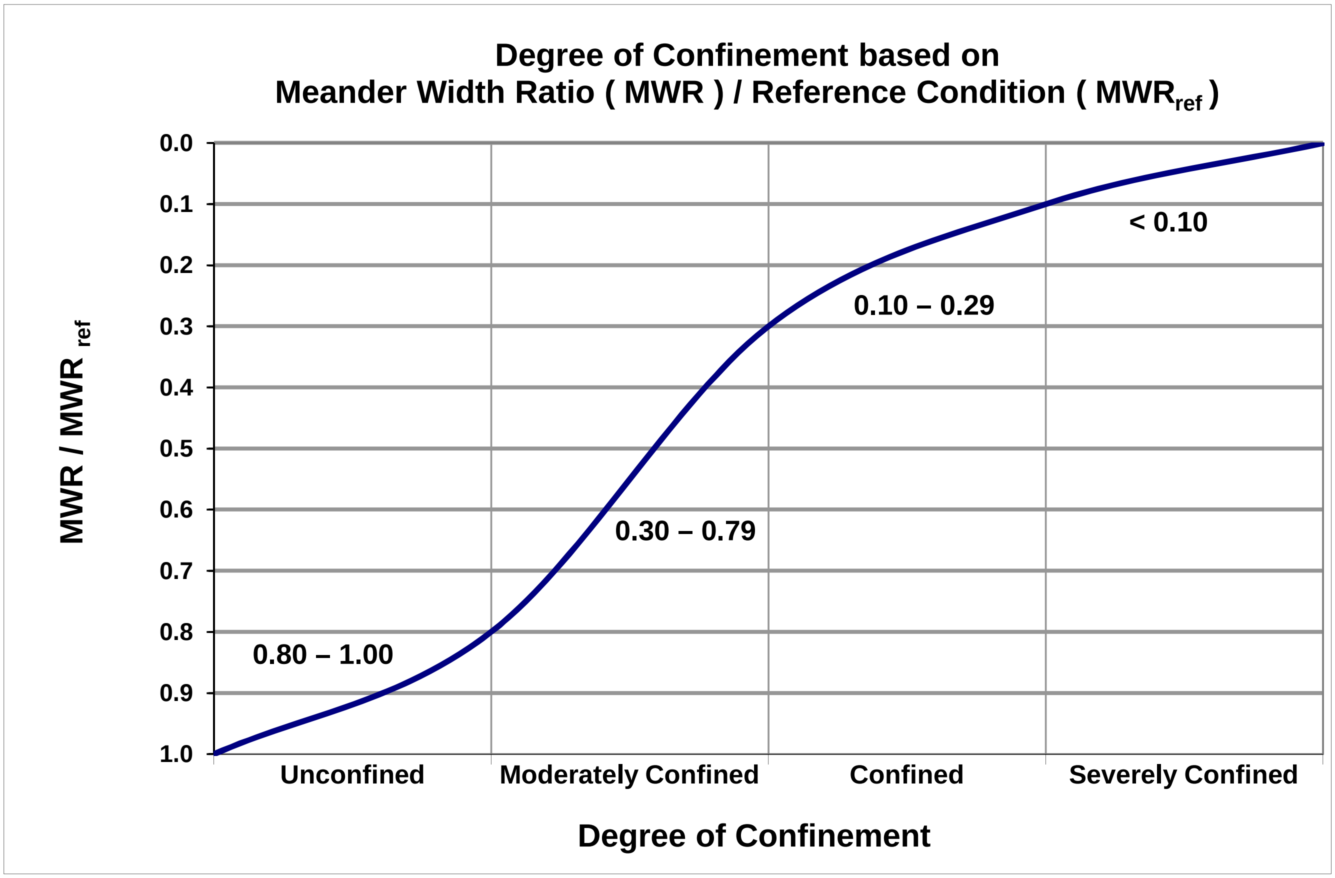
Degree of Confinement

Existing Meander Width Ratio (MWR): **1.18**

Reference Meander Width Ratio (MWR_{ref}): **2.7**

Ratio of MWR to MWR_{ref}: **0.44**

Degree of Confinement Stability Rating ☞ **Mod. Confined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, F4b Fair-Poor Reach **Location:** Pike National Forest, CO **Valley Type:** VIII **Observers:** K. Wright, L. Chavez *et al*. **Date:** 8/26/2010

Location	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	8	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	7	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	9	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	14	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	4	Good total =	19	Fair total =	56	Poor total =	24

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	103
Existing stream type =	F4
*Potential stream type =	B4

Modified channel stability rating =
Poor

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

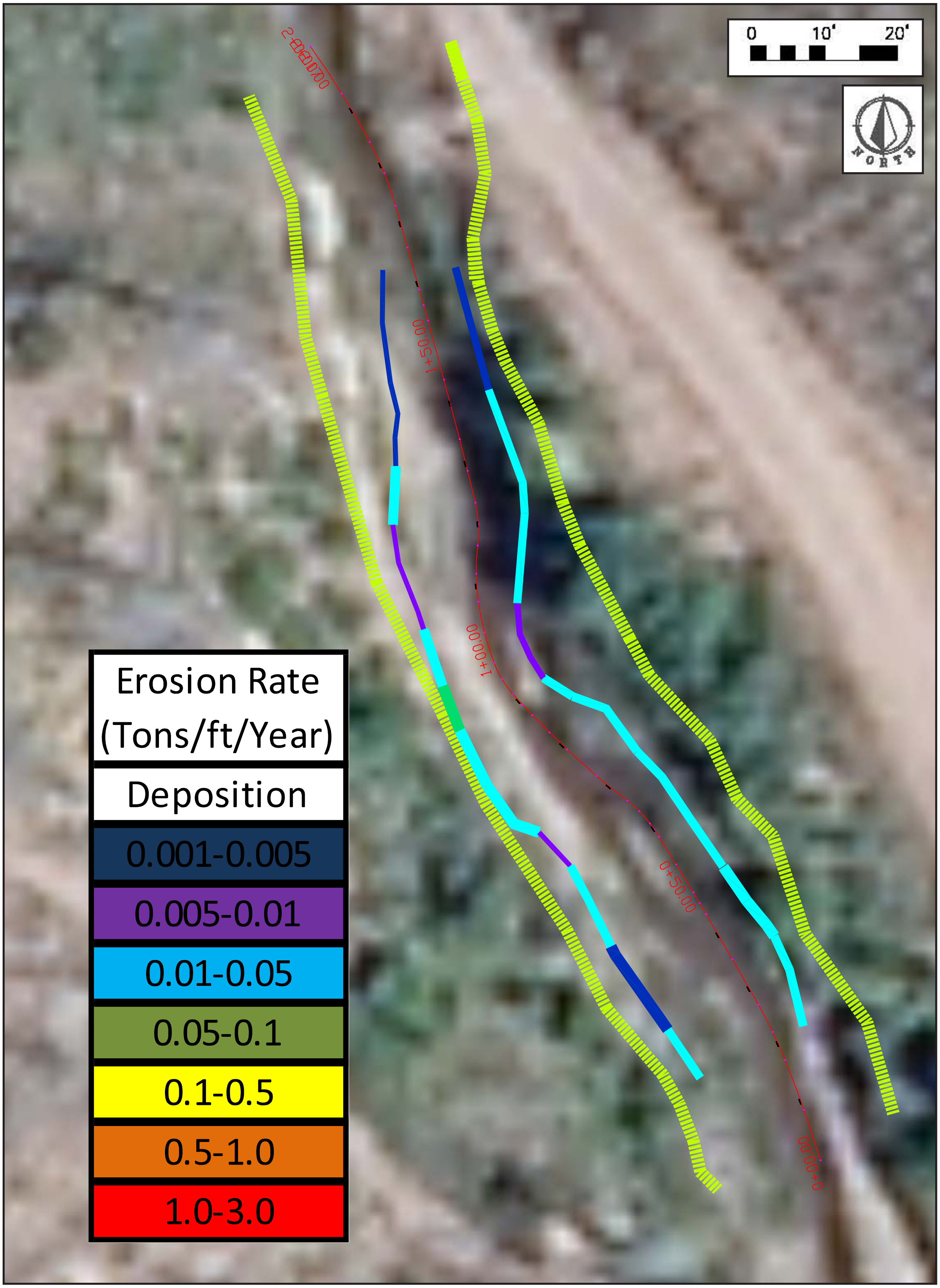
Stream: **Trail Creek, F4b Fair-Poor Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **221** Date: **8/26/2010**

Observers: **K. Wright, L. Chavez *et al*.** Valley Type: **VIII** Stream Type: **F4b**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **1-13 RB**	**Moderate**	**Moderate**	**0.25348**	**13.0**	**1.4**	**4.48**	**0.01660**
2. **85-100 LB**	**Very High**	**Moderate**	**0.37957**	**15.0**	**1.8**	**10.25**	**0.03290**
3. **172-182 RB**	**Moderate**	**Low**	**0.15287**	**10.0**	**4.5**	**6.88**	**0.03312**
4. **1-10 LB**	**Moderate**	**Low**	**0.15287**	**10.0**	**1.4**	**2.08**	**0.01001**
5. **13-29 RB**	**Moderate**	**Low**	**0.15287**	**16.0**	**1.8**	**4.28**	**0.01288**
6. **10-35 LB**	**Low**	**Moderate**	**0.07435**	**25.0**	**1.4**	**2.53**	**0.00487**
7. **35-48 LB**	**Low**	**Low**	**0.03566**	**13.0**	**1.4**	**0.63**	**0.00233**
8 **29-62 RB**	**Moderate**	**Moderate**	**0.25348**	**33.0**	**1.4**	**11.38**	**0.01660**
9 **48-85 LB**	**Moderate**	**Moderate**	**0.25348**	**37.0**	**0.8**	**7.50**	**0.00976**
10 **62-86 RB**	**Low**	**High**	**0.15505**	**24.0**	**1.0**	**3.72**	**0.00747**
11 **86-101 RB**	**Moderate**	**High**	**0.42031**	**15.0**	**1.0**	**6.30**	**0.02024**
12 **100-114 LB**	**High**	**Moderate**	**0.37957**	**15.0**	**1.8**	**10.25**	**0.03290**
13 **101-137 RB**	**Low**	**Low**	**0.03566**	**36.0**	**0.8**	**1.03**	**0.00137**
14 **114-121 LB**	**High**	**Very High**	**0.87205**	**7.0**	**1.8**	**10.99**	**0.07558**
15 **121-134 LB**	**Very High**	**High**	**0.57533**	**13.0**	**1.6**	**11.97**	**0.04432**
16 **137-172 RB**	**Low**	**Moderate**	**0.07435**	**35.0**	**1.3**	**3.38**	**0.00465**
17 **134-154 LB**	**Moderate**	**Low**	**0.15287**	**20.0**	**0.8**	**2.45**	**0.00589**
18 **154-172 LB**	**Moderate**	**Moderate**	**0.25348**	**18.0**	**1.6**	**7.30**	**0.01953**
19 **172-215 LB**	**Low**	**Low**	**0.03566**	**43.0**	**0.8**	**1.23**	**0.00137**
20 **182-221 RB**	**Low**	**Low**	**0.03566**	**39.0**	**1.2**	**1.67**	**0.00206**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**110.29**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**4.08**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**5.31**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0240**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**29.4**	**0.0163**	**22.55**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**74.8**													
0.10%	**64.2**	**0.05%**	**0.09%**	**0.34**	**69.5**	**2.363**	**7.461**	**31.56**	**6.670**	**10.33**	**23.8**	**10.83**	**3.55**	**14.38**
0.25%	**55.5**	**0.08%**	**0.15%**	**0.55**	**59.9**	**2.036**	**5.232**	**19.07**	**4.809**	**7.45**	**32.8**	**10.44**	**4.08**	**14.52**
0.50%	**48.0**	**0.13%**	**0.25%**	**0.91**	**51.8**	**1.761**	**3.706**	**11.68**	**3.494**	**5.41**	**47.2**	**10.66**	**4.94**	**15.60**
0.75%	**41.0**	**0.13%**	**0.25%**	**0.91**	**44.5**	**1.513**	**2.592**	**7.02**	**2.502**	**3.88**	**40.6**	**6.41**	**3.54**	**9.94**
1%	**35.4**	**0.13%**	**0.25%**	**0.91**	**38.2**	**1.300**	**1.817**	**4.23**	**1.790**	**2.77**	**34.9**	**3.86**	**2.53**	**6.39**
1.5%	**30.4**	**0.25%**	**0.50%**	**1.83**	**32.9**	**1.120**	**1.289**	**2.59**	**1.289**	**2.00**	**60.1**	**4.72**	**3.64**	**8.36**
2%	**25.4**	**0.25%**	**0.50%**	**1.83**	**27.9**	**0.949**	**0.886**	**1.50**	**0.893**	**1.38**	**50.9**	**2.75**	**2.52**	**5.27**
3%	**21.4**	**0.50%**	**1.00%**	**3.65**	**23.4**	**0.795**	**0.600**	**0.85**	**0.602**	**0.93**	**85.3**	**3.12**	**3.40**	**6.52**
4%	**18.3**	**0.50%**	**1.00%**	**3.65**	**19.8**	**0.674**	**0.424**	**0.51**	**0.415**	**0.64**	**72.3**	**1.87**	**2.35**	**4.22**
5%	**16.3**	**0.50%**	**1.00%**	**3.65**	**17.3**	**0.587**	**0.322**	**0.34**	**0.304**	**0.47**	**63.0**	**1.24**	**1.72**	**2.95**
10%	**10.2**	**2.50%**	**5.00%**	**18.25**	**13.2**	**0.450**	**0.200**	**0.16**	**0.165**	**0.26**	**241.5**	**2.94**	**4.66**	**7.60**
20%	**5.6**	**5.00%**	**10.00%**	**36.50**	**7.9**	**0.269**	**0.103**	**0.05**	**0.045**	**0.07**	**288.1**	**1.81**	**2.57**	**4.37**
30%	**3.7**	**5.00%**	**10.00%**	**36.50**	**4.6**	**0.158**	**0.075**	**0.02**	**0.006**	**0.01**	**169.5**	**0.77**	**0.36**	**1.13**
40%	**2.6**	**5.00%**	**10.00%**	**36.50**	**3.2**	**0.108**	**0.068**	**0.01**	**0.000**	**0.00**	**115.8**	**0.48**	**0.00**	**0.48**
50%	**2.0**	**5.00%**	**10.00%**	**36.50**	**2.3**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**84.7**	**0.34**	**0.00**	**0.34**
60%	**1.5**	**5.00%**	**10.00%**	**36.50**	**1.8**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**65.0**	**0.26**	**0.00**	**0.26**
70%	**1.2**	**5.00%**	**10.00%**	**36.50**	**1.4**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**50.8**	**0.20**	**0.00**	**0.20**
80%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.2**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**42.4**	**0.17**	**0.00**	**0.17**
90%	**0.8**	**5.00%**	**10.00%**	**36.50**	**0.9**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**33.9**	**0.13**	**0.00**	**0.13**
100%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**16.9**	**0.07**	**0.00**	**0.07**
									Annual Totals:		**1,619.7** (cfs) **3,212.7** (acre-ft)	**63.0** (tons/yr)	**39.9** (tons/yr)	**102.9** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	29.4	0.0310	44.00
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	97.4													
0.10%	86.8	0.05%	0.09%	0.34	92.1	3.132	14.647	160.23	12.384	36.58	31.6	54.97	12.55	67.52
0.25%	78.2	0.08%	0.15%	0.55	82.5	2.805	11.247	110.19	9.723	28.71	45.2	60.33	15.72	76.05
0.50%	70.6	0.13%	0.25%	0.91	74.4	2.530	8.784	77.61	7.750	22.89	67.9	70.82	20.89	91.71
0.75%	63.6	0.13%	0.25%	0.91	67.1	2.282	6.867	54.74	6.180	18.25	61.2	49.95	16.66	66.60
1%	58.1	0.13%	0.25%	0.91	60.8	2.069	5.436	39.28	4.982	14.71	55.5	35.84	13.43	49.27
1.5%	52.7	0.25%	0.50%	1.83	55.4	1.884	4.351	28.63	4.055	11.97	101.1	52.24	21.85	74.10
2%	47.4	0.25%	0.50%	1.83	50.0	1.702	3.420	20.33	3.243	9.58	91.3	37.10	17.48	54.58
3%	43.3	0.50%	1.00%	3.65	45.3	1.542	2.712	14.61	2.611	7.71	165.5	53.33	28.15	81.48
4%	38.5	0.50%	1.00%	3.65	40.9	1.391	2.128	10.34	2.079	6.14	149.3	37.74	22.41	60.15
5%	34.0	0.50%	1.00%	3.65	36.2	1.232	1.606	6.91	1.592	4.70	132.2	25.23	17.16	42.39
10%	21.2	2.50%	5.00%	18.25	27.6	0.939	0.865	2.84	0.872	2.58	503.8	51.78	47.00	98.78
20%	7.5	5.00%	10.00%	36.50	14.3	0.488	0.229	0.39	0.199	0.59	523.6	14.26	21.44	35.70
30%	3.8	5.00%	10.00%	36.50	5.7	0.193	0.081	0.05	0.016	0.05	206.8	2.00	1.74	3.73
40%	2.6	5.00%	10.00%	36.50	3.2	0.110	0.068	0.03	0.000	0.00	118.2	0.96	0.00	0.96
50%	2.0	5.00%	10.00%	36.50	2.3	0.079	0.066	0.02	0.000	0.00	84.7	0.66	0.00	0.66
60%	1.5	5.00%	10.00%	36.50	1.8	0.061	0.065	0.01	0.000	0.00	65.0	0.50	0.00	0.50
70%	1.2	5.00%	10.00%	36.50	1.4	0.047	0.064	0.01	0.000	0.00	50.8	0.39	0.00	0.39
80%	1.1	5.00%	10.00%	36.50	1.2	0.039	0.064	0.01	0.000	0.00	42.4	0.32	0.00	0.32
90%	0.8	5.00%	10.00%	36.50	0.9	0.032	0.064	0.01	0.000	0.00	33.9	0.26	0.00	0.26
100%	0.2	5.00%	10.00%	36.50	0.5	0.016	0.064	0.00	0.000	0.00	16.9	0.13	0.00	0.13
									Annual Totals:		**2,547.0** (cfs) **5,051.9** (acre-ft)	**548.8** (tons/yr)	**256.5** (tons/yr)	**805.3** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used GOOD-FAIR Curves)** Date: **08/14/10**

Observers: **S=.021, Q=29.4, 23.4, Bed.=.0682, S.Sand=22** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.15**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.77**	**0.46**	**0.64**	**5.68**	**0.11**	**0.67**	**0.0210**	**0.15**	**0.60**	**0.11**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**1.08**	**0.93**	**1.03**	**6.44**	**0.16**	**0.86**	**0.0210**	**0.21**	**1.22**	**0.19**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.24**	**1.16**	**1.20**	**6.68**	**0.18**	**0.93**	**0.0210**	**0.23**	**1.52**	**0.23**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.55**	**1.40**	**1.37**	**6.92**	**0.20**	**1.01**	**0.0210**	**0.26**	**1.83**	**0.26**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.00%	**2.01**	**1.78**	**1.60**	**7.17**	**0.22**	**1.09**	**0.0210**	**0.29**	**2.33**	**0.32**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.63**	**2.32**	**1.91**	**7.48**	**0.26**	**1.19**	**0.0210**	**0.33**	**3.04**	**0.41**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.84**	**3.24**	**2.39**	**7.88**	**0.30**	**1.34**	**0.0210**	**0.39**	**4.25**	**0.54**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**7.49**	**5.67**	**3.47**	**8.55**	**0.41**	**1.62**	**0.0210**	**0.52**	**7.43**	**0.87**	**10%**	**36.50**	**0.04**	**0.03**	**1.46**	**1.09**	**2.55**
10.00%	**21.20**	**14.35**	**6.52**	**10.06**	**0.65**	**2.20**	**0.0210**	**0.83**	**18.80**	**1.87**	**10%**	**36.50**	**0.60**	**0.20**	**21.90**	**7.30**	**29.20**
5.00%	**34.01**	**27.61**	**13.39**	**22.98**	**0.58**	**2.06**	**0.0210**	**0.75**	**36.18**	**1.57**	**5%**	**18.25**	**2.64**	**1.46**	**48.18**	**26.64**	**74.82**
4.00%	**38.45**	**36.23**															
3.00%	**43.33**	**40.89**															
2.00%	**47.35**	**45.34**															
1.50%	**52.70**	**50.03**															
1.00%	**58.05**	**55.38**															
0.75%	**63.58**	**60.82**															
0.50%	**70.59**	**67.09**															
0.25%	**78.14**	**74.37**															
0.10%	**86.77**	**82.46**															
0.0060%	**97.36**	**92.07**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**71.5**	**36.5**	**108.0**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, F4b Fair Riffle XS 0+40** Location: **Pike National Forest, Colorado (Used GOOD-FAIR Curves)** Date: **08/14/10**

Observers: **S=.021, Q=29.4, 23.4, Bed.=.0682, S.Sand=22** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.15**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.77**	**0.46**	**0.38**	**2.47**	**0.15**	**1.19**	**0.0210**	**0.19**	**0.60**	**0.24**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**1.08**	**0.93**	**0.60**	**2.67**	**0.22**	**1.52**	**0.0210**	**0.28**	**1.22**	**0.46**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
70.00%	**1.24**	**1.16**	**0.72**	**2.96**	**0.24**	**1.60**	**0.0210**	**0.30**	**1.52**	**0.51**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
60.00%	**1.55**	**1.40**	**0.86**	**3.46**	**0.25**	**1.62**	**0.0210**	**0.30**	**1.83**	**0.53**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
50.00%	**2.01**	**1.78**	**1.11**	**4.56**	**0.24**	**1.61**	**0.0210**	**0.30**	**2.33**	**0.51**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
40.00%	**2.63**	**2.32**	**1.49**	**6.46**	**0.23**	**1.56**	**0.0210**	**0.28**	**3.04**	**0.47**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
30.00%	**3.84**	**3.24**	**1.96**	**7.77**	**0.25**	**1.64**	**0.0210**	**0.31**	**4.25**	**0.55**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
20.00%	**7.49**	**5.67**	**3.42**	**13.80**	**0.25**	**1.65**	**0.0210**	**0.31**	**7.43**	**0.54**	**10%**	**36.50**	**0.00**	**0.02**	**0.00**	**0.73**	**0.73**
10.00%	**21.20**	**14.35**	**6.53**	**17.38**	**0.38**	**2.19**	**0.0210**	**0.48**	**18.80**	**1.08**	**10%**	**36.50**	**0.17**	**0.10**	**6.21**	**3.65**	**9.86**
5.00%	**34.01**	**27.61**	**10.17**	**19.69**	**0.52**	**2.71**	**0.0210**	**0.65**	**36.18**	**1.84**	**5%**	**18.25**	**0.60**	**0.38**	**10.95**	**6.94**	**17.89**
4.00%	**38.45**	**36.23**															
3.00%	**43.33**	**40.89**															
2.00%	**47.35**	**45.34**															
1.50%	**52.70**	**50.03**															
1.00%	**58.05**	**55.38**															
0.75%	**63.58**	**60.82**															
0.50%	**70.59**	**67.09**															
0.25%	**78.14**	**74.37**															
0.10%	**86.77**	**82.46**															
0.0060%	**97.36**	**92.07**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**17.2**	**12.8**	**29.9**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**71.5**	**36.5**	**108.0**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-54.3**	**-23.7**	**-78.1**
Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, > 72% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez, D. Butler & D. Bohon**	Date:	**8/26/2010**

Enter Required Information for Existing Condition

11.1	D_{50}	Riffle bed material D_{50} (mm)			
7.8	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.23	D_{max}	Largest particle from bar sample (ft)	**70**	**(mm)**	304.8 mm/ft
0.021	S	Existing bankfull water surface slope (ft/ft)			
0.53	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.43	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
6.31	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

0.695		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 **50**	CO **120**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.0**	CO **0.35**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.76**	CO **0.27**	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 **0.0302**	CO **0.0106**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, F4b Fair-Poor** Stream Type: **F4b**

Location: **Pike National Forest, CO** Valley Type: **VIII**

Observers: **K. Wright, L. Chavez *et al*.** Date: **8/26/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F),	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez, D. Butler & D. Bohon**	Date:	**8/26/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**8**
	(2)	**(4)**	**(6)**	**3.0** [✓ **(8)**]	
2 **Depositional Patterns (Worksheet5-10)**	B1, B2	**B4**, B8	**B3**	B5, B6, B7	**3**
	(1)	**(2)**	**B3, B4** [✓ **(3)**]	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4		M2, M5, M6, M7, M8		**1**
	M1 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**4**
	(2)	**M/L, MM** [✓ **(4)**]	**(6)**	**(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**2**
	(1)	**0.44** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**18**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trail Creek, F4b Fair-Poor Reach** Stream Type: **F4b**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **K. Wright, L. Chavez, D. Butler & D. Bohon** Date: **8/26/2010**

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 3-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**8**
	(2)	**(4)**	**(6)**	**[✓ (8)]**	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
	(2)	**(4)**	**(6)**	**3.0** **[✓ (8)]**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	Fb to B **[✓ (2)]**	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, **B4**	**B3**, B5	B6, B7, B8	**3**
	(1)	**(2)**	**B3, B4** **[✓ (3)]**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	**D1**, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D1 **[✓ (1)]**	**(2)**	**(3)**	**(4)**	
				Total Points	**24**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez, D. Butler & D. Bohon**	Date:	**8/26/2010**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR$_{\text{ref}}$) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**2**
	(1)	**0.44** [✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**10**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez, D. Butler & D. Bohon**	Date:	**8/26/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F)	**2**
	Fb to B [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Lateral Stability (Worksheet 5-25)**	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	**6**
	(2)	**(4)**	[✓ **(6)**]	**(8)**	
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	**6**
	(2)	**(4)**	[✓ **(6)**]	**(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
				Total Points	**16**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**K. Wright, L. Chavez, D. Butler & D. Bohon**	Date:	**8/26/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	*Stable*	1	3
	Mod. Unstable	2	
	Unstable	[✓ 3]	
	Highly Unstable	4	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	*No Deposition*	1	3
	Mod. Deposition	2	
	Excess Deposition	[✓ 3]	
	Aggradation	4	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	*Not Incised*	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 Channel Enlargement Prediction (Worksheet 5-28)	*No Increase*	1	2
	Slight Increase	[✓ 2]	
	Mod. Increase	3	
	Extensive	4	
5 Pfankuch Channel Stability (Worksheet 5-15)	*Good: Stable*	1	4
	Fair: Mod. Unstable	2	
		3	
	Poor: Unstable	[✓ 4]	
		Total Points	**13**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** 5 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☑	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, F4b Fair-Poor Reach**	Location:	**Pike National Forest, Colorado**										
Observers:	**Wright, Chavez, Butler, Bohon**	Date:	**8/26/2010**	Stream Type:	**F4b**	Valley Type:	**VIII**						
Channel Dimension (Riffle XS 0+40)	Mean Bankfull Depth (ft):	**0.53**	Bankfull Width (ft):	**19.9**	Cross-Sectional Area (ft^2):	**10.6**	Width of Flood-Prone Area (ft):	**26.336**	Entrenchment Ratio:	**1.32**			
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**1.18**	Sinuosity:	**1.03**		
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed								
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope				
		1.35	**1.4**		**2.21**	**2.3**		**0.19**	Valley:	**0.0215**	Water Surface:	**0.021**	
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Willow, Aspen, Grass, Forb**	Potential Composition/Density: **Same but mature species**	Remarks: Condition, Vigor & Usage of Existing Reach:									
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-4(4)**	Meander Patterns:	**M1**	Depositional Patterns:	**B3, B4**	Debris/Channel Blockages:	**D1**			
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**103 (Fair-Poor)**							
	Width/depth Ratio (W/d):	**37.6**	Reference W/d Ratio (W/d$_{ref}$):	**12.6**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**2.99**	W/d Ratio State Stability Rating:	**Highly Unstable**					
	Meander Width Ratio (MWR):	**1.18**	Reference MWR$_{ref}$:	**2.7**	Degree of confinement (MWR / MWR$_{ref}$):	**0.44**	MWR / MWR$_{ref}$ Stability Rating:	**Moderately Confined**					
Bank Erosion Summary	Length of Reach Studied (ft):	**221**	Annual Streambank Erosion Rate:	**5.31** (tons/yr)	**0.024** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:					
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity	Remarks: **> 70% Reduction in Transport Capacity**									
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**70**	$\tau =$	**0.695**	$\tau^* =$	**N/A**	Existing Depth:	**0.53**	Required Depth:	**0.27-0.76**	Existing Slope:	**0.021**	Required Slope: **0.01-0.03**
Successional Stage Shift	**B** → **G** → [✓ **Fb**] → **B** → →	Existing Stream State (Type):	**F4b**	Potential Stream State (Type):	**B4**								
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:								
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:								
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:								
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes: **Trending toward B**								
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes: **Banks sloughed in and vegetated, trending toward B stream type**								

Appendix C12

F4b Stream Type

Poor Stability Reach

Table of Contents

Appendix C12: F4b Poor Stability Reach

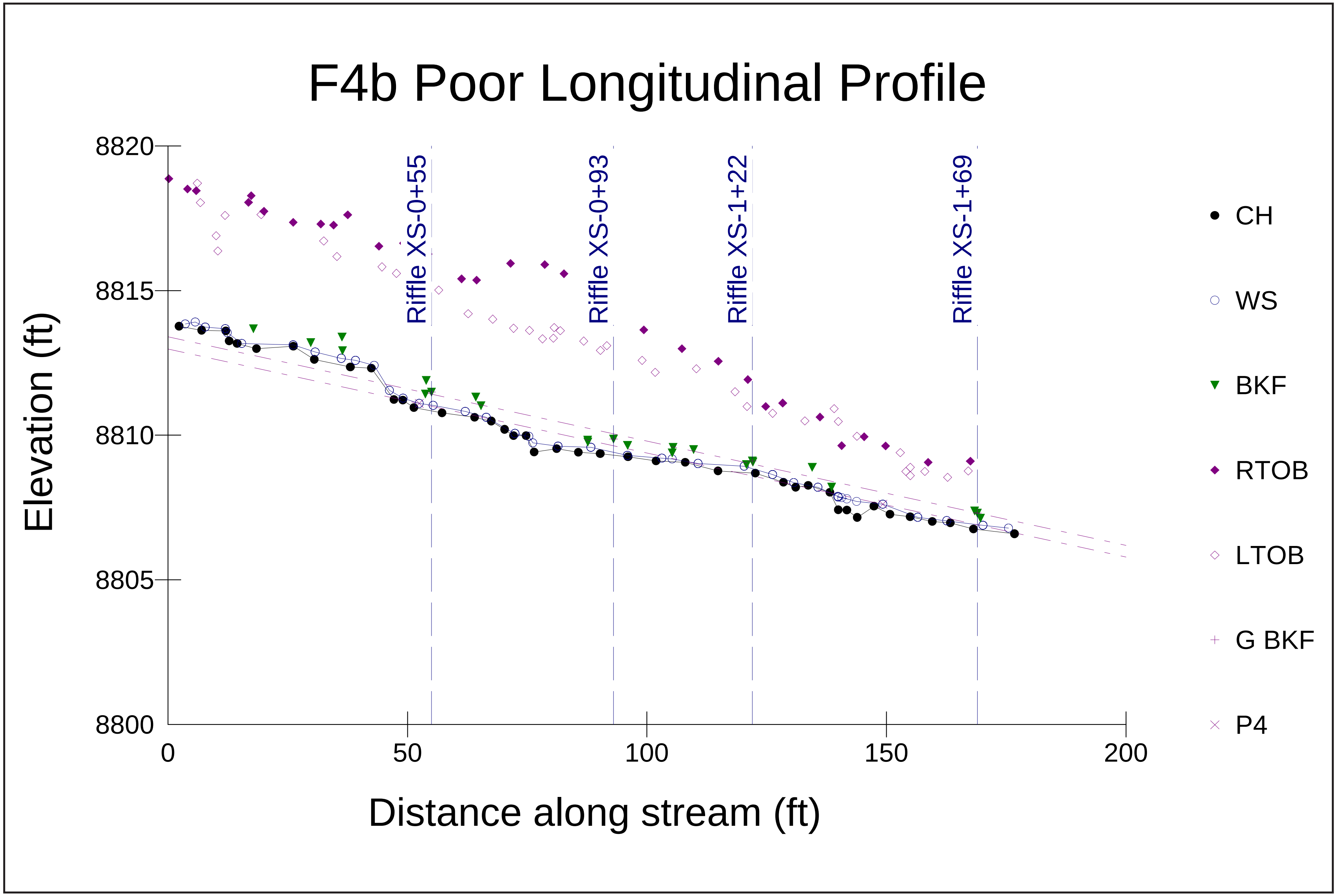
F4b Poor Reach Location & Overview

This F4b Poor reach is a 3rd order, perennial, relatively steep gradient, entrenched stream located in Northfield Gulch (**Figure C-1**). The width/depth ratio of *22* is high and will continue to promote high streambank erosion in this gulch-fill, alluvial Valley Type VIIIa. The stream is continuing to enlarge due to high peak flows following the fire. The potential stable channel in this valley type is a B4 stream type.

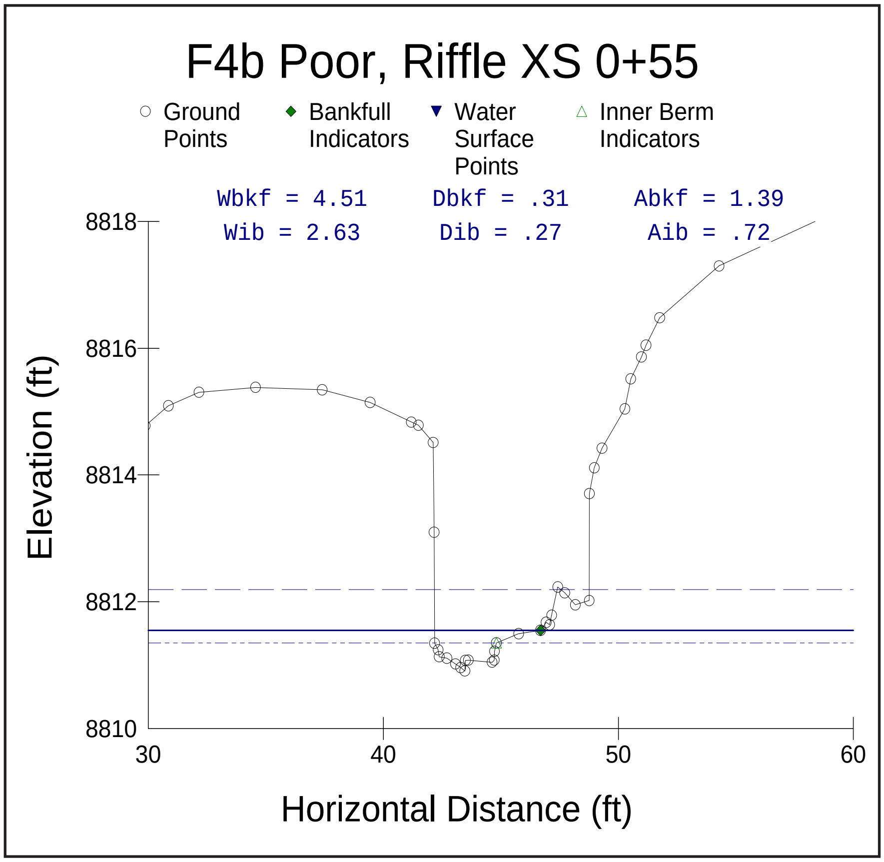
A POWERSED run was made to determine streambed stability, which predicted deposition. The stability rating is "Poor" due to a Pfankuch stability rating of 143 ("Poor") and a high streambank erosion rate of *0.27 tons/yr/ft*. The sediment supply rating is *High*, typical of an F4b stream type, due to the high banks on both sides and deposition in the bed. The "Poor" stability rating indicates a higher potential of accelerated increases in flow-related sediment compared to the same-sized B4 reference stream type. The WRENSS model indicated that the water yield due to the fire increased from *119.1 acre-ft to 159.6 acre-ft*, representing a total increase of *40.5 acre-ft pre year*. The corresponding bedload increased from *0.1 tons/year to 68.9 tons/yr*, and suspended sediment increase from *14.6 tons/yr to 1151.5 tons/yr*, representing a total increase in sediment of *1,205.7 tons/yr*. This sediment yield increase is extremely high for a stream with a bankfull discharge of 2.31 cfs.

The photograph depicts the typical character of this representative F4b Poor stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

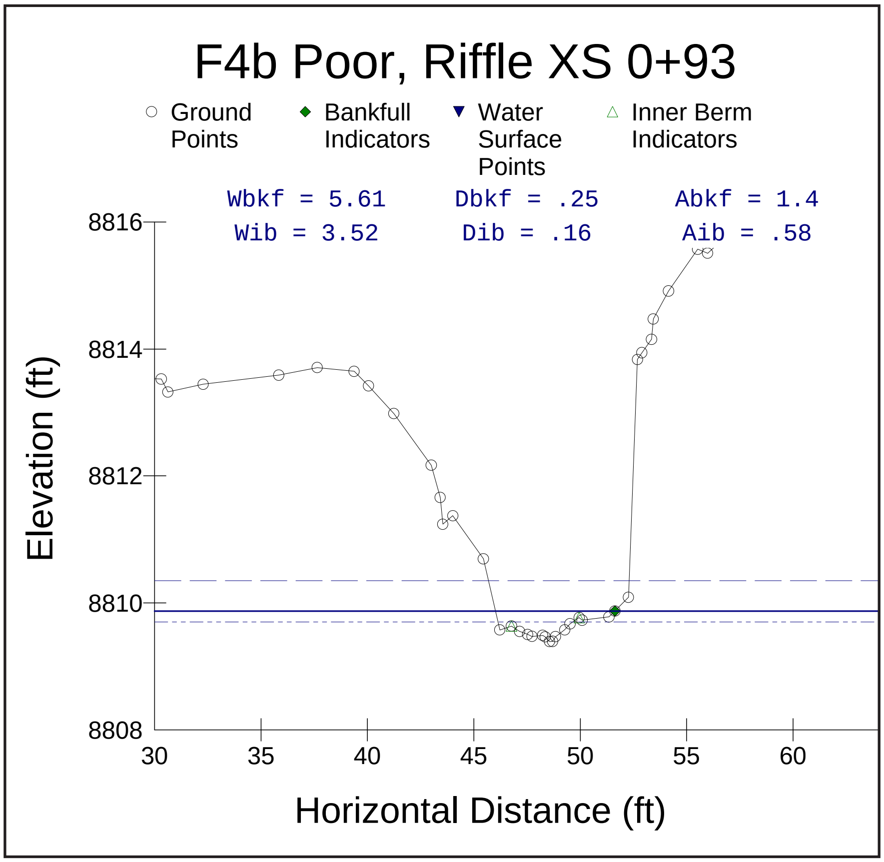
Survey Summary



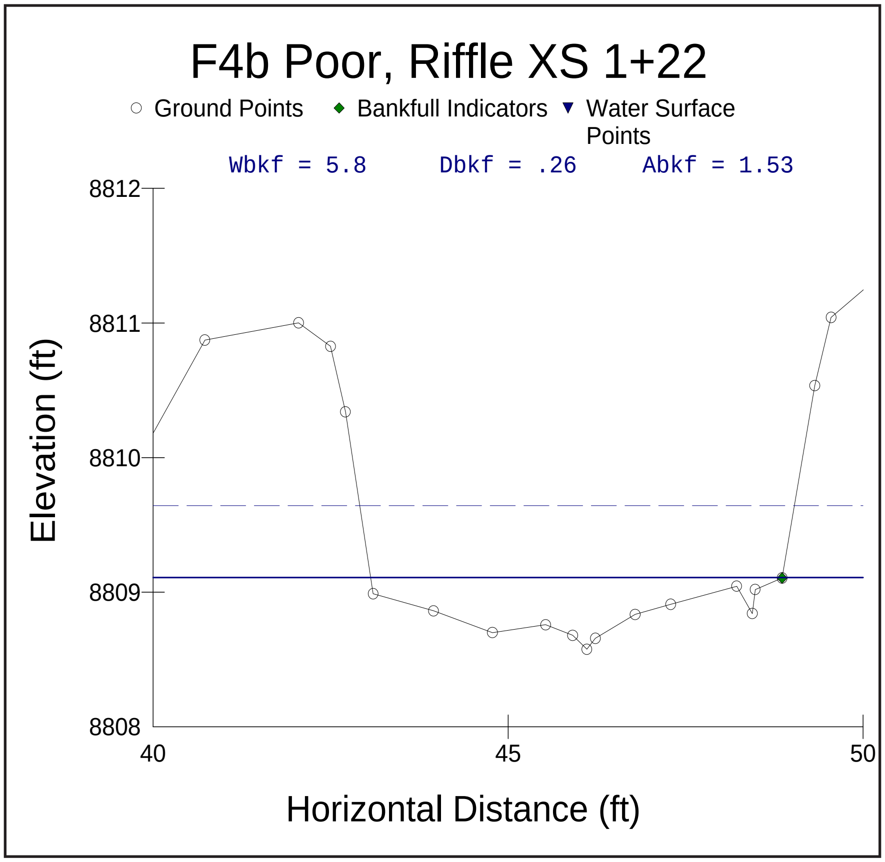
Longitudinal Profile (graph generated from RIVERMorph^{TM})



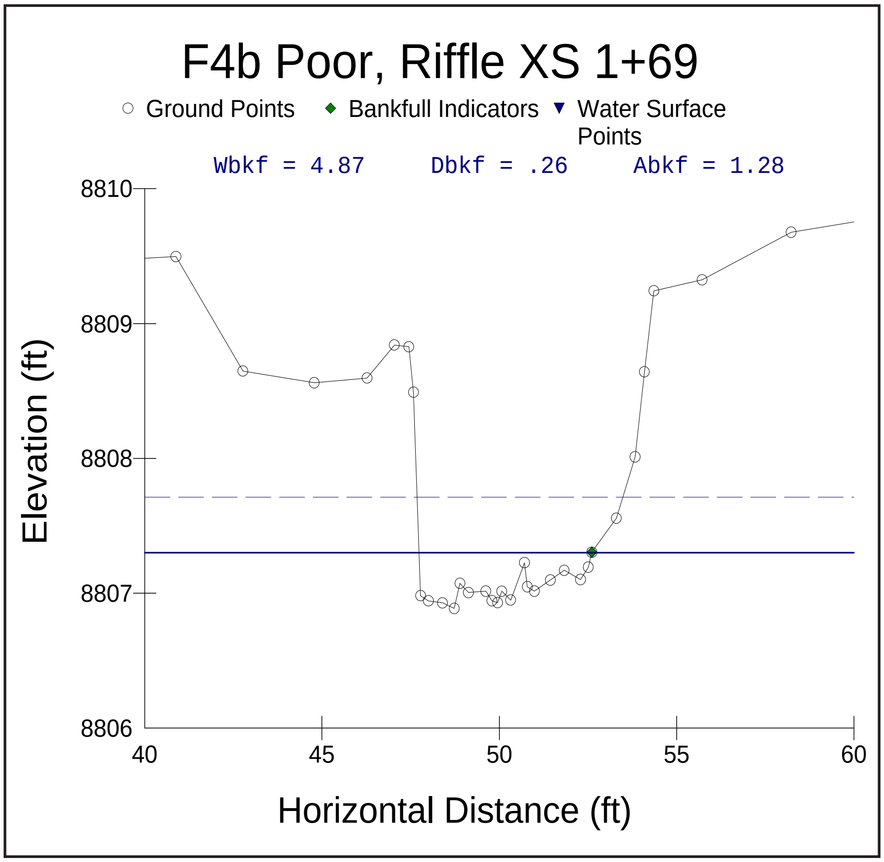
Cross-section 0+55 (graph generated from RIVERMorph^{TM})



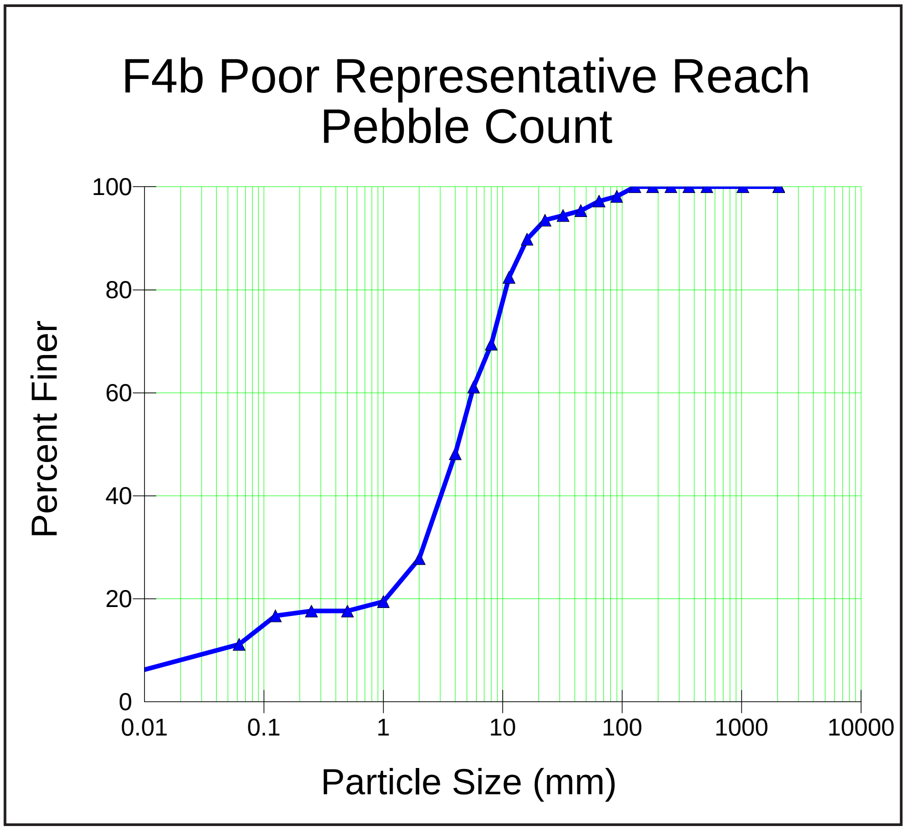
Cross-section 0+93 (graph generated from RIVERMorph^{TM})



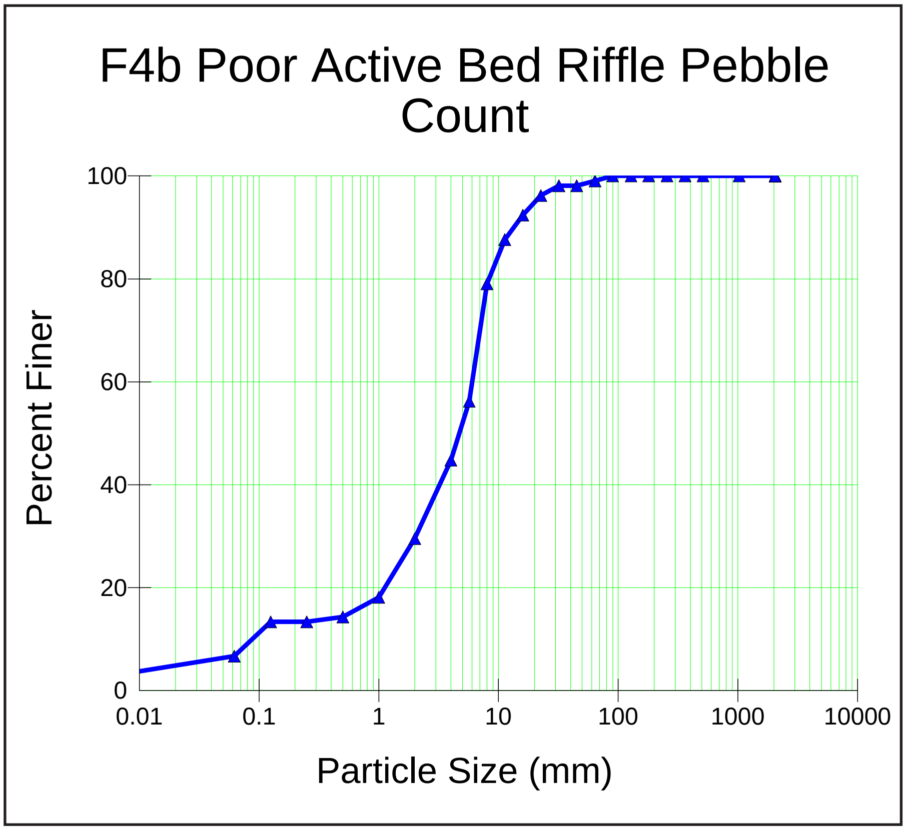
Representative Cross-section 1+22 (graph generated from RIVERMorph^{TM})



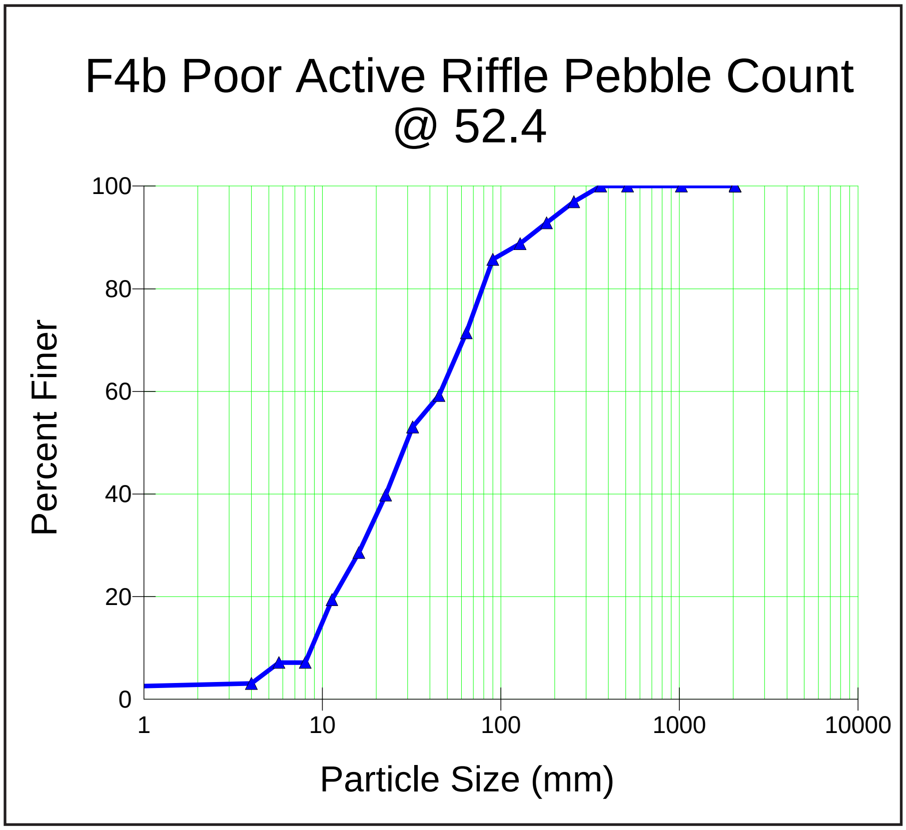
Cross-section 1+69 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Upper Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count at 52.4 (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Northfield Gulch**	Location:	**F4b Poor XS @ 1+22**
Date:	**11/2/2012**	Stream Type:	**F4b**
Valley Type:	**VIIIa**		
Observers:	**Rosgen, et. al.**	HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	1.53	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	0.26	d_{bkf} (ft)
Bankfull Riffle WIDTH	5.8	W_{bkf} (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	6.25	W_p (ft)
D_{84} at Riffle	9.9	Dia. (mm)	D_{84} (mm) / 304.8	0.03	D_{84} (ft)
Bankfull SLOPE	0.04	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	0.24	R (ft)
Gravitational Acceleration	32.2	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	7.53	R / D_{84}
Drainage Area	0.31	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	0.520	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	4.09	ft / sec	6.26	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49 * R^{2/3} * S^{1/2} / n$ n = 0.057	1.91	ft / sec	2.92	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49 * R^{2/3} * S^{1/2} / n$ n = 0.057	1.91	ft / sec	2.92	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 = 0.137 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	0.80	ft / sec	1.22	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) Darcy-Weisbach (Leopold, Wolman and Miller)	4.34	ft / sec	6.6	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A Return Period for Bankfull Discharge Q = ____ year		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **NorthfieldGulch, Reach - F4b Poor**

Basin: Drainage Area: **201** acres **0.31** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 1+22** Date: **11/2/2012**

Observers: **Rosgen, et. al.** Valley Type: **VIIIa**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**5.8**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.26**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**1.53**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**22.31**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.53**	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.	**6.12**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.06**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**4.22**	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.	**0.036**	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 (S_{val} / S).	**1.05**	

Stream Type **F4b** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Northfield Gulch F4b Poor**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen et. al.**
Date: **11/2/12**
Valley Type: **VIIIa**
Stream Type: **F4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Riffle Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Riffle Width (W_{bkf})	**5.2**	**4.5**	**5.8**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**1.4**	**1.3**	**1.5**
Mean Riffle Depth (d_{bkf})	**0.27**	**0.25**	**0.31**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**19.5**	**14.6**	**22.4**
Maximum Riffle Depth (d_{max})	**0.52**	**0.41**	**0.64**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.900**	**1.577**	**2.065**
Width of Flood-Prone Area (W_{fpa})	**6.2**	**5.8**	**6.6**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.2**	**1.1**	**1.4**
Riffle Inner Berm Width (W_{ib})	**3.9**	**2.6**	**5.1**	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	**0.743**	**0.583**	**0.903**
Riffle Inner Berm Depth (d_{ib})	**0.22**	**0.17**	**0.27**	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	**0.781**	**0.681**	**0.883**
Riffle Inner Berm Area (A_{ib})	**0.8**	**0.7**	**0.9**	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	**0.566**	**0.516**	**0.615**
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	**19.7**	**9.6**	**29.8**					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Northfield Gulch F4b Poor** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/2/2012** Valley Type: **VIIIa** Stream Type: **F4b**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**1.91**	ft/sec	Estimation Method	**Friction Factor**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**2.92**	cfs	Drainage Area	**0.30**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**63.0**			ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**12.12**		
Stream Meander Length (L_m)	**68.0**			ft	Stream Meander Length Ratio (L_m / W_{bkf})	**13.08**		
Radius of Curvature (R_c)	**34.5**	**32.0**	**37.0**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**6.63**	**6.15**	**7.12**
Belt Width (W_{blt})	**25.0**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**10.45**	**5.94**	**18.51**
Arc Length (L_a)	**33.0**	**33.0**	**33.0**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**6.35**	**6.35**	**6.35**
Riffle Length (L_r)	**20.4**	**17.8**	**24.4**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**3.92**	**3.42**	**4.69**
Individual Pool Length (L_p)	**6.2**	**5.0**	**7.4**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.19**	**0.96**	**1.43**
Pool to Pool Spacing (P_s)	**66.1**	**66.1**	**66.1**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**12.71**	**12.71**	**12.71**

Channel Profile

Valley Slope (S_{val})	**0.0378**	ft/ft	Average Water Surface Slope (S)	**0.0360**	ft/ft	Sinuosity (S_{val} / S)	**1.05**
Stream Length (SL)	**167.0**	ft	Valley Length (VL)	**159.0**	ft	Sinuosity (SL / VL)	**1.05**

Low Bank Height (LBH)	start	**4.37**	ft	Max Bankfull Depth (d_{max})	start	**0.50**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**8.7**
	end	**2.09**	ft		end	**0.43**	ft		end	**4.8**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.540**	**0.490**	**0.570**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**15.000**	**13.611**	**15.833**
Run Slope (S_{run})	**0.820**	**0.680**	**0.960**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**22.778**	**18.889**	**26.667**
Pool Slope (S_p)	**1.120**	**1.010**	**1.220**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**31.111**	**28.056**	**33.889**
Glide Slope (S_g)	**0.780**	**0.550**	**0.960**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**21.667**	**15.278**	**26.667**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**0.54**	**0.49**	**0.57**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.000**	**1.815**	**2.111**
Max Run Depth (d_{maxr})	**0.82**	**0.68**	**0.96**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**3.037**	**2.519**	**3.556**
Max Pool Depth (d_{maxp})	**1.12**	**1.01**	**1.22**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**4.148**	**3.741**	**4.519**
Max Glide Depth (d_{maxg})	**0.87**	**0.55**	**0.96**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**3.222**	**2.037**	**3.556**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**11.11**	**6.67**		D_{16}	**0.12**	**0.72**		**10.39**	mm
% Sand	**16.67**	**22.85**		D_{35}	**2.71**	**2.72**		**19.78**	mm
% Gravel	**69.44**	**69.53**		D_{50}	**4.24**	**4.78**		**29.83**	mm
% Cobble	**2.78**	**0.95**		D_{84}	**12.31**	**9.91**		**86.89**	mm
% Boulder	**0.00**	**0.00**		D_{95}	**39.83**	**20.54**		**219.86**	mm
% Bedrock	**0.00**	**0.00**		D_{100}	**128.00**	**90.00**		**362.00**	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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Northfield Gulch, F4b Poor**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **11/2/2012**

Existing species composition: **Burnt trees & young aspen**

Potential species composition: **Aspen, Doug-fir, Ponderosa pine, Spruce**

Riparian cover categories		**Percent aerial cover***	**Percent of site coverage****	**Species composition**	**Percent of total species composition**
1. Overstory	Canopy layer	**5%**	**25%**	**Aspen**	**2%**
				Douglass-Fir	**5%**
				Ponderoso Pine	**3%**
					0%
					0%
					0%
					10%
2. Understory	Shrub layer	▨	**5%**	**Willow**	**40%**
				Aspen	**60%**
					0%
					0%
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	**40%**	**Grass**	**80%**
				Forbs	**20%**
					0%
					0%
					0%
					0%
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**25%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Burnt tress dominate landscape, few young aspen repopulating.

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Northfield Gulch F4b Poor** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/2/2012**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Northfield Gulch F4b Poor**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.**

Date: **11/2/2012**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

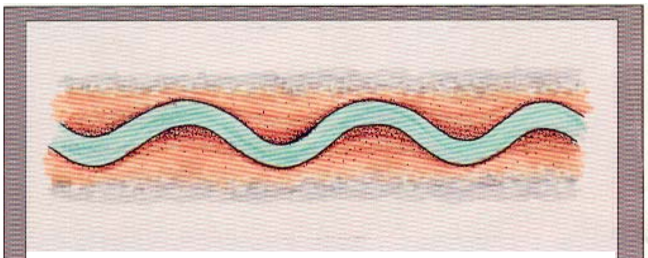
Meander Patterns

Stream: **Northfield Gulch F4b Poor** Location: **Pike National Forest, CO**

Observers: **Rosgen et. al.** Date: **11/2/2012**

List ALL CATEGORIES that APPLY ☞	**M3**				

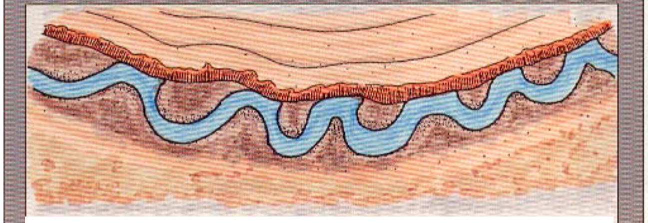
Various Meander Pattern variables modified from Galay et al. (1973)



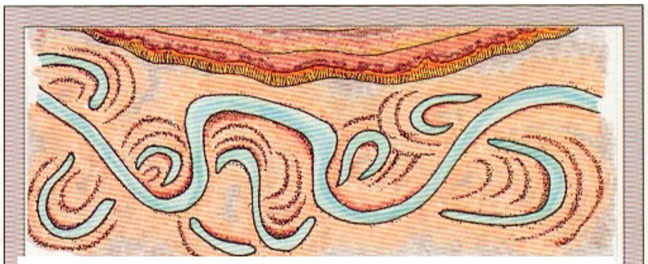
M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

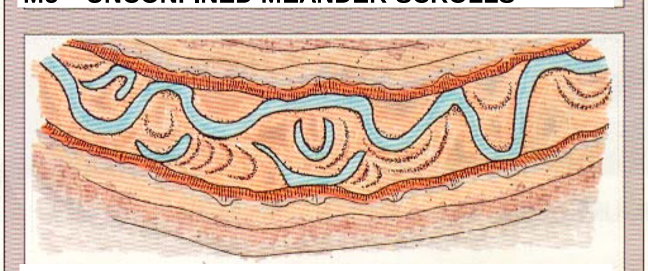
M3 IRREGULAR MEANDERS



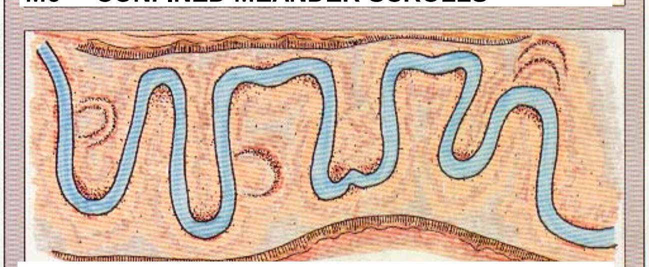
M4 TRUNCATED MEANDERS



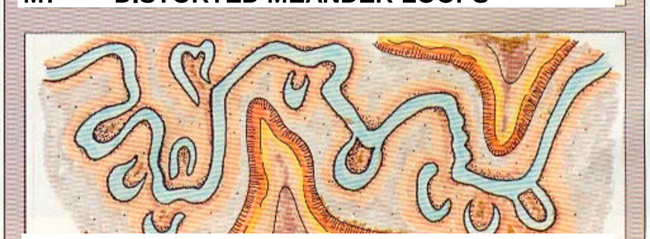
M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS



M8 IRREGULAR MEANDERS with oxbows and oxbow cutoffs

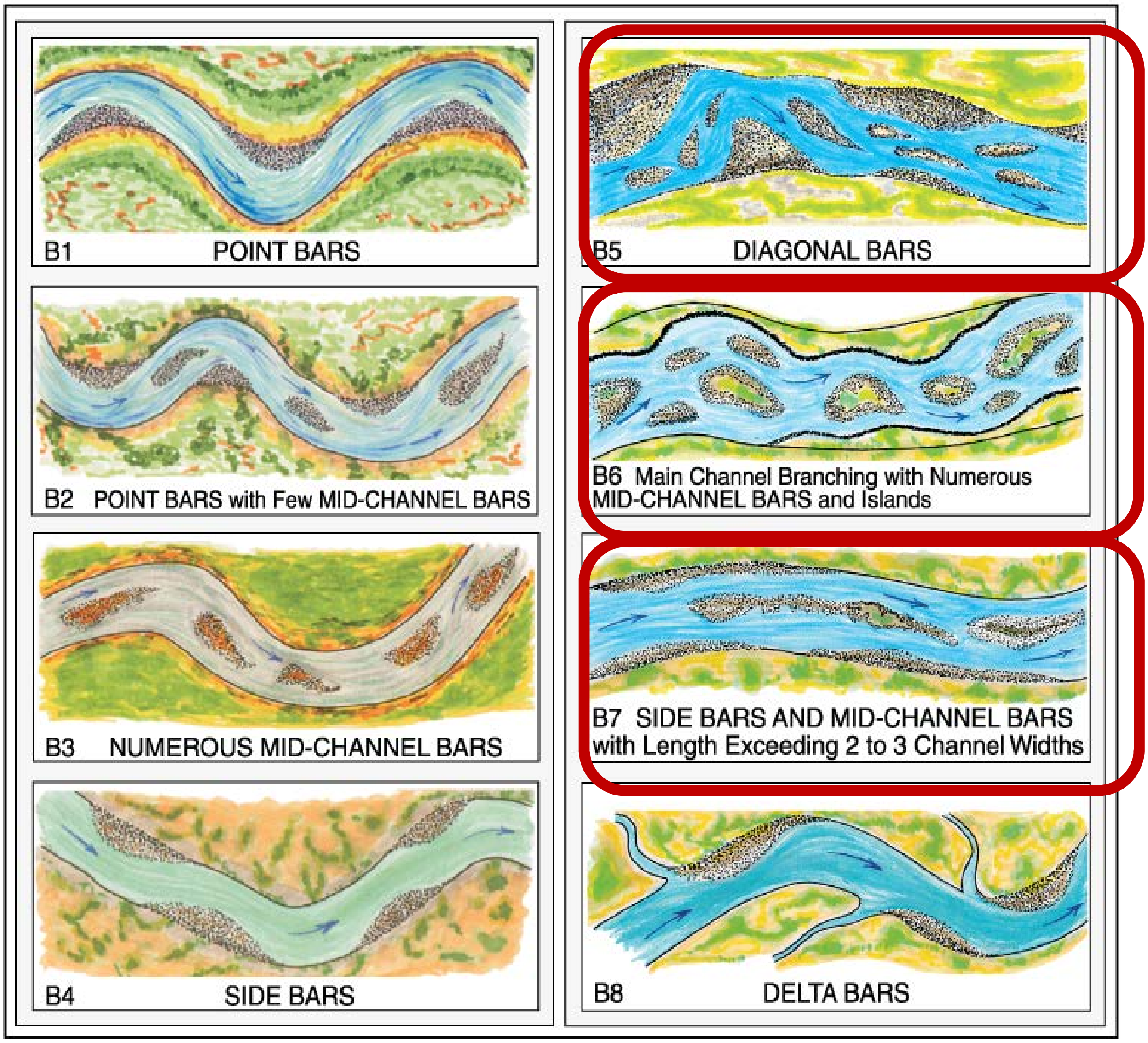
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**Northfield Gulch F4b Poor**	Location:	**Pike National Forest, Colorado**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

List ALL CATEGORIES that APPLY ☞	**B5**	**B6**	**B7**		

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Northfield Gulch F4b Poor** Location: **Pike National Forest, Colorado**

Observers: **Rosgen et. al.** Date: **11/2/2012**

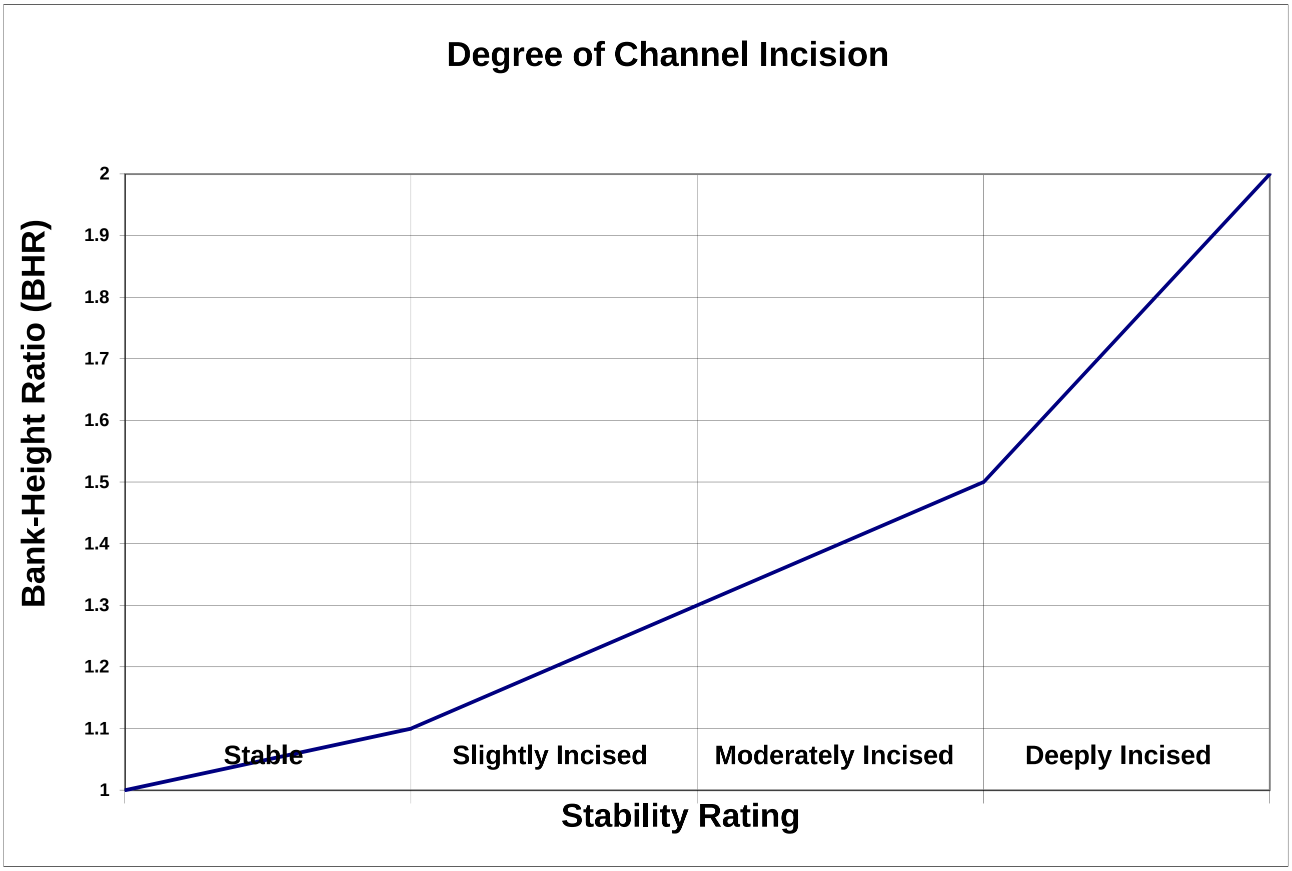
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris 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 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**4.37**	Bank-Height Ratio:	**8.7**
Max Bankfull Depth:	**0.5**		

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



Worksheet 5-13. Width/depth ratio state.

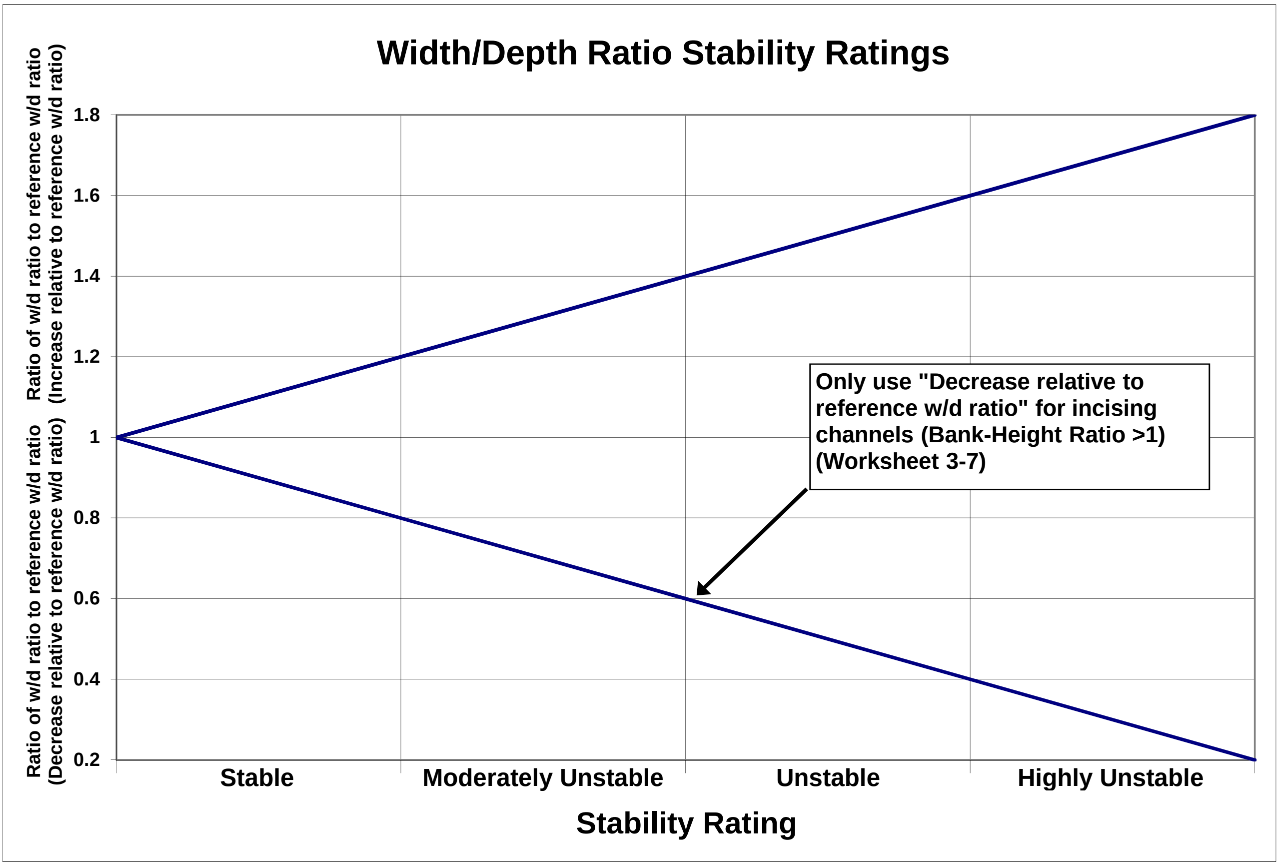
Width/Depth Ratio State

Existing Width/Depth Ratio: **22.3**

Reference Width/Depth Ratio: **16**

Ratio of existing W/d to reference W/d: **1.39**

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



Width/Depth Ratio Stability Ratings

Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

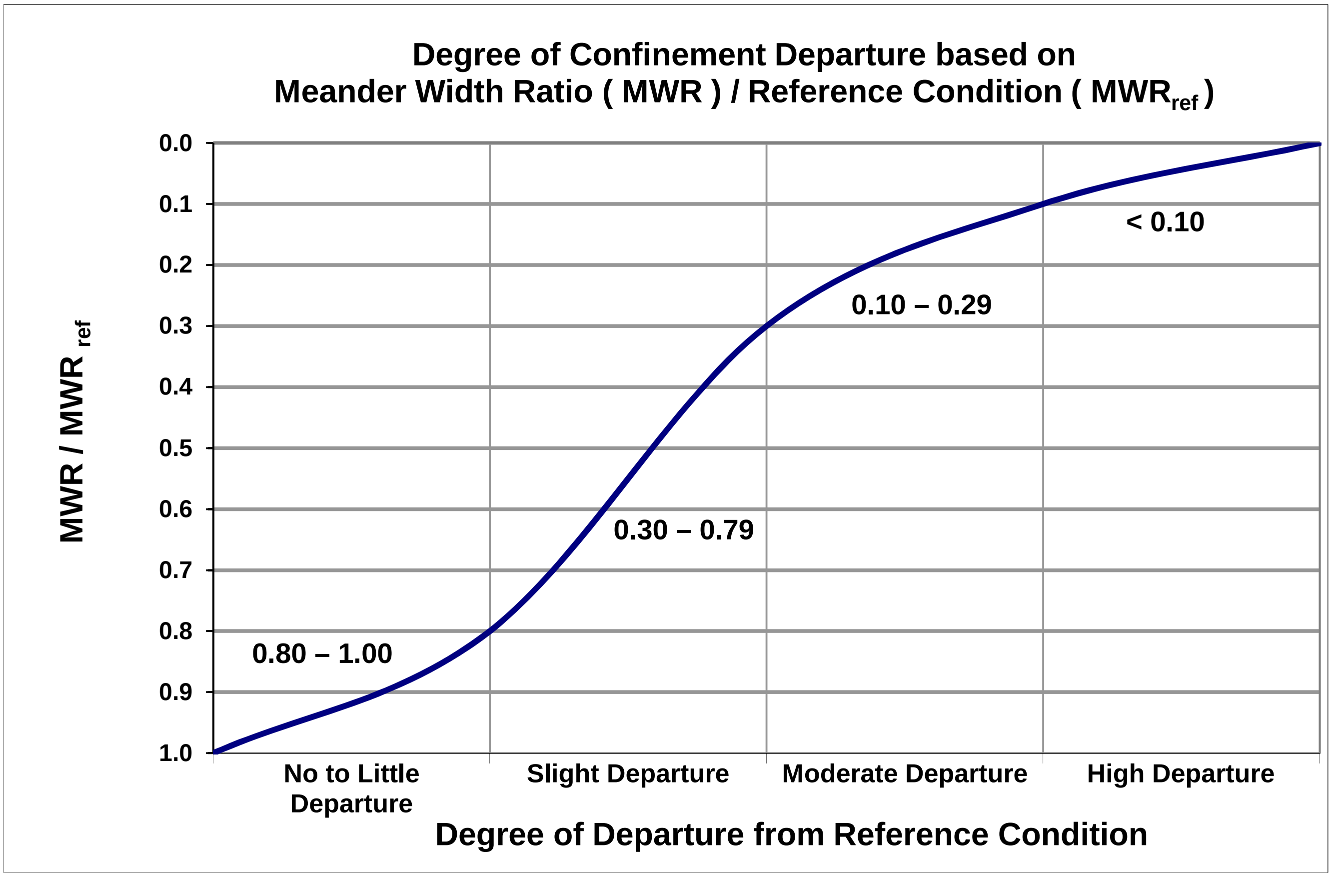
Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**4.81**
Reference Meander Width Ratio (MWR_{ref}):	**4**

Ratio of MWR to MWR_{ref}:	**1.20**

Degree of Confinement Stability Rating ☞	**Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Northfield Gulch F4b Poor **Location:** Pike National Forest, CO **Valley Type:** VIIIa **Observers:** Rosgen et al. **Date:** 11/2/2012

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	[✓ **8**]
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ **12**]
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	[✓ **5**]	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ **12**]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	[✓ **4**]
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ **8**]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	[✓ **5**]	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	[✓ **16**]
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	[✓ **16**]
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	[✓ **3**]	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ **4**]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ **8**]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ **14**]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	**20**	More than 50% of the bottom in a state of flux or change nearly yearlong.	[✓ **24**]
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ **4**]
			Excellent total =	**0**	**Good total =**	**0**	**Fair total =**	**13**	**Poor total =**	**130**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	[✓ **B4**]	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**143**
Existing stream type =	**F4b**
***Potential stream type =**	**B4**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Northfield Gulch Fb4 Poor** Location: **Fb4 Poor**

Graph Used: **Colorado** Total Stream Length (ft): **167** Date: **11/2/2012**

Observers: **Rosgen et. al.** Valley Type: **VIIIa** Stream Type: **F4b**

(1) Station (ft)	(2) BEHI rating (Worksheet 3-11) (adjective)	(3) NBS rating (Worksheet 3-12) (adjective)	(4) Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. L0 -12	Extreme	Very Low	0.165	12.0	4.3	8.51	0.03420
2. L12-28	Extreme	Very High	7.027	16.0	4.2	472.21	1.42100
3. L28-36	Extreme	Very Low	0.165	8.0	2.9	3.83	0.02300
4. L36-49	High	Very Low	0.165	13.0	3.9	8.36	0.03100
5. L49-75	Very High	High	0.664	26.0	4.2	72.52	0.13430
6. L78-88	Very High	Low	0.250	10.0	3.8	9.50	0.04570
7. L88-100	Very High	Low	0.529	12.0	3.8	24.12	0.09680
8. L100-116	Very High	Very Low	0.190	16.0	3.0	9.12	0.02744
9. L116-123	Very High	Very Low	0.165	7.0	2.1	2.42	0.01670
10. L123-131	Very High	Very High	2.066	8.0	2.0	32.40	0.19500
11. L131-135	High	Low	0.529	4.0	2.0	4.15	0.05000
12. L135-141	High	Low	0.529	6.0	2.5	7.94	0.06370
13. L141-152	High	Low	0.529	9.0	2.2	10.47	0.05600
14. L152-167	Moderate	Low	0.168	15.0	1.8	4.54	0.01460
15. R0-17	Very High	Very High	0.832	17.0	5.1	72.17	0.20440
16 R17-28	Very High	Very Low	0.190	11.0	4.0	8.36	0.03659
17 R28-42	High	High	0.664	14.0	4.9	45.56	0.15670
18 R42-49	High	Very Low	0.160	7.0	5.4	6.03	0.04150
19 R49-75	Moderate	Very Low	0.090	26.0	4.5	10.53	0.01950
20 R75-83	Very High	Moderate	0.380	8.0	5.7	17.33	0.10430
21 R83-100	Very High	Low	0.529	17.0	5.1	45.86	0.13000

Worksheet 5-18, con't. Annual streambank erosion estimates.

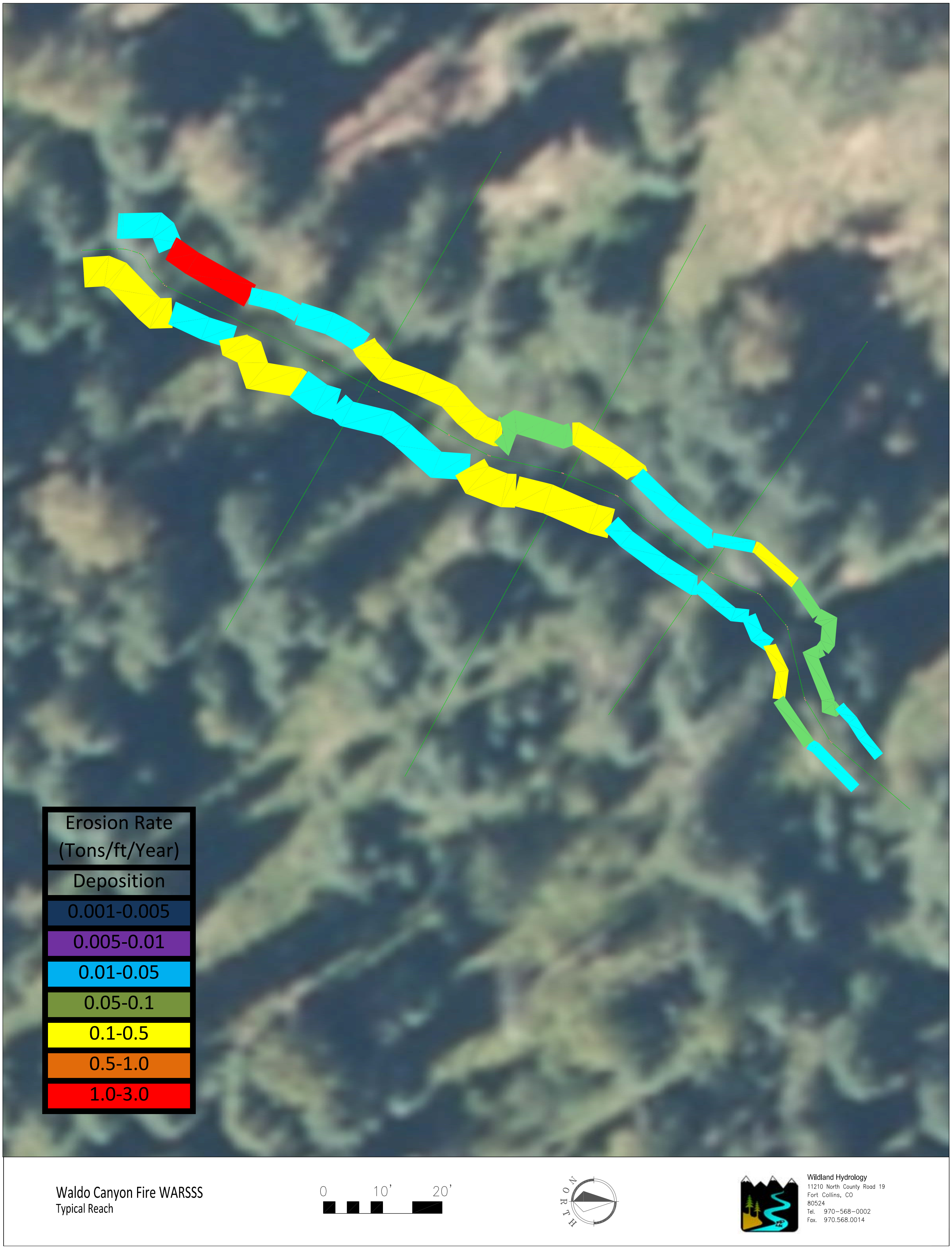
Stream: **Northfield Gulch Fb4 Poor** Location: **Fb4 Poor**

Graph Used: **Colorado** Total Stream Length (ft): **167** Date: **11/2/2012**

Observers: **Rosgen et. al.** Valley Type: **VIIIa** Stream Type: **F4b**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
22 **R100-119**	**Extreme**	**Very Low**	**0.200**	**19.0**	**3.3**	**12.54**	**0.03178**
23 **R119-124**	**Very High**	**Very Low**	**0.368**	**5.0**	**2.3**	**4.23**	**0.04070**
24 **R124-137**	**Low**	**Moderate**	**0.100**	**13.0**	**2.5**	**3.19**	**0.01180**
25 **R137-145**	**Very High**	**Very High**	**1.573**	**8.0**	**2.1**	**26.43**	**0.15910**
26 **R145-154**	**Very High**	**Low**	**0.529**	**9.0**	**2.1**	**10.00**	**0.05350**
27 **R154-167**	**Moderate**	**Low**	**0.168**	**13.0**	**1.9**	**4.04**	**0.01500**
28							
29							
30							
31							
32							
33							
34							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**936.36**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**34.68**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**45.08**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.2700**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

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	0.0													
90.000	0.1	95.00	10.00	36.50	0.1	0.02	5.9	0.0	0.0253	0.00	0.50	0.00	0.00	0.00
80.000	0.1	85.00	10.00	36.50	0.1	0.04	5.9	0.0	0.0253	0.00	1.00	0.00	0.00	0.00
70.000	0.1	75.00	10.00	36.50	0.1	0.05	5.9	0.0	0.0253	0.00	1.10	0.00	0.00	0.00
60.000	0.2	65.00	10.00	36.50	0.1	0.06	5.9	0.0	0.0253	0.00	1.40	0.00	0.00	0.00
50.000	0.2	55.00	10.00	36.50	0.2	0.07	5.9	0.0	0.0253	0.00	1.70	0.00	0.00	0.00
40.000	0.3	45.00	10.00	36.50	0.2	0.10	5.9	0.0	0.0253	0.00	2.30	0.00	0.00	0.00
30.000	0.4	35.00	10.00	36.50	0.3	0.14	5.9	0.0	0.0259	0.00	3.20	0.00	0.00	0.00
20.000	0.6	25.00	10.00	36.50	0.5	0.20	6.0	0.0	0.0288	0.00	4.60	0.00	0.00	0.00
10.000	1.0	15.00	10.00	36.50	0.8	0.34	6.4	0.0	0.0394	0.04	7.80	0.00	1.46	1.46
5.000	1.6	7.50	5.00	18.25	1.3	0.57	9.0	0.0	0.0754	0.09	6.55	0.00	1.64	1.64
4.000	1.8	4.50	1.00	3.65	1.7	0.74	13.8	0.0	0.1196	0.17	1.71	0.00	0.62	0.62
3.000	2.1	3.50	1.00	3.65	2.0	0.85	19.0	0.0	0.1565	0.22	1.96	0.00	0.80	0.80
2.000	2.5	2.50	1.00	3.65	2.3	1.00	29.5	0.0	0.2189	0.35	2.31	0.00	1.28	1.28
1.500	2.9	1.75	0.50	1.83	2.7	1.16	47.2	0.0	0.3042	0.48	1.34	0.00	0.88	0.88
1.000	3.5	1.25	0.50	1.83	3.2	1.38	82.3	0.0	0.4434	0.69	1.59	0.02	1.26	1.28
0.900	3.7	0.95	0.10	0.37	3.6	1.57	113.4	0.0	0.5477	0.91	0.36	0.00	0.33	0.33
0.800	4.0	0.85	0.10	0.37	3.8	1.66	113.4	0.0	0.5477	1.04	0.38	0.00	0.38	0.38
0.700	4.2	0.75	0.10	0.37	4.1	1.75	113.4	0.0	0.5477	1.17	0.41	0.00	0.43	0.43
0.600	4.4	0.65	0.10	0.37	4.3	1.86	113.4	0.0	0.5477	1.30	0.43	0.01	0.47	0.48
0.500	4.7	0.55	0.10	0.37	4.6	1.99	113.4	0.0	0.5477	1.51	0.46	0.01	0.55	0.56
0.250	5.5	0.38	0.25	0.91	5.1	2.22	113.4	0.0	0.5477	1.94	1.28	0.03	1.77	1.80
0.100	6.4	0.18	0.15	0.55	5.9	2.56	113.4	0.0	0.5477	2.64	0.89	0.02	1.45	1.47
0.050	6.8	0.08	0.05	0.18	6.6	2.84	113.4	0.1	0.5477	3.33	0.33	0.01	0.61	0.62
0.010	7.4	0.03	0.04	0.15	7.1	3.07	113.4	0.1	0.5477	3.93	0.28	0.01	0.57	0.58
0.005	7.4	0.01	0.01	0.02	7.4	3.20	113.4	0.1	0.5477	4.32	0.04	0.00	0.08	0.08
0.001	7.4	0.00	0.00	0.01	7.4	3.20	113.4	0.1	0.5477	4.32	0.03	0.00	0.06	0.06
										Annual totals:		**0.1** (tons/yr)	**14.6** (tons/yr)	**14.7** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment **[(5)×(9)]**	(14) Bedload sediment **[(5)×(11)]**	(15) 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	**0.0**													
90.000	**0.1**	**95.00**	**10.00**	**36.50**	**0.0**	**0.02**	**5.9**	**0.0**	**0.0253**	**1.04**	**0.40**	**0.00**	**37.96**	**37.96**
80.000	**0.1**	**85.00**	**10.00**	**36.50**	**0.1**	**0.04**	**5.9**	**0.0**	**0.0253**	**1.04**	**1.00**	**0.00**	**37.96**	**37.96**
70.000	**0.1**	**75.00**	**10.00**	**36.50**	**0.1**	**0.05**	**5.9**	**0.0**	**0.0253**	**1.04**	**1.10**	**0.00**	**37.96**	**37.96**
60.000	**0.2**	**65.00**	**10.00**	**36.50**	**0.1**	**0.06**	**5.9**	**0.0**	**0.0253**	**1.04**	**1.40**	**0.00**	**37.96**	**37.96**
50.000	**0.2**	**55.00**	**10.00**	**36.50**	**0.2**	**0.07**	**5.9**	**0.0**	**0.0253**	**1.04**	**1.70**	**0.00**	**37.96**	**37.96**
40.000	**0.3**	**45.00**	**10.00**	**36.50**	**0.2**	**0.10**	**5.9**	**0.0**	**0.0253**	**1.08**	**2.30**	**0.00**	**39.42**	**39.42**
30.000	**0.4**	**35.00**	**10.00**	**36.50**	**0.3**	**0.14**	**6.0**	**0.0**	**0.0261**	**1.12**	**3.30**	**0.36**	**40.88**	**41.24**
20.000	**0.8**	**25.00**	**10.00**	**36.50**	**0.6**	**0.26**	**6.1**	**0.0**	**0.0324**	**1.38**	**6.10**	**0.36**	**50.37**	**50.73**
10.000	**1.7**	**15.00**	**10.00**	**36.50**	**1.2**	**0.54**	**8.5**	**0.0**	**0.0689**	**2.94**	**12.40**	**1.09**	**107.31**	**108.40**
5.000	**2.5**	**7.50**	**5.00**	**18.25**	**2.1**	**0.90**	**22.0**	**0.1**	**0.1760**	**7.56**	**10.40**	**2.19**	**137.97**	**140.16**
4.000	**2.7**	**4.50**	**1.00**	**3.65**	**2.6**	**1.12**	**41.7**	**0.3**	**0.2798**	**12.05**	**2.59**	**1.06**	**43.98**	**45.04**
3.000	**3.1**	**3.50**	**1.00**	**3.65**	**2.9**	**1.25**	**59.3**	**0.5**	**0.3558**	**15.34**	**2.89**	**1.68**	**55.99**	**57.67**
2.000	**3.5**	**2.50**	**1.00**	**3.65**	**3.3**	**1.42**	**89.9**	**0.8**	**0.4693**	**20.22**	**3.27**	**2.88**	**73.80**	**76.68**
1.500	**3.9**	**1.75**	**0.50**	**1.83**	**3.7**	**1.59**	**113.4**	**1.3**	**0.5477**	**26.31**	**1.83**	**2.41**	**48.02**	**50.43**
1.000	**4.5**	**1.25**	**0.50**	**1.83**	**4.2**	**1.81**	**113.4**	**2.4**	**0.5477**	**35.47**	**2.09**	**4.34**	**64.73**	**69.07**
0.900	**4.7**	**0.95**	**0.10**	**0.37**	**4.6**	**2.00**	**113.4**	**3.7**	**0.5477**	**44.45**	**0.46**	**1.36**	**16.22**	**17.58**
0.800	**4.9**	**0.85**	**0.10**	**0.37**	**4.8**	**2.09**	**113.4**	**4.6**	**0.5477**	**49.55**	**0.48**	**1.68**	**18.09**	**19.77**
0.700	**5.2**	**0.75**	**0.10**	**0.37**	**5.0**	**2.18**	**113.4**	**5.6**	**0.5477**	**54.73**	**0.50**	**2.05**	**19.98**	**22.03**
0.600	**5.4**	**0.65**	**0.10**	**0.37**	**5.3**	**2.29**	**113.4**	**7.0**	**0.5477**	**61.30**	**0.53**	**2.56**	**22.37**	**24.93**
0.500	**5.7**	**0.55**	**0.10**	**0.37**	**5.6**	**2.42**	**113.4**	**9.0**	**0.5477**	**69.42**	**0.56**	**3.27**	**25.34**	**28.61**
0.250	**6.5**	**0.38**	**0.25**	**0.91**	**6.1**	**2.65**	**113.4**	**13.7**	**0.5477**	**85.88**	**1.53**	**12.46**	**78.37**	**90.83**
0.100	**7.3**	**0.18**	**0.15**	**0.55**	**6.9**	**2.99**	**113.4**	**24.2**	**0.5477**	**114.74**	**1.04**	**13.23**	**62.82**	**76.05**
0.050	**7.8**	**0.08**	**0.05**	**0.18**	**7.6**	**3.27**	**113.4**	**36.7**	**0.5477**	**141.83**	**0.38**	**6.70**	**25.88**	**32.58**
0.010	**8.4**	**0.03**	**0.04**	**0.15**	**8.1**	**3.50**	**113.4**	**50.0**	**0.5477**	**165.93**	**0.32**	**7.30**	**24.23**	**31.53**
0.005	**8.4**	**0.01**	**0.01**	**0.02**	**8.4**	**3.63**	**113.4**	**59.2**	**0.5477**	**180.88**	**0.04**	**1.08**	**3.30**	**4.38**
0.001	**8.4**	**0.00**	**0.00**	**0.01**	**8.4**	**3.63**	**113.4**	**59.2**	**0.5477**	**180.88**	**0.03**	**0.86**	**2.64**	**3.50**
										Annual totals:		**68.9** (tons/yr)	**1151.5** (tons/yr)	**1220.4** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

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	**0.01**									**0.00**					**0.00**	**0.00**	**0.00**
90.000	**0.08**	**0.04**	**0.09**	**1.92**	**0.05**	**0.63**	**0.0360**	**0.10**	**0.09**	**0.05**	**10.000**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.000	**0.11**	**0.10**	**0.13**	**2.02**	**0.06**	**0.72**	**0.0360**	**0.14**	**0.22**	**0.11**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
70.000	**0.12**	**0.11**	**0.14**	**2.03**	**0.07**	**0.73**	**0.0360**	**0.15**	**0.25**	**0.12**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
60.000	**0.15**	**0.14**	**0.16**	**2.08**	**0.08**	**0.78**	**0.0360**	**0.17**	**0.31**	**0.15**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
50.000	**0.20**	**0.17**	**0.18**	**2.13**	**0.08**	**0.82**	**0.0360**	**0.19**	**0.38**	**0.18**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
40.000	**0.26**	**0.23**	**0.22**	**2.23**	**0.10**	**0.90**	**0.0360**	**0.22**	**0.52**	**0.23**	**10.000**	**36.50**	**1.08**	**0.00**	**39.00**	**0.00**	**39.00**
30.000	**0.40**	**0.33**	**0.29**	**2.39**	**0.12**	**1.05**	**0.0360**	**0.27**	**0.74**	**0.31**	**10.000**	**36.50**	**1.12**	**0.01**	**41.00**	**0.00**	**41.00**
20.000	**0.82**	**0.61**	**0.45**	**2.67**	**0.17**	**1.31**	**0.0360**	**0.37**	**1.37**	**0.51**	**10.000**	**36.50**	**1.38**	**0.01**	**50.00**	**0.00**	**51.00**
10.000	**1.67**	**1.24**	**0.73**	**3.02**	**0.24**	**1.66**	**0.0360**	**0.52**	**2.79**	**0.92**	**10.000**	**36.50**	**2.94**	**0.03**	**107.00**	**1.00**	**108.00**
5.000	**2.48**	**2.08**	**1.07**	**3.48**	**0.31**	**1.94**	**0.0360**	**0.66**	**4.67**	**1.34**	**5.000**	**18.25**	**7.56**	**0.12**	**138.00**	**2.00**	**140.00**
4.000	**2.71**	**2.59**	**1.27**	**3.86**	**0.33**	**2.04**	**0.0360**	**0.70**	**5.82**	**1.51**	**1.000**	**3.65**	**11.97**	**0.19**	**44.00**	**1.00**	**44.00**
3.000	**3.07**	**2.89**															
2.000	**3.48**	**3.27**															
1.500	**3.87**	**3.67**															
1.000	**4.49**	**4.18**															
0.900	**4.72**	**4.61**															
0.800	**4.94**	**4.83**															
0.700	**5.15**	**5.04**															
0.600	**5.43**	**5.29**															
0.500	**5.73**	**5.58**															
0.250	**6.48**	**6.11**															
0.100	**7.34**	**6.91**															
0.050	**7.78**	**7.56**															
0.010	**8.38**	**8.08**															
0.005	**8.38**	**8.38**															
0.001	**8.38**	**8.38**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**571.7**	**4.8**	**576.3**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

(1) Percentage of time	(2) Daily mean discharge	(3) Mid-ordinate stream-flow	(4) Area	(5) Width	(6) Depth	(7) Velocity	(8) Slope	(9) Shear stress	(10) Stream power	(11) Unit power	(12) Time increment	(13) Time increment	(14) Daily mean bedload transport	(15) Daily mean suspended sand transport	(16) Time adjusted bedload transport **[(13)×(14)]**	(17) Time adjusted suspended sand transport **[(13)×(15)]**	(18) 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	**0.01**								**0.00**						**0.00**	**0.00**	**0.00**
90.000	**0.08**	**0.04**	**0.06**	**1.40**	**0.04**	**0.59**	**0.0360**	**0.09**	**0.09**	**0.06**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
80.000	**0.11**	**0.10**	**0.11**	**1.71**	**0.06**	**0.73**	**0.0360**	**0.14**	**0.22**	**0.13**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
70.000	**0.12**	**0.11**	**0.11**	**1.76**	**0.06**	**0.75**	**0.0360**	**0.14**	**0.25**	**0.14**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
60.000	**0.15**	**0.14**	**0.14**	**1.92**	**0.07**	**0.82**	**0.0360**	**0.16**	**0.31**	**0.16**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
50.000	**0.20**	**0.17**	**0.16**	**2.07**	**0.08**	**0.89**	**0.0360**	**0.17**	**0.38**	**0.18**	**10.000**	**36.50**	**1.04**	**0.00**	**38.00**	**0.00**	**38.00**
40.000	**0.26**	**0.23**	**0.21**	**2.38**	**0.09**	**1.03**	**0.0360**	**0.19**	**0.52**	**0.22**	**10.000**	**36.50**	**1.08**	**0.00**	**39.00**	**0.00**	**39.00**
30.000	**0.40**	**0.33**	**0.27**	**2.63**	**0.10**	**1.15**	**0.0360**	**0.22**	**0.74**	**0.28**	**10.000**	**36.50**	**1.12**	**0.01**	**41.00**	**0.00**	**41.00**
20.000	**0.82**	**0.61**	**0.42**	**3.10**	**0.14**	**1.36**	**0.0360**	**0.29**	**1.37**	**0.44**	**10.000**	**36.50**	**1.30**	**0.01**	**47.00**	**0.00**	**48.00**
10.000	**1.67**	**1.24**	**0.76**	**4.39**	**0.17**	**1.61**	**0.0360**	**0.37**	**2.79**	**0.64**	**10.000**	**36.50**	**1.86**	**0.02**	**68.00**	**1.00**	**69.00**
5.000	**2.48**	**2.08**	**1.12**	**5.41**	**0.21**	**1.82**	**0.0360**	**0.45**	**4.67**	**0.86**	**5.000**	**18.25**	**2.72**	**0.04**	**50.00**	**1.00**	**50.00**
4.000	**2.71**	**2.59**	**1.28**	**5.53**	**0.23**	**1.97**	**0.0360**	**0.50**	**5.82**	**1.05**	**1.000**	**3.65**	**4.36**	**0.09**	**16.00**	**0.00**	**16.00**
3.000	**3.07**	**2.89**	**1.38**	**5.59**	**0.25**	**2.05**	**0.0360**	**0.53**	**6.49**	**1.16**	**1.000**	**3.65**	**5.57**	**0.13**	**20.00**	**0.00**	**21.00**
2.000	**3.48**	**3.27**															
1.500	**3.87**	**3.67**															
1.000	**4.49**	**4.18**															
0.900	**4.72**	**4.61**															
0.800	**4.94**	**4.83**															
0.700	**5.15**	**5.04**															
0.600	**5.43**	**5.29**															
0.500	**5.73**	**5.58**															
0.250	**6.48**	**6.11**															
0.100	**7.34**	**6.91**															
0.050	**7.78**	**7.56**															
0.010	**8.38**	**8.08**															
0.005	**8.38**	**8.38**															
0.001	**8.38**	**8.38**															
Notes:										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**471.5**	**3.0**	**474.4**
										Upstream total annual sediment comparative reach (tons/yr) (**WS 5-20a**):					**571.5**	**4.7**	**576.2**
										Difference in sediment transport capacity (tons/yr) (+ or -):					**-100.0**	**-1.7**	**-101.8**
										Stability evaluation: Aggradation, Degradation or Stable:					**Aggradation**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Northfield Gulch F4b Poor**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIa**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

Enter Required Information for Existing Condition

4.8	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.410	D_{max}	Largest particle from **Bed Material** (ft)	**125**	**(mm)**	304.8 mm/ft
0.03500	S	Existing bankfull water surface slope (ft/ft)			
0.26	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	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

N/A	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

0.568		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 **43.23**	CO **100.3**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.573**	CO **0.766**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.72**	CO **0.35**	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 **0.0970**	CO **0.0472**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Northfield Gulch F4b Poor** Stream Type: **F4b**

Location: **Pike National Forest, CO** Valley Type: **VIIIa**

Observers: **Rosgen et. al.** Date: **11/2/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Northfield Gulch F4b Poor**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIa**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

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 5-13)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 [✓ **(6)**]	> 1.6 **(8)**	**6**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex [✓ **(8)**]	**8**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**20**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Northfield Gulch F4b Poor**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIa**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

	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 5-22)**	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)**	**4**
2	**Sediment Capacity (POWERSED) (Worksheet 5-20)**	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)**]	**8**
3	**W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 [✓ **(6)**]	>1.6 **(8)**	**6**
4	**Stream Succession States (Worksheet 5-24)**	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) [✓ **(6)**]	(C→D), (F→D) **(8)**	**6**
5	**Depositional Patterns (Worksheet 5-10)**	B1 [✓ **(1)**]	B2, B4 **(2)**	B3, **B5** **(3)**	**B6, B7**, B8 **(4)**	**1**
6	**Debris / Blockages (Worksheet 5-11)**	D1, D2, D3 [✓ **(1)**]	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**1**
					Total Points	**26**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Northfield Gulch F4b Poor**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIa**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	[✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**15**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Northfield Gulch F4b Poor** Stream Type: **F4b**
Location: **Pike National Forest, Colorado** Valley Type: **VIIIa**
Observers: **Rosgen et. al.** Date: **11/2/2012**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) [✓ **(6)**]	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**6**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* [✓ **(6)**]	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*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*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Northfield Gulch F4b Poor**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIa**
Observers:	**Rosgen et. al.**	Date:	**11/2/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	1	3
	Mod. Unstable	2	
	Unstable	[✓ 3]	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	1	3
	Mod. Deposition	2	
	Excess Deposition	[✓ 3]	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	1	2
	Slightly Incised	[✓ 2]	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	1	3
	Slight Increase	2	
	Mod. Increase	[✓ 3]	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	1	4
	Fair: Mod. Unstable	2	
	Poor: Unstable	[✓ 4]	
		Total Points	**15**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** 5 ☐	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☑	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Northfield Gulch F4b Poor**						Location:	**Pike National Forest, Colorado**			
Observers:	**Rosgen et. al.**			Date: **11/2/2012**			Stream Type: **F4b**		Valley Type: **VIIIa**		
Channel Dimension	Mean Bankfull Depth (ft):	**0.26**	Bankfull Width (ft):	**5.8**	Cross-Sectional Area (ft^2):	**1.53**	Width of Flood-Prone Area (ft):	**22.31**	Entrenchment Ratio:	**1.06**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**10.86** **0.00 - 0.00**	L_m/W_{bkf}:	**11.72** **0.00 - 0.00**	R_c/W_{bkf}:	**5.95** **5.52 - 6.38**	MWR:	**4.31**	Sinuosity:	**1.05**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence			☐ Dunes/Antidunes/Smooth Bed				
	Max Bankfull Depth (ft):	Riffle **0.53**	Pool **0**	Depth Ratio (max to mean):	Riffle **2.04**	Pool	Pool-to-Pool Spacing:	Ratio	Slope Valley: **0.0378**	Water Surface: **0.036**	
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **< 5% Annual Grass/Forb**		Potential Composition/Density: **Willow/Alder/Grass/Aspen**		Remarks: Condition, Vigor & Usage of Existing Reach: **Burnt, 5% Ponderosa Pine Aerial**					
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(3)**	Meander Patterns:	**M3**	Depositional Patterns:	**B5, B6, B7**	Debris/Channel Blockages:	**D2**	
	Degree of Incision (Bank-Height Ratio):	**8.7**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**143 (Poor)**					
	Width/depth Ratio (W/d):	**52**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**4.14**	W/d Ratio State Stability Rating:	**Highly Unstable**			
	Meander Width Ratio (MWR):	**4.81**	Reference MWR_{ref}:	**4**	Degree of confinement (MWR / MWR_{ref}):	**1.2025**	MWR / MWR_{ref} Stability Rating:	**Unstable**			
Bank Erosion Summary	Length of Reach Studied (ft):	**167**	Annual Streambank Erosion Rate: **43.13** (tons/yr)	**0.2583** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:	**Used Yellowstone curve for very low BEHI**				
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity	Remarks:							
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**125**	$\tau =$	**0.528**	$\tau^* =$	**N/A**	Existing Depth:	**0.19**	Required Depth:	**0.07**	Existing Slope: **0.035** Required Slope: **0.04**
Successional Stage Shift	**B** → **G** → **Fb** → **B** → →						Existing Stream State (Type):	**F4b**	Potential Stream State (Type):	**B4**	
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Fire and Flood effects**					
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:	**Fire and Flood effects**					
Vertical Stability (Degradation)	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Fire and Flood effects**					
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**Fire and Flood effects**					
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:	**Been in flood after fire.**					

Appendix C13

F4b Stream Type

Poor Stability Mainstem Reach

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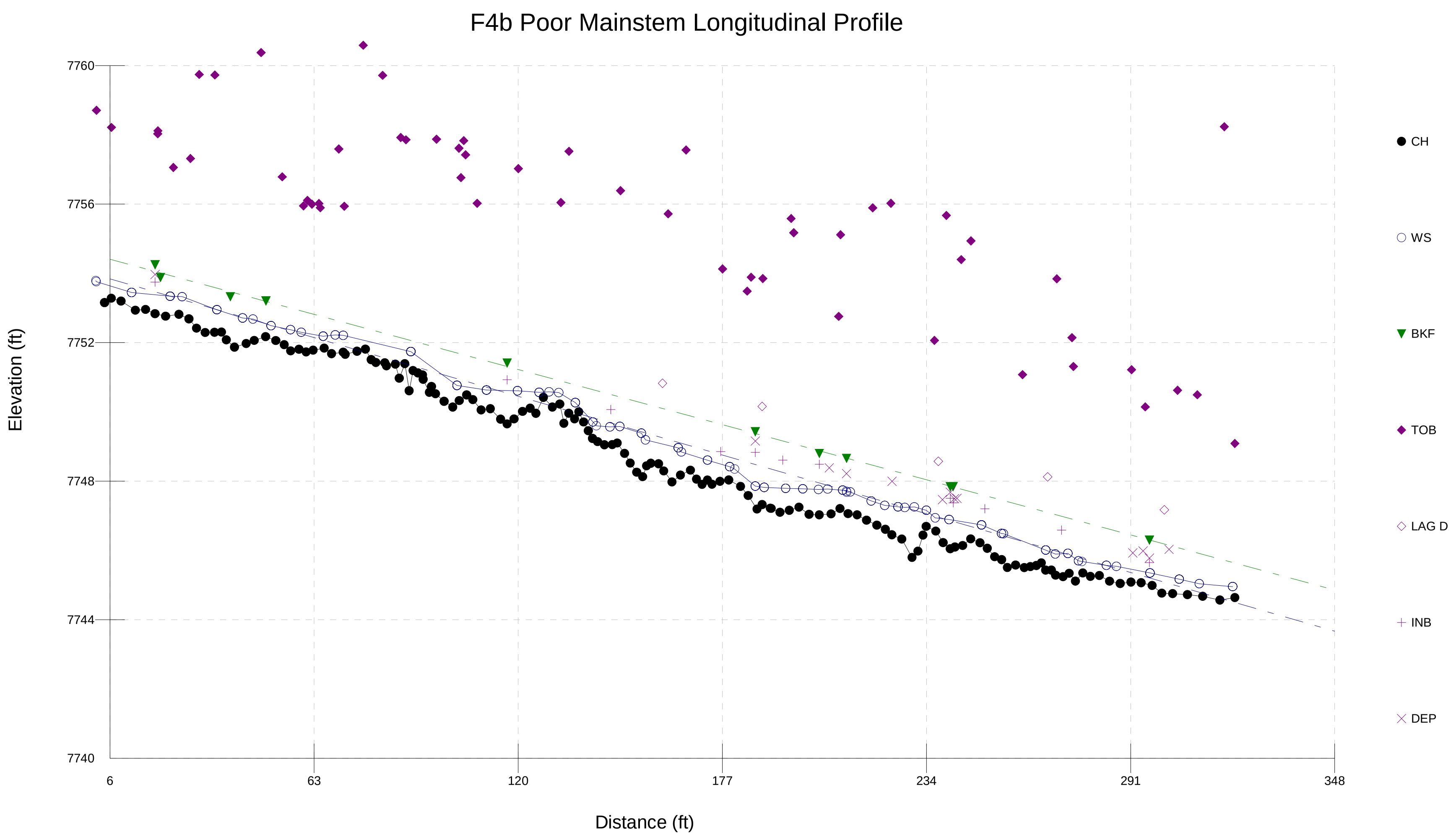
Appendix C13: F4b Poor Mainstem Reach

F4b Poor Mainstem Reach Location & Overview

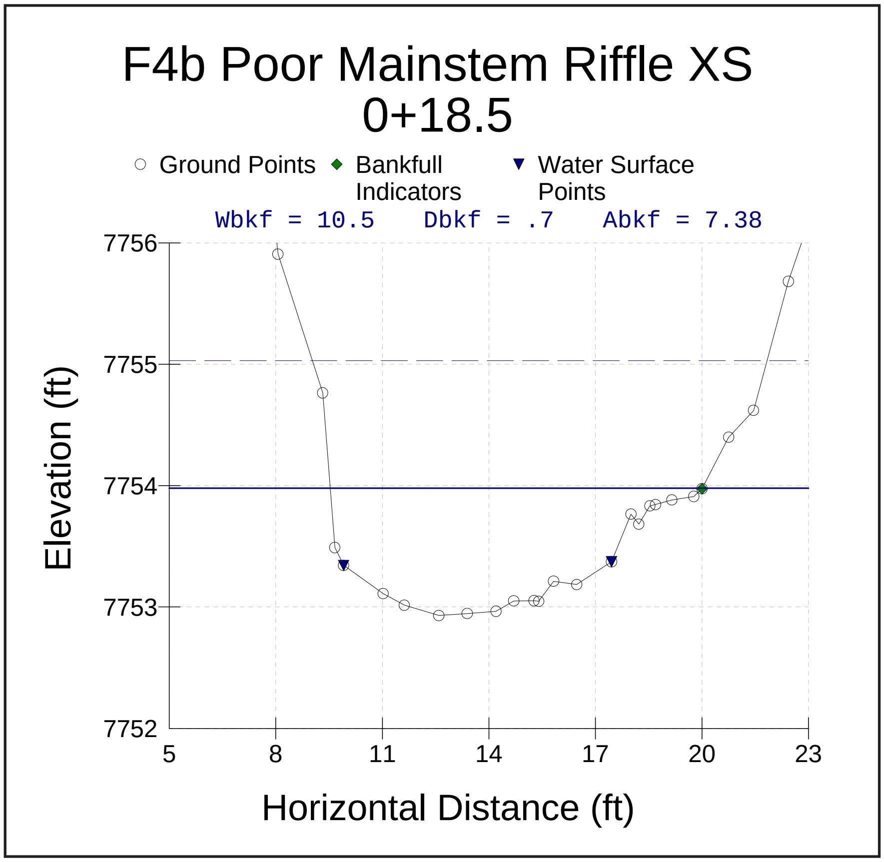
The F4b Poor Mainstem representative reach is a 3rd order, perennial, relatively steep gradient, entrenched stream located in the Trail Creek Mainstem (see location map **Figure C-2**). The width/depth ratio of *32* is very high and will continue to promote excess deposition and high bank erosion in this gulch-fill, alluvial Valley Type VIIIa. The stream is still enlarging due to the high peak flows following the fire. The potential stable stream type in this valley type is a B4; thus a POWERSED run was made to determine streambed stability, which indicated approximately *1,077 tons/yr* of deposition. The stability rating is "Poor" due to a Pfankuch stability rating of "Poor" and the extremely high streambank erosion rate of *0.472 tons/yr/ft*. This rate is two and a half orders of magnitude larger than the B4 reference rate of *0.0048 tons/yr/ft*. The sediment supply rating is *High*, typical of an F4 stream type, due to the high banks on both sides and the sediment deposition in the bed. The "Poor" stability rating indicates a higher potential accelerated increase in flow-related sediment compared to the same-sized B4 reference stream type. The WRENSS model indicated that the water yield increased from *3,917 acre-ft* to *6,376 acre-ft*, representing a total increase of *2,458 acre-ft*. The corresponding bedload increased from *43 tons/yr* to *5,471 tons/yr* and suspended sediment increased from *99 tons/yr* to *9,354 tons/yr*, representing a total increase in sediment of *14,683 tons/yr*. This increase is the result of the increased sediment supply due to the unstable banks and high width/depth ratio that encourages increased sediment deposition in the streambed. This increased sediment loading is equivalent to *1,130 ten-yard, end dump truck loads per year*. For a stark comparison, the reference condition total sediment increase, for the same bankfull discharge and relatively similar streamflow, is only *557 tons/yr*.

The photograph depicts the typical character of this representative F4b Poor stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

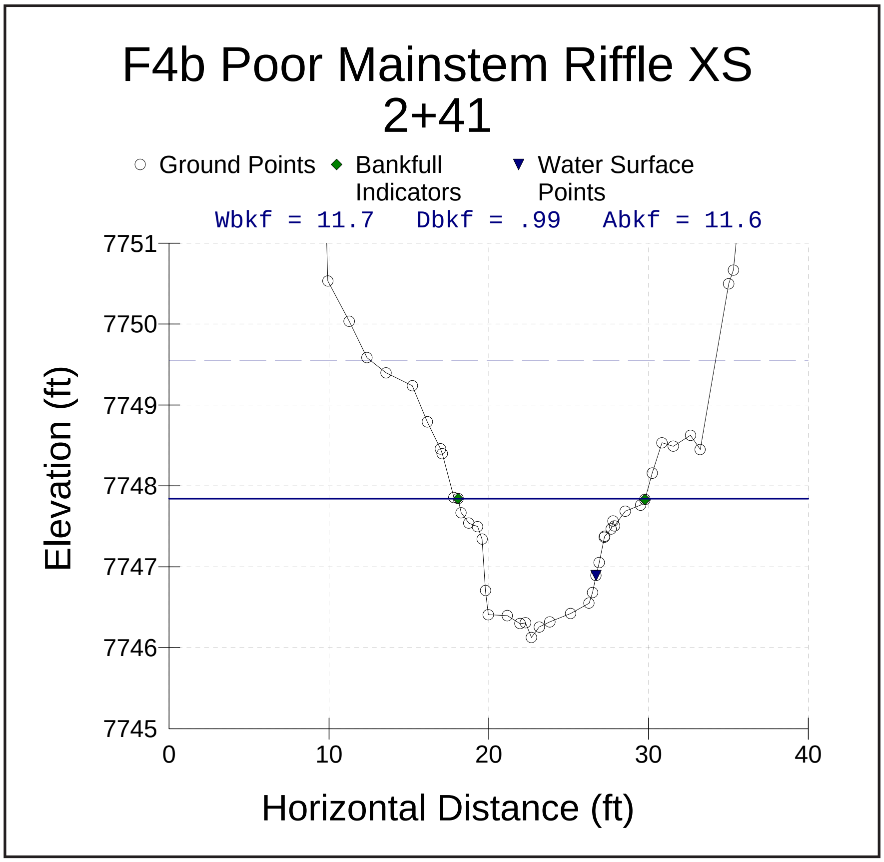
Survey Summary



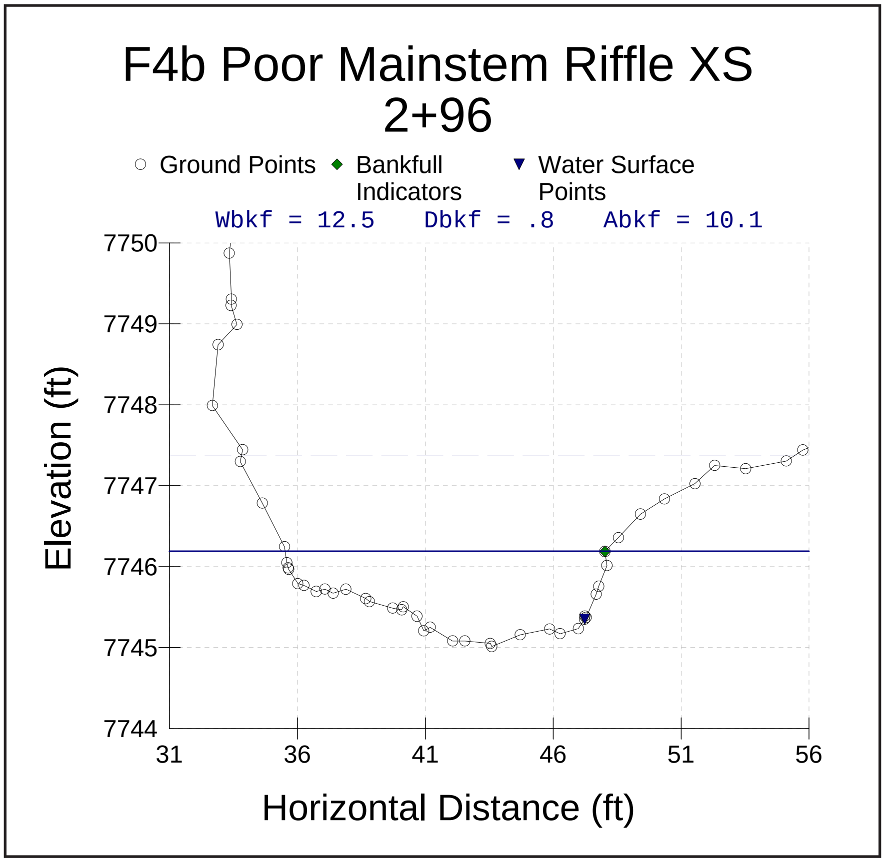
Longitudinal Profile (graph generated from RIVERMorph^{TM})



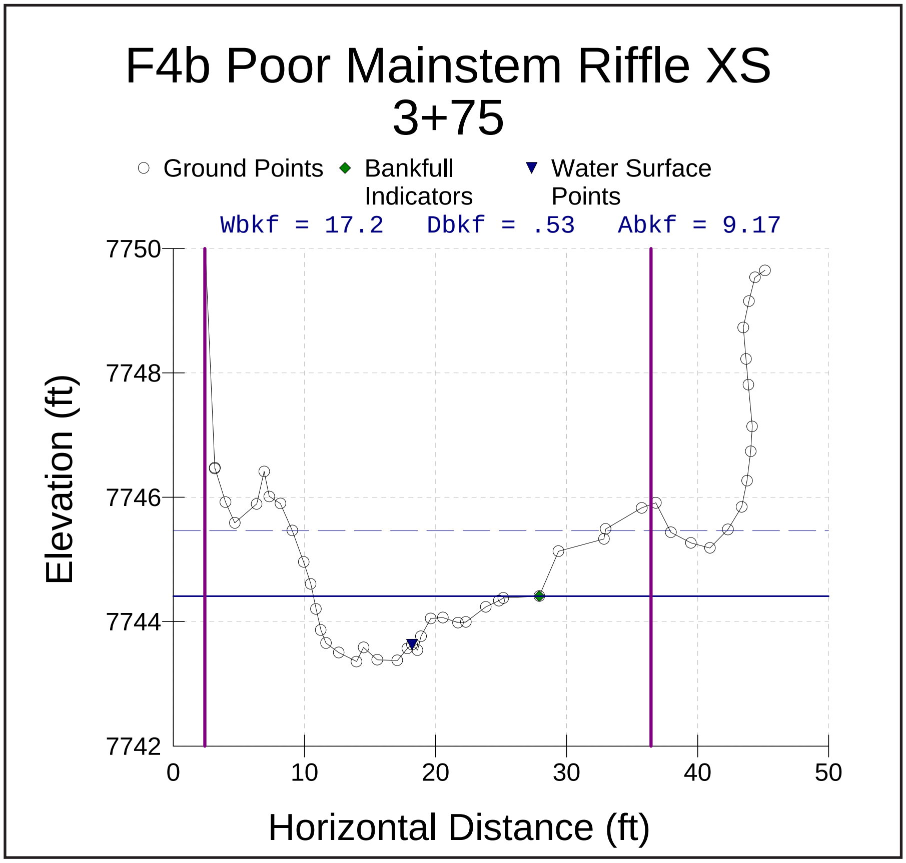
Riffle Cross-section 0+18.5 (graph generated from RIVERMorph^{TM})



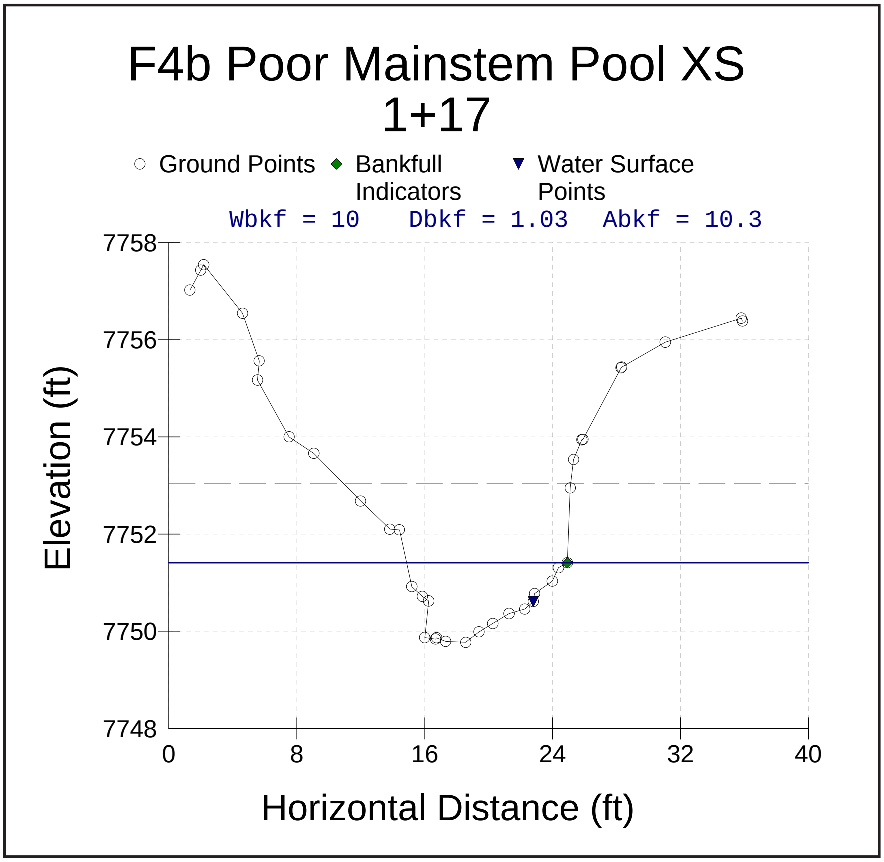
Riffle Cross-section 2+41 (graph generated from RIVERMorph^{TM})



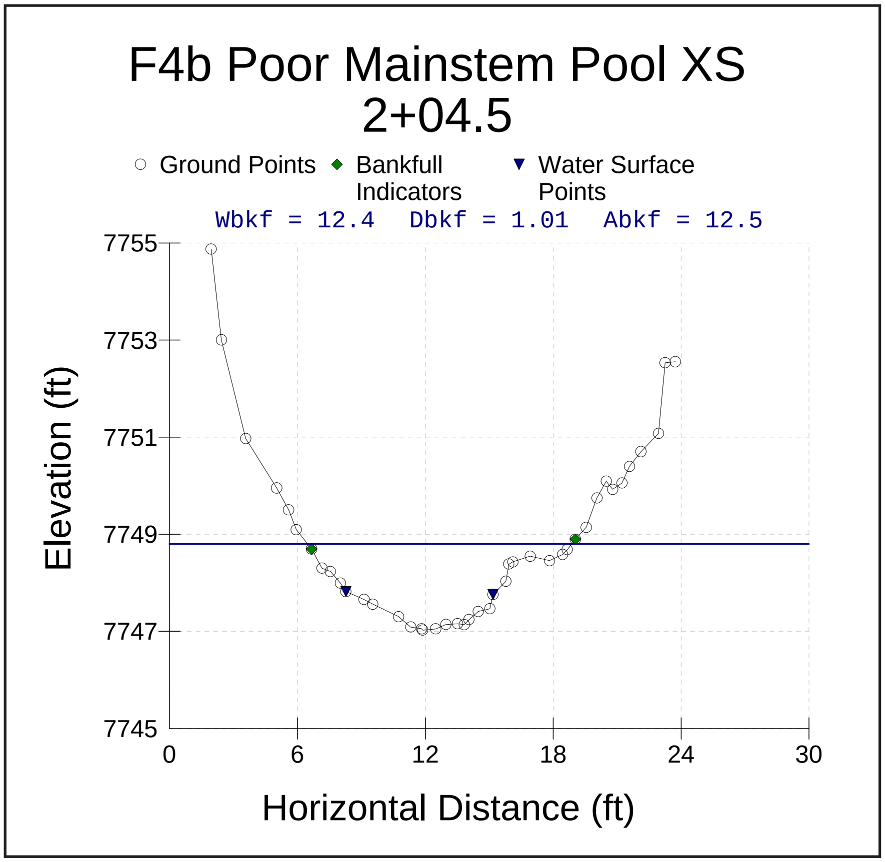
Riffle Cross-section 2+96 (graph generated from RIVERMorph^{TM})



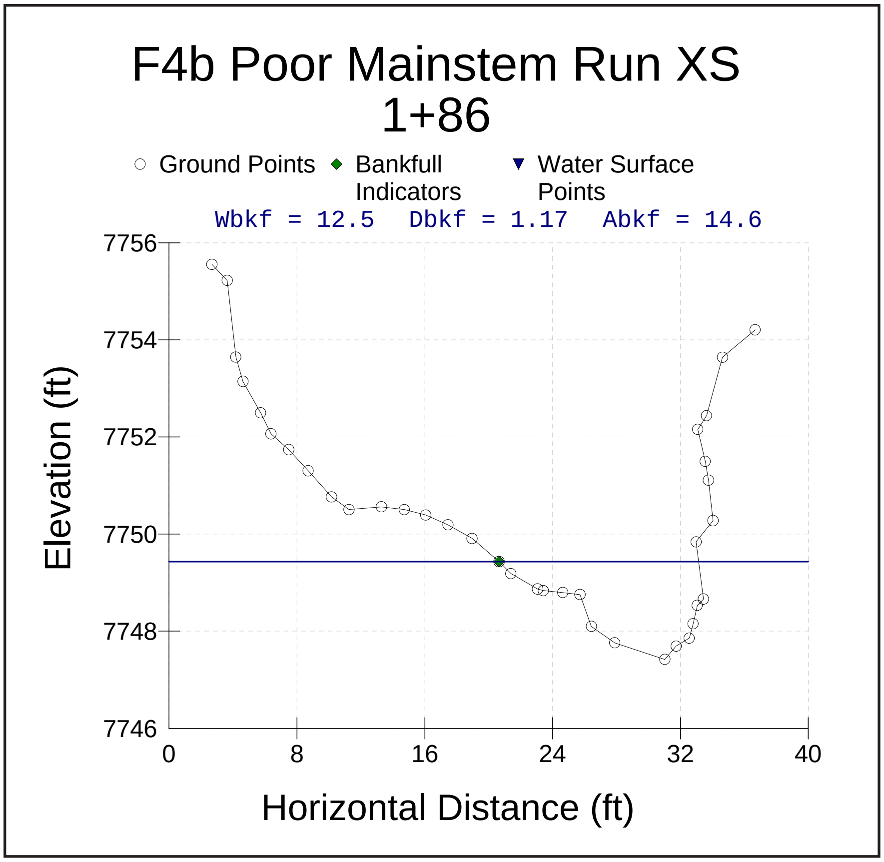
Representative Cross-Section 3+75 (graph generated from RIVERMorph^{TM})



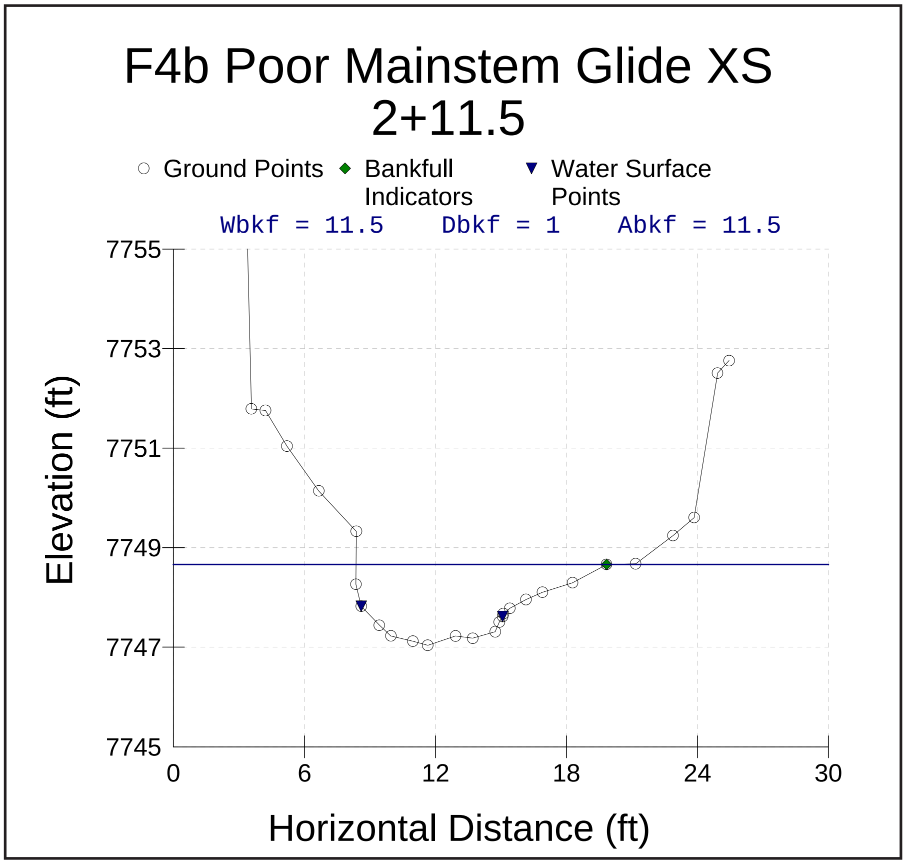
Pool Cross-section 1+17 (graph generated from RIVERMorph^{TM})



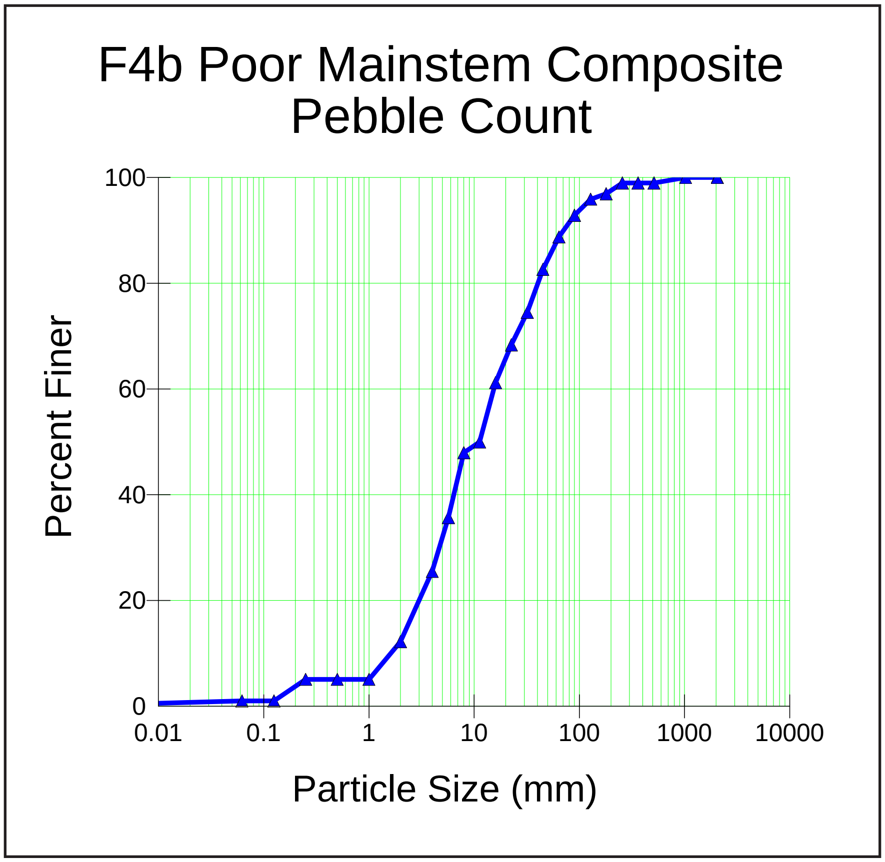
Pool Cross-section 2+04.5 (graph generated from RIVERMorph^{TM})



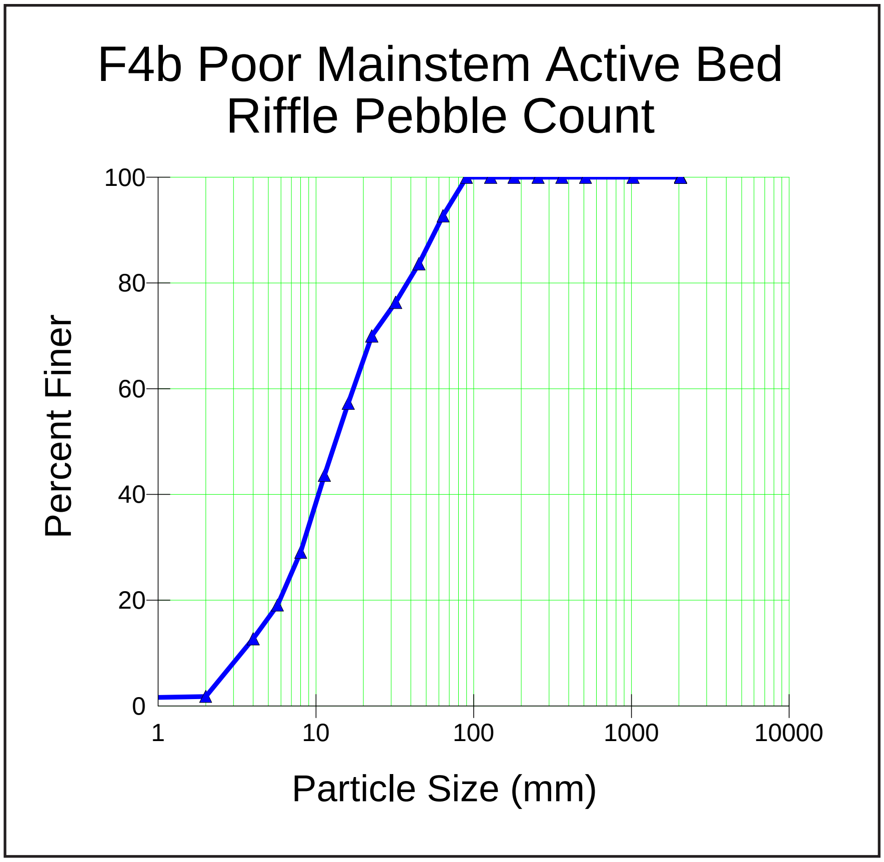
Run Cross-section 1+86 (graph generated from RIVERMorph^{TM})



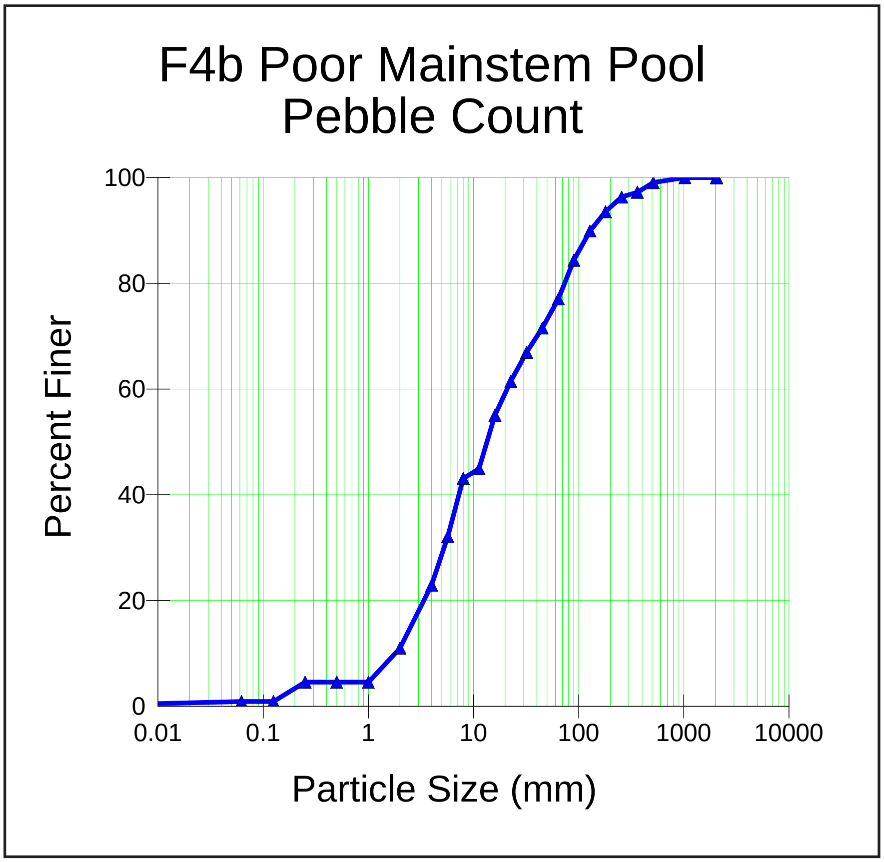
Glide Cross-Section 2+11.5 (graph generated from RIVERMorph^{TM})



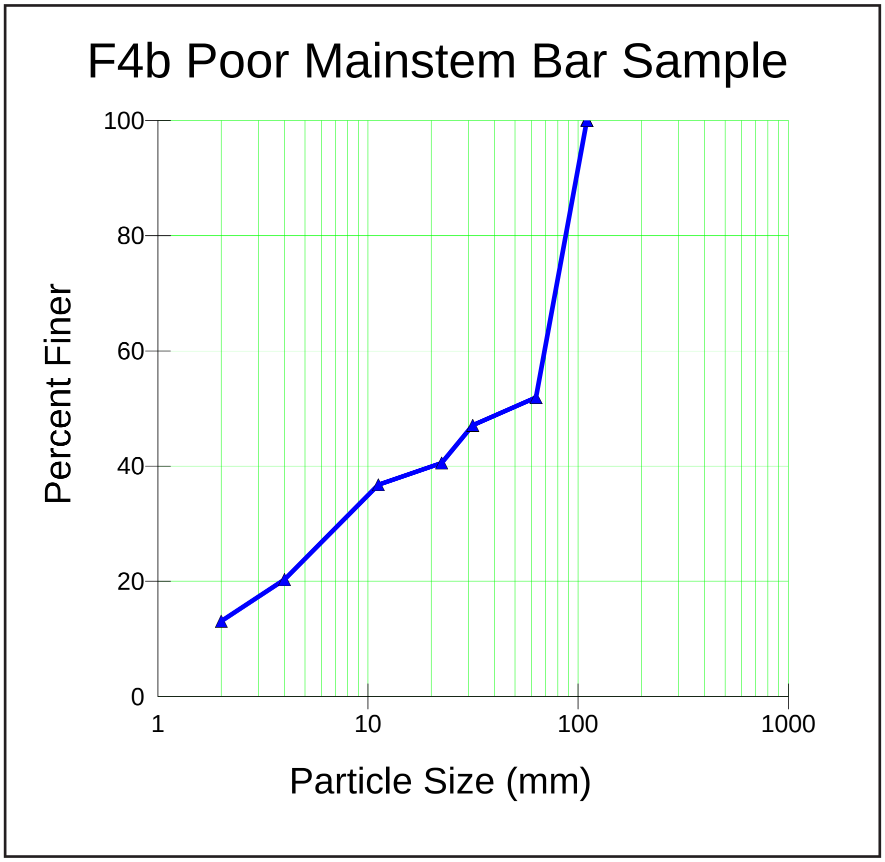
Composite Pebble Count (graph generated from RIVERMorph™)



Active Bed Riffle Pebble Count (graph generated from RIVERMorph™)



Pool Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS **Worksheets**

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, F4b Poor Mainstem**			Location:	**XS Riffle 3+75, Pike N.F., CO**
Date:	**8/12/2010**	Stream Type:	**F4b**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**			HUC:	__ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**9.17**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.53**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**17.2**	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**18.22**	W_p (ft)
D_{84} at Riffle	**45.8**	Dia. (mm)	D_{84} (mm) / 304.8	**0.15**	D_{84} (ft)
Bankfull SLOPE	**0.028**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.50**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.35**	R / D_{84}
Drainage Area	**14.3**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.674**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}]\, u^*$	**3.91**	ft / sec	**35.85**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.05**	**3.16**	ft / sec	**28.93**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.057**	**2.77**	ft / sec	**25.38**	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 Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.112**	**1.41**	ft / sec	**12.93**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, F4b Poor Mainstem Reach**

Basin: Drainage Area: acres **14.3** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 3+75** Date: **8/13/10**

Observers: **Rosgen *et al*.** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**17.15**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.53**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**9.17**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**32.4**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.05**	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.	**24.04**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.40**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**30**	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.	**0.028**	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 (S_{val} / S).	**1.25**	

Stream Type **F4b** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Trail Creek, F4b Poor Mainstem Reach**		Location:	**Pike National Forest, Colorado**
Observers:	**Rosgen *et al*.**	Date: **8/12/2010**	Valley Type: **VIII**	Stream Type: **F4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	13.0	10.5	17.2	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	9.54	7.38	11.56
Mean Riffle Depth (d_{bkf})	0.76	0.53	0.99	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	18.69	11.82	32.36
Maximum Riffle Depth (d_{max})	1.25	1.05	1.71	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.67	1.48	1.98
Width of Flood-Prone Area (W_{fpa})	17.9	12.8	24.0	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.38	1.22	1.54
Riffle Inner Berm Width (W_{ib})	5.7	5.4	6.0	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.44	0.42	0.46
Riffle Inner Berm Depth (d_{ib})	0.12	0.09	0.17	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.16	0.12	0.23
Riffle Inner Berm Area (A_{ib})	0.7	0.5	1.0	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.08	0.06	0.11
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	47.5	45.0	50.0					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	11.2	10.1	12.4	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.866	0.776	0.955
Mean Pool Depth (d_{bkfp})	1.02	1.01	1.03	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.351	1.338	1.364
Pool Cross-Sectional Area (A_{bkfp})	11.4	10.3	12.5	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.198	1.084	1.312
Maximum Pool Depth (d_{maxp})	1.71	1.64	1.77	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.265	2.172	2.344
Pool Inner Berm Width (W_{ibp})	4.8	3.4	6.1	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.428	0.303	0.544
Pool Inner Berm Depth (d_{ibp})	0.31	0.18	0.44	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.304	0.176	0.431
Pool Inner Berm Area (A_{ibp})	1.6	0.6	2.7	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.143	0.052	0.234
Point Bar Slope (S_{pb})	0.220	0.190	0.240	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	15.5	11.0	19.7

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	12.5			ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.963		
Mean Run Depth (d_{bkfr})	1.17			ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.550		
Run Cross-Sectional Area (A_{bkfr})	14.6			ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.532		
Maximum Run Depth (d_{maxr})	2.01			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	2.662		
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	10.7			ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	11.5			ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.884		
Mean Glide Depth (d_{bkfg})	1.00			ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	1.325		
Glide Cross-Sectional Area (A_{bkfg})	11.5			ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.206		
Maximum Glide Depth (d_{maxg})	1.62			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	2.146		
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	11.5			ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})			
Glide Inner Berm Width (W_{ibg})				ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})			
Glide Inner Berm Depth (d_{ibg})				ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})			
Glide Inner Berm Area (A_{ibg})				ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})			

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, F4b Poor Mainstem Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/12/2010** Valley Type: **VIII** Stream Type: **F4b**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.91**	ft/sec	Estimation Method	**u/u***	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**35.85**	cfs	Drainage Area	**14.3**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**119.8**	**93.0**	**143.2**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**9.90**	**7.69**	**11.83**
Stream Meander Length (L_m)	**129.93**	**95.70**	**155.20**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**10.74**	**7.91**	**12.83**
Radius of Curvature (R_c)	**35.6**	**28.8**	**45.0**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**2.75**	**2.22**	**3.47**
Belt Width (W_{blt})	**25.8**	**15.1**	**36.6**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.99**	**1.17**	**2.82**
Arc Length (L_a)	**48.4**	**34.5**	**70.5**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**3.74**	**2.66**	**5.44**
Riffle Length (L_r)	**7.5**	**1.7**	**31.1**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.58**	**0.13**	**2.40**
Individual Pool Length (L_p)	**9.9**	**3.6**	**31.1**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**0.77**	**0.28**	**2.40**
Pool to Pool Spacing (P_s)	**18.3**	**2.9**	**67.4**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**1.41**	**0.22**	**5.20**

Channel Profile

Valley Slope (S_{val})	**0.0350**	ft/ft	Average Water Surface Slope (S)	**0.028**	ft/ft	Sinuosity (S_{val} / S)	**1.25**
Stream Length (SL)	**320.1**	ft	Valley Length (VL)	**256.1**	ft	Sinuosity (SL / VL)	**1.25**

Low Bank Height (LBH)	start	**4.10**	ft	Max Bankfull Depth (d_{max})	start	**1.47**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start **2.8**
	end	**1.40**	ft		end	**1.47**	ft		end **1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0420**	**0.0060**	**0.0990**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.5000**	**0.2143**	**3.5357**
Run Slope (S_{run})	**0.0510**	**0.0030**	**0.1540**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**1.8214**	**0.1071**	**5.5000**
Pool Slope (S_p)	**0.0190**	**0.0000**	**0.0460**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.6786**	**0.0000**	**1.6429**
Glide Slope (S_g)	**0.0100**	**0.0040**	**0.0170**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.3571**	**0.1429**	**0.6071**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.49**	**1.29**	**1.71**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.974**	**1.709**	**2.265**
Max Run Depth (d_{maxr})	**2.01**			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**2.662**		
Max Pool Depth (d_{maxp})	**1.71**			ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.265**		
Max Glide Depth (d_{maxg})	**1.62**			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**2.146**		
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**1**	**0**	**0**	D_{16}	**2.57**	**4.87**	**2.82**		mm
% Sand	**11**	**2**	**13**	D_{35}	**5.58**	**9.34**	**8.91**		mm
% Gravel	**77**	**91**	**40**	D_{50}	**11.30**	**13.49**	**50.63**		mm
% Cobble	**10**	**7**	**47**	D_{84}	**49.18**	**45.75**	**94.37**		mm
% Boulder	**1**	**0**	**0**	D_{95}	**116.58**	**72.12**	**105.12**		mm
% Bedrock				D_{100}	**1023.95**	**90.00**	**110.00**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, F4b Poor Mainstem**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al* .**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/13/2010**

Existing species composition: **Alder, Willow, Grass/Forb, Aspen**

Potential species composition: **Spruce, Willow, Alder, Carex/Juncus**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**<10%**	**<5%**	**Alder**	**27%**
					100%
2. Understory	Shrub layer	▨	**30%**	**Willow**	**30%**
				Alder	**5%**
					100%
3. Ground level	Herbaceous	▨	**40%**	**Forbs**	**25%**
				Perrenial Grasses	**55%**
				Toadflax	**10%**
				Thistle	**5%**
				Mullen	**2%**
				Hairgrass	**2%**
					100%
	Leaf or needle litter	▨			
	Bare ground	▨			
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Active bank erosion precludes active colonization of willows; invasive species are colonizing disturbed sites

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, F4b Poor Mainstem** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/13/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

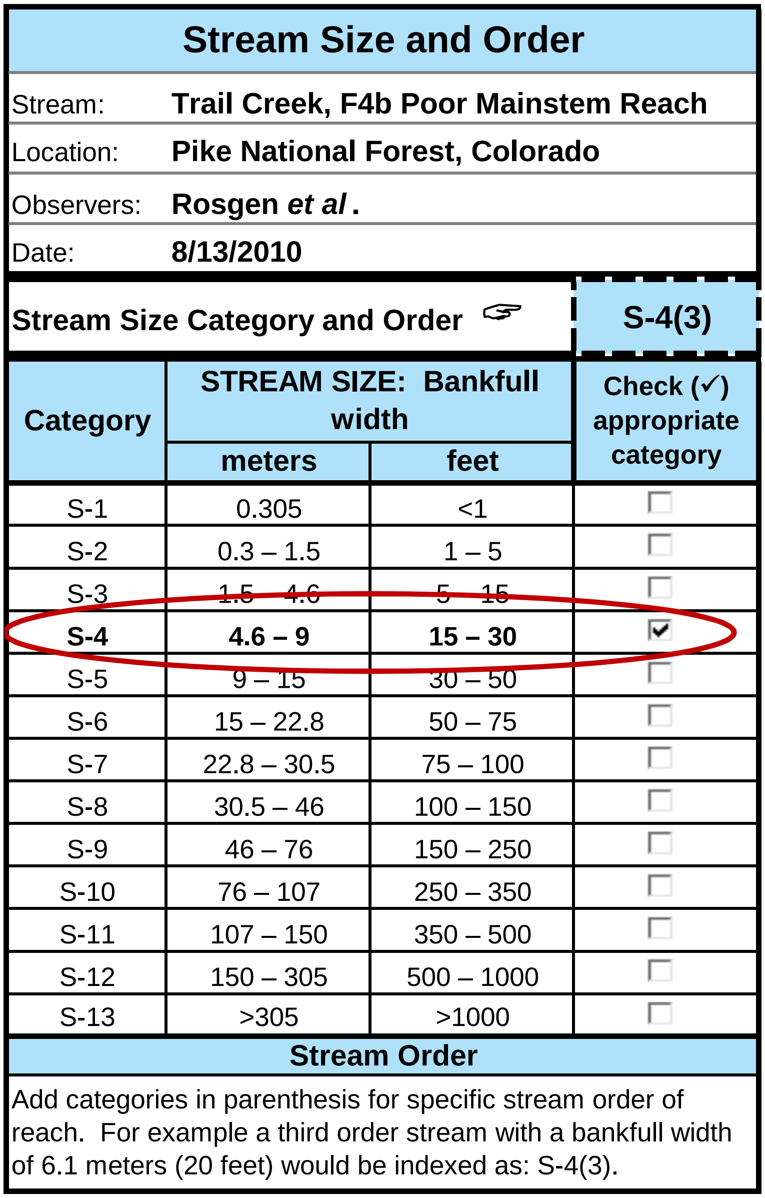
General Category

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 5-8. Stream order & stream size.



Stream Size and Order

Stream: **Trail Creek, F4b Poor Mainstem Reach**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen *et al*.**
Date: **8/13/2010**

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 5-9. Meander patterns.

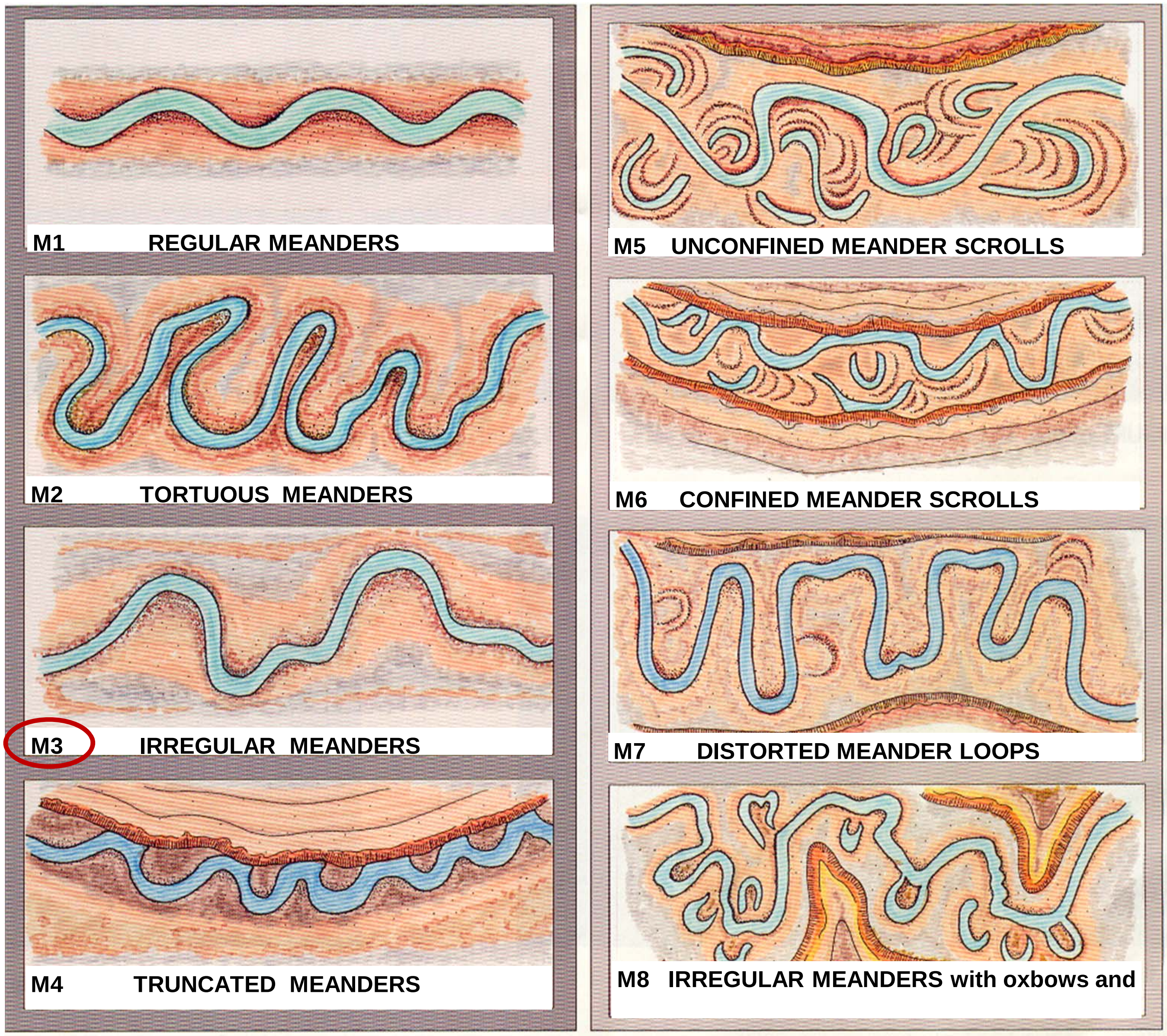
Meander Patterns

Stream: **Trail Creek, F4b Poor Mainstem Reach** Location: **Pike National Forest, CO**

Observers: **Rosgen *et al*.** Date: **8/13/2010**

List ALL CATEGORIES that APPLY ☞	**M3**				

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



Worksheet 5-10. Depositional patterns.

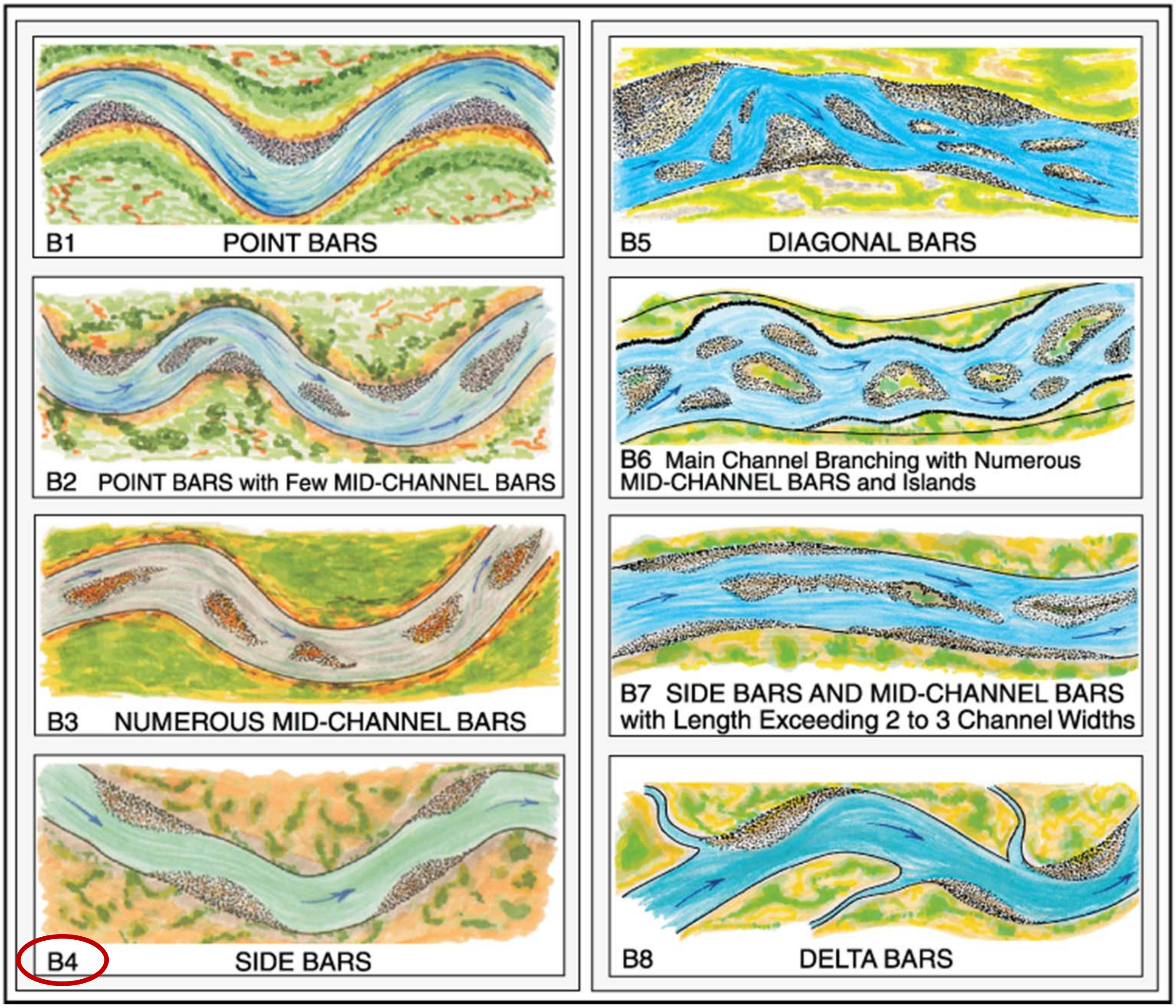
Depositional Patterns

Stream: **Trail Creek, F4b Poor Mainstem Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al* .** Date: **8/13/2010**

List ALL CATEGORIES that APPLY ☞	**B4**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, F4b Poor Mainstem Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/13/2010**

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 5-12. Degree of channel incision.

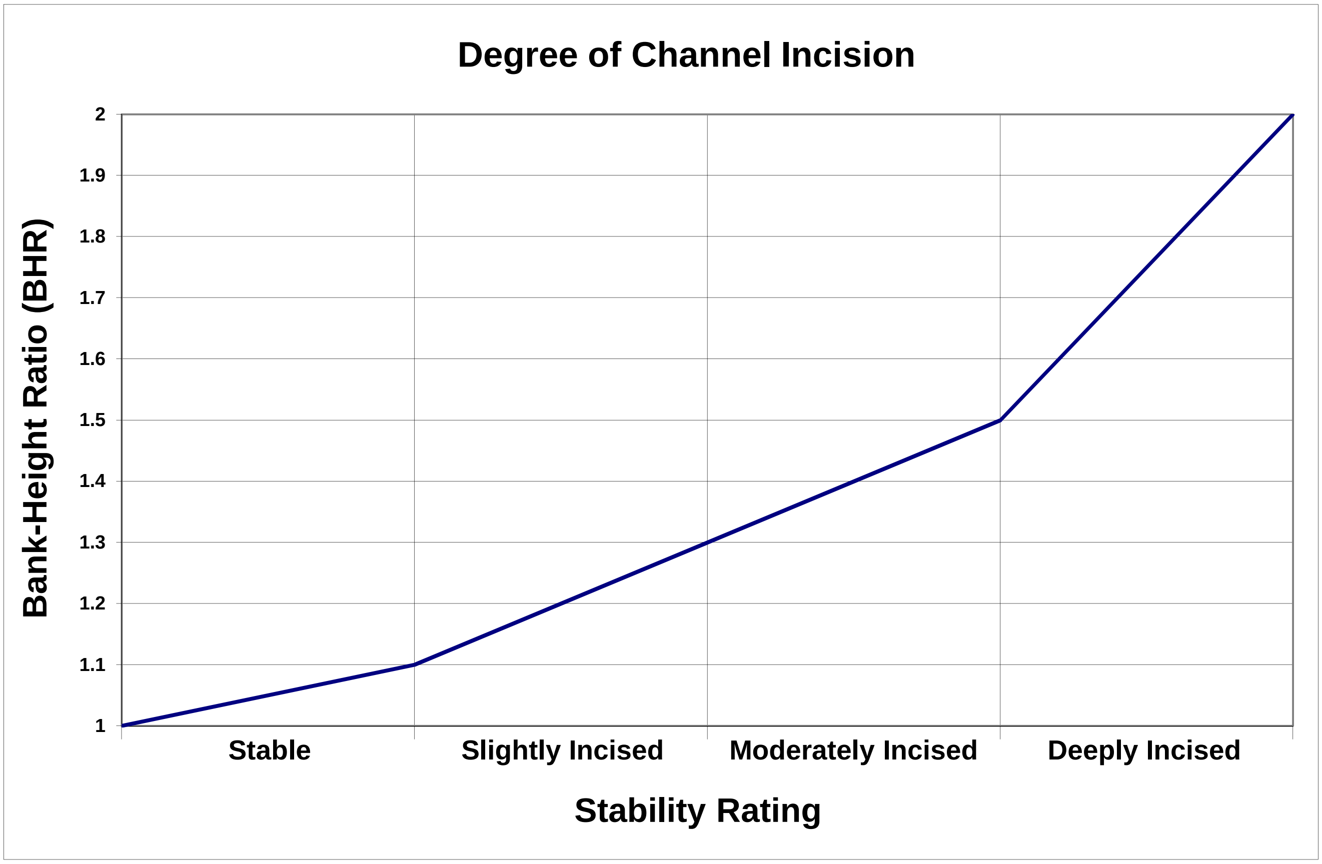
Degree of Channel Incision

Low Bank Height: **1.12**

Max Bankfull Depth: **1.12**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

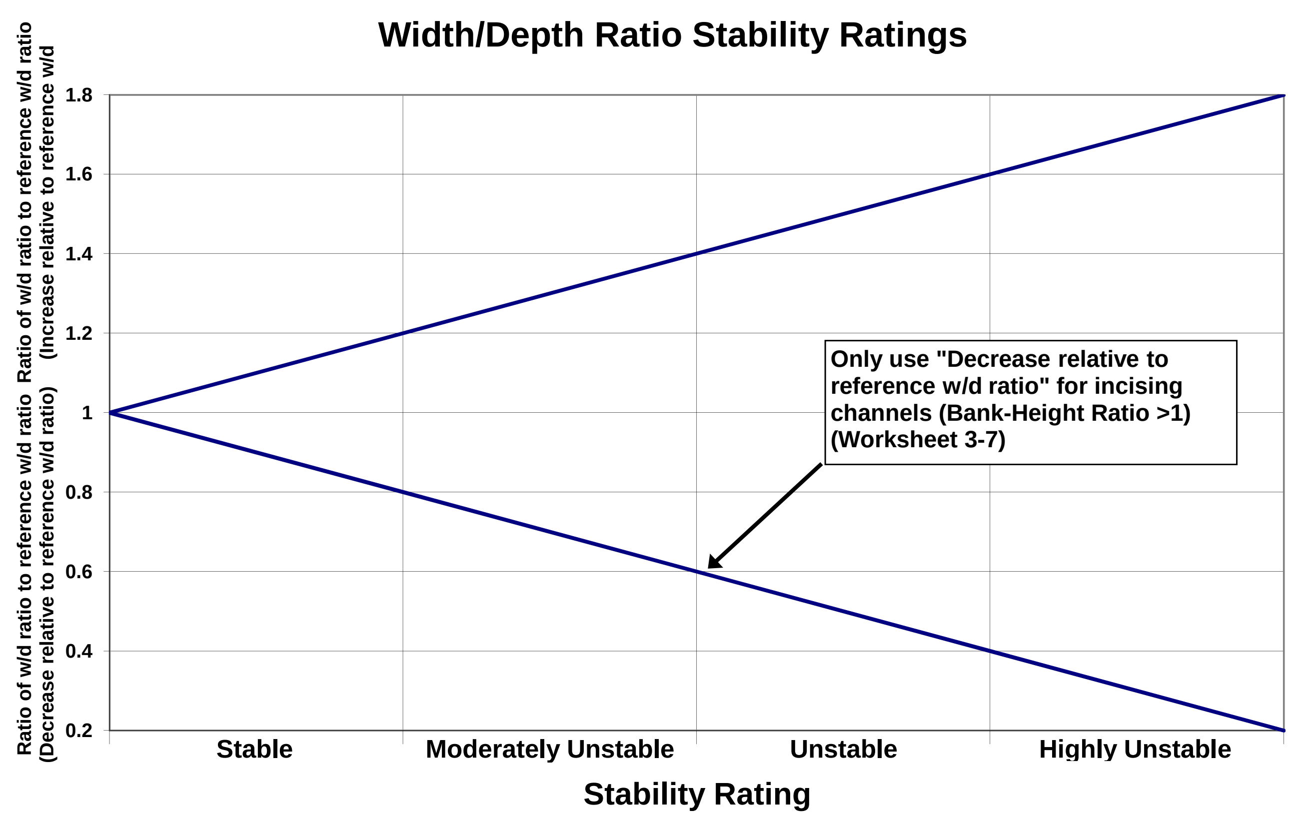
Width/Depth Ratio State

Existing Width/Depth Ratio: **32.36**

Reference Width/Depth Ratio: **12.6**

Ratio of existing W/d to reference W/d: **2.57**

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



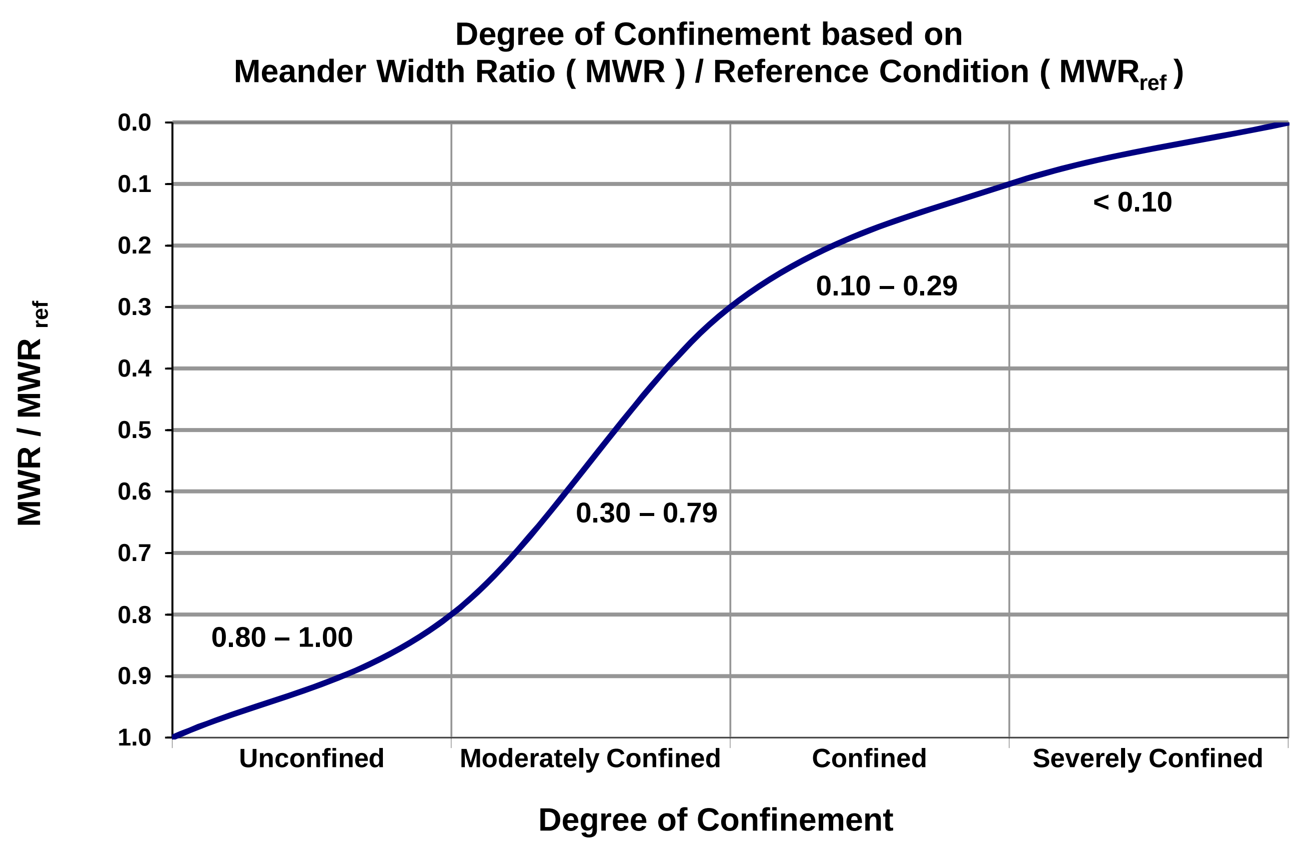
Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**2.13**
Reference Meander Width Ratio (MWR_{ref}):	**2.7**

Ratio of MWR to MWR_{ref}:	**0.8**

Degree of Confinement Stability Rating ☞	**Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, F4b Poor Mainstem Location: Pike National Forest, CO Valley Type: VIII Observers: Rosgen *et al*. Date: 8/13/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	[✓ 8]
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ 12]
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 3]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ 12]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	[✓ 3]	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 5]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	[✓ 16]
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	[✓ 10]	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	[✓ 3]	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ 8]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	[✓ 14]	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	[✓ 24]
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	**0**	**Good total =**	**8**	**Fair total =**	**30**	**Poor total =**	**96**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**[✓ B4]**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	**134**
Existing stream type =	**F4b**
***Potential stream type =**	**B4**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

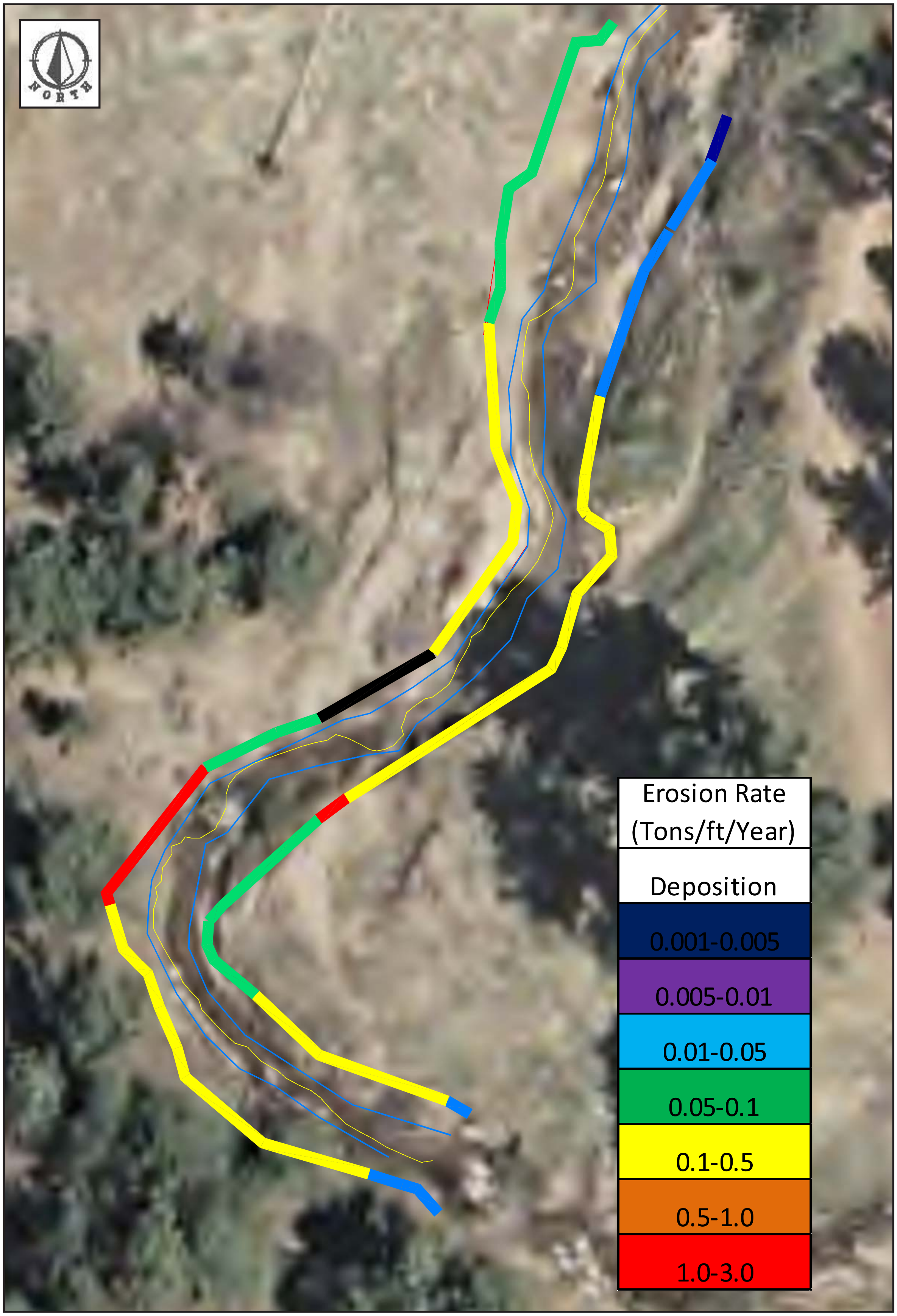
BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, F4b Poor Mainstem Reach** Location: **Pike National Forest, Colorado**
Graph Used: **Colorado** Total Stream Length (ft): **322** Date: **8/13/2010**
Observers: **Rosgen *et al*.** Valley Type: **VIII** Stream Type: **F4b**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+00L**	**High**	**Low**	**0.25042**	**7.0**	**4.1**	**7.19**	**0.04944**
2. **0+05R**	**High**	**Low**	**0.25042**	**5.0**	**4.5**	**5.63**	**0.05426**
3. **0+21L**	**High**	**Low**	**0.25042**	**14.0**	**4.5**	**15.78**	**0.05426**
4. **0+45R**	**High**	**High**	**0.57533**	**40.0**	**4.5**	**103.56**	**0.12466**
5. **0+78L**	**Very High**	**Low**	**0.25042**	**33.0**	**8.0**	**66.11**	**0.09646**
6. **0+97L**	**High**	**High**	**0.57533**	**19.0**	**4.0**	**43.73**	**0.11080**
7. **0+75R**	**Very High**	**Low**	**0.25042**	**30.0**	**4.0**	**30.05**	**0.04823**
8 **1+32L**	**Extreme**	**Very High**	**7.02692**	**35.0**	**8.0**	**1967.54**	**2.70666**
9 **1+29R**	**Very High**	**Low**	**0.25042**	**29.0**	**4.5**	**32.68**	**0.05426**
10 **1+49L**	**Moderate**	**High**	**0.42031**	**17.0**	**3.5**	**25.01**	**0.07083**
11 **1+62L**	**High**	**High**	**0.57533**	**13.0**	**2.0**	**14.96**	**0.05540**
12 **1+40R**	**Extreme**	**Extreme**	**2.76027**	**11.0**	**6.0**	**182.18**	**0.79741**
13 **1+90R**	**Extreme**	**Low**	**0.41998**	**50.0**	**7.0**	**146.99**	**0.14155**
14 **2+87L**	**Extreme**	**Low**	**0.41998**	**105.0**	**8.0**	**352.78**	**0.16177**
15 **2+07R**	**Moderate**	**Very High**	**0.69693**	**17.0**	**6.0**	**71.09**	**0.20133**
16 **2+32R**	**Low**	**Low**	**0.03566**	**25.0**	**1.4**	**1.25**	**0.00240**
17 **2+40R**	**Extreme**	**High**	**2.74738**	**8.0**	**1.4**	**30.77**	**0.18519**
18 **2+57R**	**Low**	**Low**	**0.03566**	**17.0**	**1.4**	**0.85**	**0.00240**
19 **3+34L**	**High**	**Low**	**0.25042**	**47.0**	**5.0**	**58.85**	**0.06029**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**3156.98**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**116.93**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**152.00**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.4721**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**35.85**	**0.0177**	**28.94**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**91.2**													
0.10%	**78.2**	**0.05%**	**0.09%**	**0.34**	**84.7**	**2.363**	**7.461**	**49.39**	**6.670**	**11.24**	**29.1**	**16.94**	**3.86**	**20.80**
0.25%	**67.7**	**0.08%**	**0.15%**	**0.55**	**73.0**	**2.036**	**5.232**	**29.84**	**4.809**	**8.10**	**40.0**	**16.34**	**4.44**	**20.77**
0.50%	**58.5**	**0.13%**	**0.25%**	**0.91**	**63.1**	**1.761**	**3.706**	**18.28**	**3.494**	**5.89**	**57.6**	**16.68**	**5.37**	**22.05**
0.75%	**50.0**	**0.13%**	**0.25%**	**0.91**	**54.2**	**1.513**	**2.592**	**10.98**	**2.502**	**4.22**	**49.5**	**10.02**	**3.85**	**13.87**
1%	**43.2**	**0.13%**	**0.25%**	**0.91**	**46.6**	**1.300**	**1.817**	**6.62**	**1.790**	**3.02**	**42.5**	**6.04**	**2.75**	**8.79**
1.5%	**37.1**	**0.25%**	**0.50%**	**1.83**	**40.2**	**1.120**	**1.289**	**4.05**	**1.289**	**2.17**	**73.3**	**7.38**	**3.96**	**11.35**
2%	**31.0**	**0.25%**	**0.50%**	**1.83**	**34.0**	**0.949**	**0.886**	**2.35**	**0.893**	**1.50**	**62.1**	**4.30**	**2.74**	**7.04**
3%	**26.0**	**0.50%**	**1.00%**	**3.65**	**28.5**	**0.795**	**0.600**	**1.34**	**0.602**	**1.01**	**104.0**	**4.88**	**3.70**	**8.58**
4%	**22.3**	**0.50%**	**1.00%**	**3.65**	**24.2**	**0.674**	**0.424**	**0.80**	**0.415**	**0.70**	**88.2**	**2.92**	**2.55**	**5.48**
5%	**19.8**	**0.50%**	**1.00%**	**3.65**	**21.0**	**0.587**	**0.322**	**0.53**	**0.304**	**0.51**	**76.8**	**1.93**	**1.87**	**3.80**
10%	**12.5**	**2.50%**	**5.00%**	**18.25**	**16.1**	**0.450**	**0.200**	**0.25**	**0.165**	**0.28**	**294.5**	**4.60**	**5.07**	**9.67**
20%	**6.8**	**5.00%**	**10.00%**	**36.50**	**9.6**	**0.269**	**0.103**	**0.08**	**0.045**	**0.08**	**351.4**	**2.83**	**2.79**	**5.62**
30%	**4.5**	**5.00%**	**10.00%**	**36.50**	**5.7**	**0.158**	**0.075**	**0.03**	**0.006**	**0.01**	**206.7**	**1.20**	**0.39**	**1.60**
40%	**3.2**	**5.00%**	**10.00%**	**36.50**	**3.9**	**0.108**	**0.068**	**0.02**	**0.000**	**0.00**	**141.2**	**0.75**	**0.00**	**0.75**
50%	**2.5**	**5.00%**	**10.00%**	**36.50**	**2.8**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**103.3**	**0.53**	**0.00**	**0.53**
60%	**1.9**	**5.00%**	**10.00%**	**36.50**	**2.2**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**79.2**	**0.40**	**0.00**	**0.40**
70%	**1.5**	**5.00%**	**10.00%**	**36.50**	**1.7**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**62.0**	**0.31**	**0.00**	**0.31**
80%	**1.3**	**5.00%**	**10.00%**	**36.50**	**1.4**	**0.039**	**0.064**	**0.01**	**0.000**	**0.00**	**51.7**	**0.26**	**0.00**	**0.26**
90%	**0.9**	**5.00%**	**10.00%**	**36.50**	**1.1**	**0.032**	**0.064**	**0.01**	**0.000**	**0.00**	**41.3**	**0.21**	**0.00**	**0.21**
100%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.6**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**20.7**	**0.10**	**0.00**	**0.10**
									Annual Totals:		**1,975.0** (cfs) **3,917.5** (acre-ft)	**98.6** (tons/yr)	**43.4** (tons/yr)	**142.0** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Poor" Pagosa	$y = 0.07176+1.02176x^{2.3772}$	35.85	0.4367	219.74
2. Suspended Sediment	"Poor" Pagosa	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	121.4													
0.10%	108.5	0.05%	0.09%	0.34	114.9	3.206	65.506	4466.63	16.367	681.02	39.4	1532.50	233.66	1766.16
0.25%	97.9	0.08%	0.15%	0.55	103.2	2.879	44.227	2708.12	12.691	528.04	56.5	1482.69	289.10	1771.80
0.50%	88.7	0.13%	0.25%	0.91	93.3	2.604	30.649	1697.29	10.009	416.46	85.2	1548.78	380.02	1928.80
0.75%	80.2	0.13%	0.25%	0.91	84.5	2.356	21.290	1066.85	7.907	329.01	77.1	973.50	300.22	1273.72
1%	73.4	0.13%	0.25%	0.91	76.8	2.143	15.075	687.05	6.325	263.18	70.1	626.93	240.16	867.08
1.5%	66.9	0.25%	0.50%	1.83	70.2	1.957	10.851	451.69	5.114	212.78	128.1	824.33	388.33	1212.65
2%	60.3	0.25%	0.50%	1.83	63.6	1.774	7.606	287.01	4.064	169.11	116.1	523.79	308.63	832.42
3%	55.4	0.50%	1.00%	3.65	57.9	1.614	5.412	185.80	3.261	135.69	211.2	678.18	495.28	1173.46
4%	49.3	0.50%	1.00%	3.65	52.3	1.460	3.776	117.24	2.583	107.48	191.0	427.94	392.29	820.23
5%	43.6	0.50%	1.00%	3.65	46.4	1.294	2.467	67.91	1.958	81.49	169.4	247.87	297.43	545.29
10%	27.1	2.50%	5.00%	18.25	35.3	0.986	0.974	20.42	1.060	44.10	645.1	372.68	804.74	1177.42
20%	9.4	5.00%	10.00%	36.50	18.2	0.509	0.177	1.91	0.277	11.52	666.1	69.86	420.66	490.52
30%	4.7	5.00%	10.00%	36.50	7.0	0.196	0.101	0.42	0.093	3.87	256.5	15.41	141.24	156.66
40%	3.2	5.00%	10.00%	36.50	4.0	0.110	0.099	0.23	0.077	3.21	144.3	8.49	117.20	125.70
50%	2.5	5.00%	10.00%	36.50	2.8	0.079	0.099	0.17	0.074	3.09	103.3	6.07	112.70	118.77
60%	1.9	5.00%	10.00%	36.50	2.2	0.061	0.099	0.13	0.073	3.04	79.2	4.65	110.96	115.61
70%	1.5	5.00%	10.00%	36.50	1.7	0.047	0.099	0.10	0.072	3.02	62.0	3.64	110.09	113.72
80%	1.3	5.00%	10.00%	36.50	1.4	0.039	0.099	0.08	0.072	3.01	51.7	3.03	109.70	112.73
90%	0.9	5.00%	10.00%	36.50	1.1	0.032	0.099	0.07	0.072	3.00	41.3	2.43	109.40	111.83
100%	0.2	5.00%	10.00%	36.50	0.6	0.016	0.099	0.03	0.072	2.99	20.7	1.21	109.06	110.28
									Annual Totals:		3,214.3 (cfs) 6,375.5 (acre-ft)	9,354.0 (tons/yr)	5,470.9 (tons/yr)	14,824.8 (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado** **(Used "Poor" Curves)** Date: **08/14/10**

Observers: **S=.028, Q=36, 28, Bed.=.9608, S.Sand=109.87** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.19**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.94**	**0.57**	**0.54**	**5.18**	**0.10**	**0.95**	**0.0280**	**0.18**	**1.00**	**0.19**	**10%**	**36.50**	**2.98**	**0.02**	**108.77**	**0.73**	**109.50**
80.00%	**1.32**	**1.13**	**0.88**	**6.02**	**0.15**	**1.24**	**0.0280**	**0.25**	**1.97**	**0.33**	**10%**	**36.50**	**2.98**	**0.03**	**108.77**	**1.09**	**109.86**
70.00%	**1.51**	**1.42**	**1.02**	**6.24**	**0.16**	**1.33**	**0.0280**	**0.28**	**2.48**	**0.40**	**10%**	**36.50**	**2.98**	**0.04**	**108.77**	**1.46**	**110.23**
60.00%	**1.89**	**1.70**	**1.16**	**6.45**	**0.18**	**1.42**	**0.0280**	**0.31**	**2.97**	**0.46**	**10%**	**36.50**	**3.02**	**0.05**	**110.23**	**1.83**	**112.06**
50.00%	**2.45**	**2.17**	**1.39**	**6.79**	**0.20**	**1.56**	**0.0280**	**0.36**	**3.79**	**0.56**	**10%**	**36.50**	**3.02**	**0.06**	**110.23**	**2.19**	**112.42**
40.00%	**3.21**	**2.83**	**1.64**	**7.02**	**0.23**	**1.69**	**0.0280**	**0.41**	**4.94**	**0.70**	**10%**	**36.50**	**3.07**	**0.08**	**112.05**	**2.92**	**114.97**
30.00%	**4.70**	**3.96**	**2.06**	**7.40**	**0.28**	**1.91**	**0.0280**	**0.48**	**6.92**	**0.94**	**10%**	**36.50**	**3.20**	**0.12**	**116.80**	**4.38**	**121.18**
20.00%	**9.36**	**7.03**	**3.01**	**8.02**	**0.38**	**2.32**	**0.0280**	**0.65**	**12.28**	**1.53**	**10%**	**36.50**	**3.84**	**0.21**	**140.16**	**7.67**	**147.83**
10.00%	**27.14**	**18.25**	**5.74**	**9.50**	**0.60**	**3.17**	**0.0280**	**1.03**	**31.89**	**3.36**	**10%**	**36.50**	**11.40**	**0.95**	**416.10**	**34.67**	**450.77**
5.00%	**43.55**	**35.35**	**11.78**	**21.41**	**0.55**	**2.99**	**0.0280**	**0.94**	**61.76**	**2.88**	**5%**	**18.25**	**43.59**	**10.08**	**795.52**	**183.96**	**979.48**
4.00%	**49.25**	**46.40**															
3.00%	**55.41**	**52.33**															
2.00%	**60.32**	**57.87**															
1.50%	**66.88**	**63.60**															
1.00%	**73.44**	**70.16**															
0.75%	**80.19**	**76.82**															
0.50%	**88.73**	**84.46**															
0.25%	**97.95**	**93.34**															
0.10%	**108.47**	**103.21**															
0.0060%	**121.38**	**114.93**															
											Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):				**2127.4**	**240.9**	**2368.3**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, F4b Poor Mainstem, Riffle XS 3+75** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/14/10**

Observers: **S=.028, Q=36, 28, Bed.=.9608, S.Sand=109.87** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.19**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.94**	**0.57**	**0.43**	**4.45**	**0.10**	**1.19**	**0.0280**	**0.17**	**1.00**	**0.22**	**10%**	**36.50**	**2.98**	**0.02**	**108.77**	**0.73**	**109.50**
80.00%	**1.32**	**1.13**	**0.73**	**5.65**	**0.13**	**1.51**	**0.0280**	**0.22**	**1.97**	**0.35**	**10%**	**36.50**	**2.98**	**0.03**	**108.77**	**1.09**	**109.86**
70.00%	**1.51**	**1.42**	**0.85**	**5.97**	**0.14**	**1.59**	**0.0280**	**0.24**	**2.48**	**0.42**	**10%**	**36.50**	**2.98**	**0.04**	**108.77**	**1.46**	**110.23**
60.00%	**1.89**	**1.70**	**0.97**	**6.28**	**0.15**	**1.68**	**0.0280**	**0.26**	**2.97**	**0.47**	**10%**	**36.50**	**3.02**	**0.05**	**110.23**	**1.83**	**112.06**
50.00%	**2.45**	**2.17**	**1.17**	**6.81**	**0.17**	**1.82**	**0.0280**	**0.29**	**3.79**	**0.56**	**10%**	**36.50**	**3.02**	**0.06**	**110.23**	**2.19**	**112.42**
40.00%	**3.21**	**2.83**	**1.39**	**7.17**	**0.19**	**1.99**	**0.0280**	**0.33**	**4.94**	**0.69**	**10%**	**36.50**	**3.07**	**0.08**	**112.05**	**2.92**	**114.97**
30.00%	**4.70**	**3.96**	**1.71**	**7.31**	**0.23**	**2.25**	**0.0280**	**0.40**	**6.92**	**0.95**	**10%**	**36.50**	**3.20**	**0.12**	**116.80**	**4.38**	**121.18**
20.00%	**9.36**	**7.03**	**2.49**	**7.71**	**0.32**	**2.79**	**0.0280**	**0.55**	**12.28**	**1.59**	**10%**	**36.50**	**4.10**	**0.22**	**149.65**	**8.03**	**157.68**
10.00%	**27.14**	**18.25**	**5.28**	**11.92**	**0.44**	**3.44**	**0.0280**	**0.75**	**31.89**	**2.68**	**10%**	**36.50**	**8.60**	**0.80**	**313.90**	**29.20**	**343.10**
5.00%	**43.55**	**35.35**															
4.00%	**49.25**	**46.40**															
3.00%	**55.41**	**52.33**															
2.00%	**60.32**	**57.87**															
1.50%	**66.88**	**63.60**															
1.00%	**73.44**	**70.16**															
0.75%	**80.19**	**76.82**															
0.50%	**88.73**	**84.46**															
0.25%	**97.95**	**93.34**															
0.10%	**108.47**	**103.21**															
0.0060%	**121.38**	**114.93**															
Notes:										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**1239.2**	**51.8**	**1291.0**
										Upstream total annual sediment supply (tons/yr) (**Worksheet 5-12a**):					**2127.4**	**240.9**	**2368.3**
										Difference in sediment transport capacity (tons/yr) (+ or -):					**-888.2**	**-189.1**	**-1077.3**
										Stability evaluation: Aggradation, Degradation or Stable:					**Aggradation, > 45% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, F4b Poor Mainstem**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/13/2010**

Enter Required Information for Existing Condition

13.5	D_{50}	Riffle bed material D_{50} (mm)			
50.6	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.36	D_{max}	Largest particle from bar sample (ft)	**110**	**(mm)**	304.8 mm/ft
0.028	S	Existing bankfull water surface slope (ft/ft)			
0.53	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.27	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
8.15	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**1**

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

N/A	**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

N/A	**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

0.926		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 **65**	CO **150**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **1.2**	CO **0.65**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.69**	CO **0.37**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\mathbf{d} = \dfrac{\tau}{\gamma S}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0363**	CO **0.0197**	Predicted slope required to initiate movement of measured D_{max} (mm) $\mathbf{S} = \dfrac{\tau}{\gamma d}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, F4b Poor Mainstem**	Stream Type: **F4b**
Location: **Pike National Forest, CO**	Valley Type: **VIII**
Observers: **Rosgen *et al*.**	Date: **8/13/2010**
Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, F4b Poor Mainstem Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/13/2010**

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 5-13)**	< 1.2 **(2)**	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **2.6** [✓ **(8)**]	**8**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	**B4**, B8 **B4** [✓ **(2)**]	B3 **(3)**	B5, B6, B7 **(4)**	**2**
3 **Meander Patterns (Worksheet 5-9)**	M1, **M3**, M4 **M3** [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex [✓ **(8)**]	**8**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 **0.8** [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**20**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trail Creek, F4b Poor Mainstem Reach** Stream Type: **F4b**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **Rosgen *et al*.** Date: **8/13/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**1**
	[✓ 1]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**6**
	(2)	**(4)**	**≈ 18% [✓ (6)]**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
	(2)	**(4)**	**(6)**	**2.6 [✓ (8)]**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**6**
	(2)	**(4)**	**[✓ (6)]**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, B4	B3, B5	B6, B7, B8	**2**
	(1)	**B4 [✓ (2)]**	**(3)**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, **D3**	D4, D7	D5, D8	D6, D9, D10	**1**
	D3 [✓ (1)]	**(2)**	**(3)**	**(4)**	
				Total Points	**24**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, F4b Poor Mainstem Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al*.**	Date:	**8/13/2010**

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 5-22)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	0.80 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**9**
	Vertical Stability Category Point Range for Channel Incision / Degradation				
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐	

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, F4b Poor Mainstem Reach** Stream Type: **F4b**

Location: **Pike National Forest, Colorado** Valley Type: **VIII**

Observers: **Rosgen *et al*.** Date: **8/13/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) [✓ **(6)**]	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**6**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* [✓ **(6)**]	*Highly Unstable* **(8)**	**6**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**20**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☑	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, F4b Poor Mainstem Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen *et al* .**	Date:	**8/13/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	***Stable***	**1**	**3**
	Mod. Unstable	**2**	
	Unstable	**[✓ 3]**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	***No Deposition***	**1**	**3**
	Mod. Deposition	**2**	
	Excess Deposition	**[✓ 3]**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	***Not Incised***	**[✓ 1]**	**1**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 5-28)	***No Increase***	**1**	**3**
	Slight Increase	**2**	
	Mod. Increase	**[✓ 3]**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 5-15)	***Good: Stable***	**1**	**4**
	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*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☑	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, F4b Poor Mainstem Reach**						Location:	**Pike National Forest, Colorado**				
Observers:	**Rosgen *et al*.**		Date:	**8/13/2010**			Stream Type:	**F4b**		Valley Type:	**VIII**	
Channel Dimension (Riffle XS 3+75)	Mean Bankfull Depth (ft):	**0.53**	Bankfull Width (ft):	**17.15**	Cross-Sectional Area (ft^2):	**9.17**	Width of Flood-Prone Area (ft):	**24.04**	Entrenchment Ratio:	**1.4**		
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**9.9** **7.7-11.8**	L_m/W_{bkf}:	**10.7** **7.9-12.8**	R_c/W_{bkf}:	**2.75** **2.2-3.5**	MWR:	**1.99** **1.17-2.82**	Sinuosity:	**1.25**	
River Profile & Bed Features	Check: ☑ Riffle/Pool		☐ Step/Pool		☐ Plane Bed		☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed			
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope			
		1.49	**1.71**		**1.987**	**2.28**		**1.51**	Valley:	**0.035**	Water Surface:	**0.028**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:			Remarks: Condition, Vigor & Usage of Existing Reach:					
		Alder,Willow,Forbs/Mod.		**Willow, C-wd., c-junc/High**			**Active bank erosion precludes colonization.**					
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-4(3)**	Meander Patterns:	**M3**	Depositional Patterns:	**B4**	Debris/Channel Blockages:	**D3**		
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**134 (Poor)**						
	Width/depth Ratio (W/d):	**32.4**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**2.57**	W/d Ratio State Stability Rating:	**Highly Unstable**				
	Meander Width Ratio (MWR):	**2.13**	Reference MWR_{ref}:	**2.7**	Degree of confinement (MWR / MWR_{ref}):	**0.8**	MWR / MWR_{ref} Stability Rating:	**Unconfined**				
Bank Erosion Summary	Length of Reach Studied (ft):	**322**	Annual Streambank Erosion Rate:	**152** (tons/yr)	**0.4721** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:				
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity	Remarks: **>18% Reduction in Transport**								
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**110**	τ =	**2.2**	τ* =	**N/A**	Existing Depth:	**1.3**	Required Depth:	**0.75**	Existing Slope: **0.03**	Required Slope: **0.02**
Successional Stage Shift	**B → G → [✓ F] → B → →**						Existing Stream State (Type):	**F4b**	Potential Stream State (Type):	**B4**		
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Fire and flood effects**						
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:	**Fire and flood effects**						
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Fire and flood effects**						
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☑ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**Fire and flood effects**						
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☑ *High*	☐ *Very High*	Remarks/causes:	**Fire and flood effects**						

Appendix C14

F4b Stream Type

Poor Stability Trib. Reach

Table of Contents

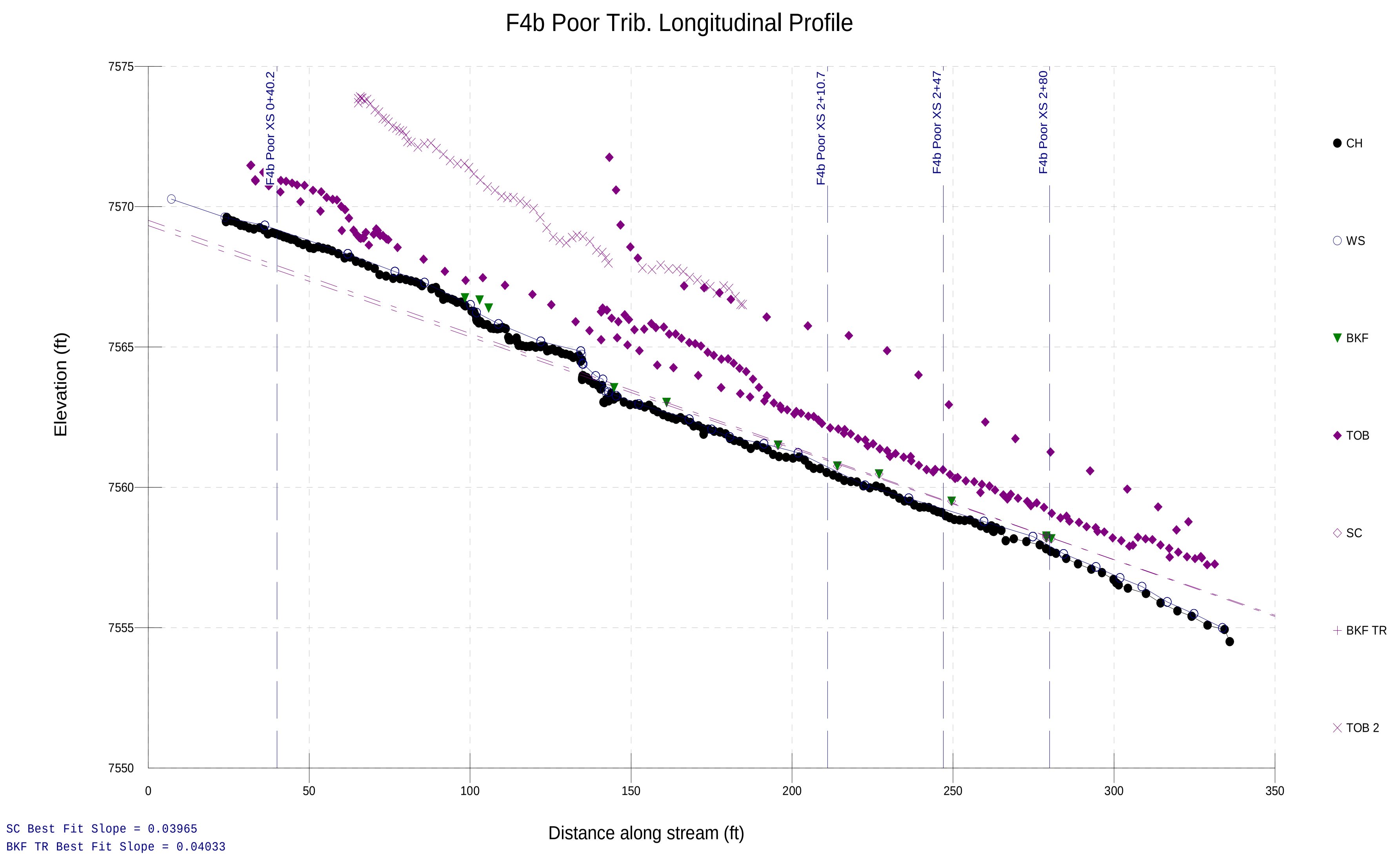
Appendix C14: F4b Poor Trib. Reach

F4b Poor Trib. Reach Location & Overview

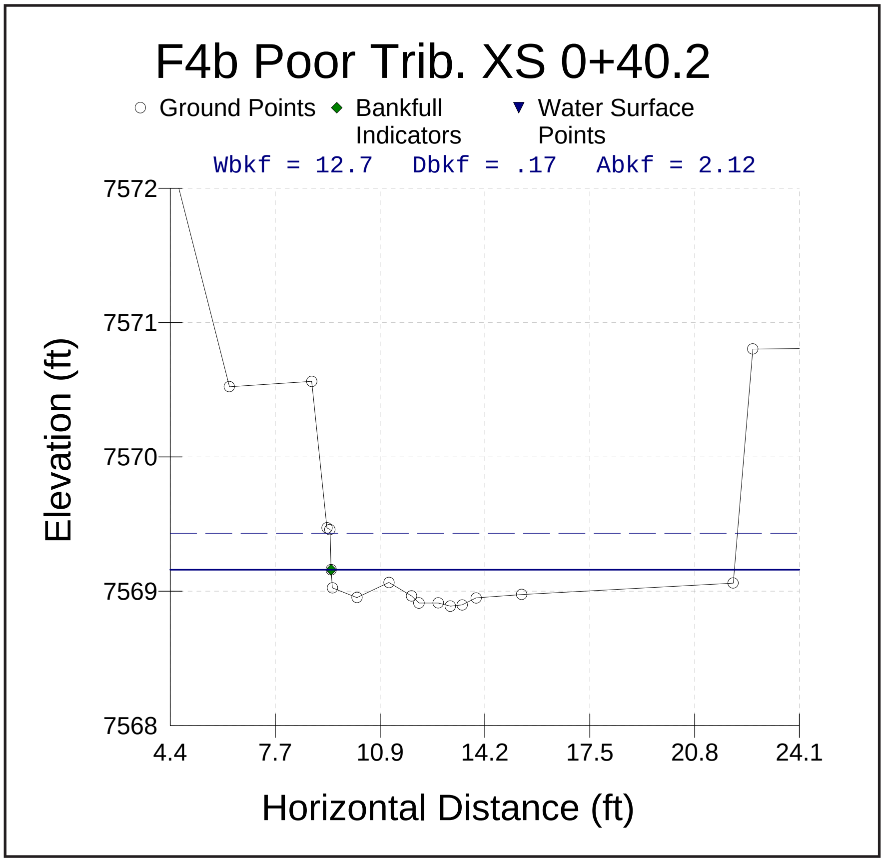
The F4b Poor tributary representative reach is a perennial, relatively steep gradient, entrenched stream located in the upper Trail Creek Watershed (see location map **Figure C-2**). This channel had previously been a D4 stream type on an active alluvial fan (Valley Type IIIa), then shifted to a G4 stream type, and over time has widened to the current F4b stream type. The stable potential stream type is a B4 stream type as the stream is apparently trying to recover from past floods and high sediment supply impacts. The width/depth ratio of *47* is very high and will continue to promote excess deposition and high streambank erosion. The stream is still enlarging due to the high peak flows following the fire. A POWERSED run was made to determine streambed stability, which approximated *129 tons/yr* of deposition. The stability rating is "Poor" due to a Pfankuch stability rating of 144 ("Poor") and the high streambank erosion rate of *0.39 tons/yr/ft*. This rate is nearly two orders of magnitude larger than the B4 reference rate of *0.0048 tons/yr/ft*. The sediment supply rating is *Very High*, typical of an F4b stream type, due to the high banks on both sides and sediment deposition in the bed. The "Poor" stability rating indicates a higher potential accelerated increase in flow-related sediment compared to the same-sized B4 reference stream type. The WRENSS model indicated that the water yield due to the fire increased from *921 acre-ft* to *1,179 acre-ft*, representing a total increase of *258 acre-ft*. The corresponding bedload increased from *23 tons/yr* to *709 tons/yr*, and suspended sediment increased from *3.3 tons/yr* to *558 tons/yr*, representing a total increase in sediment of *1,240 tons/yr*. This sediment yield increase is extremely high for a stream with a bankfull discharge of 8.4 cfs. The increased sediment supply is due to the very unstable banks and high width/depth ratio that encourages increased sediment deposition in the streambed. This increased sediment loading is equivalent to *95 ten-yard, end dump truck loads per year*.

The photograph depicts the typical character of this representative F4b Poor stream type. The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

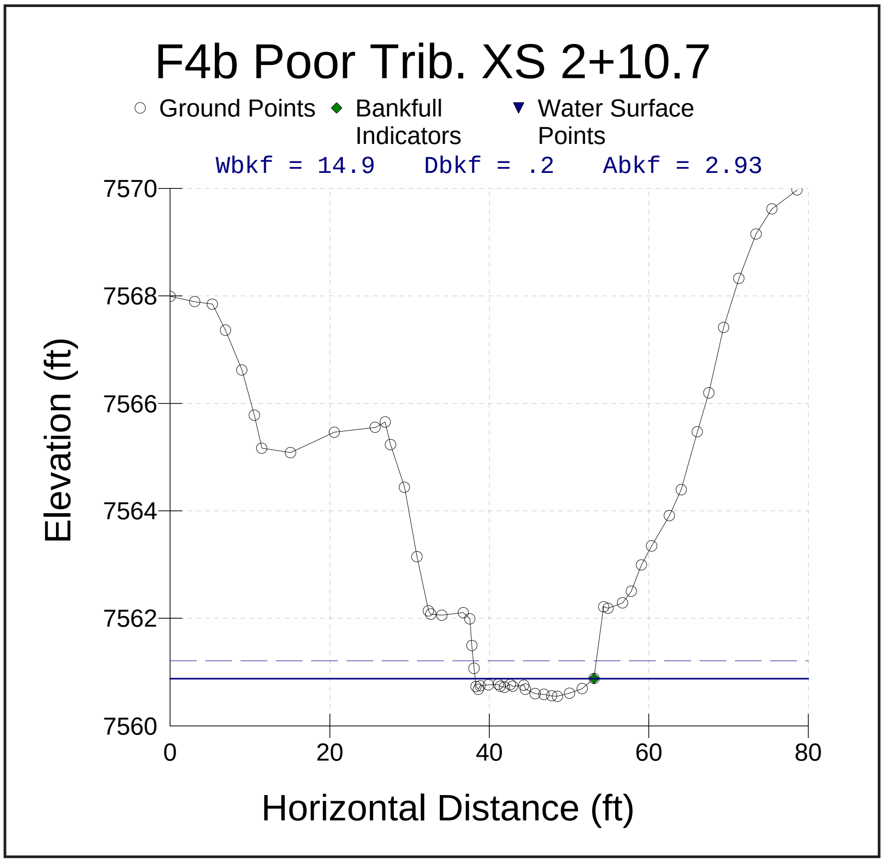
Survey Summary



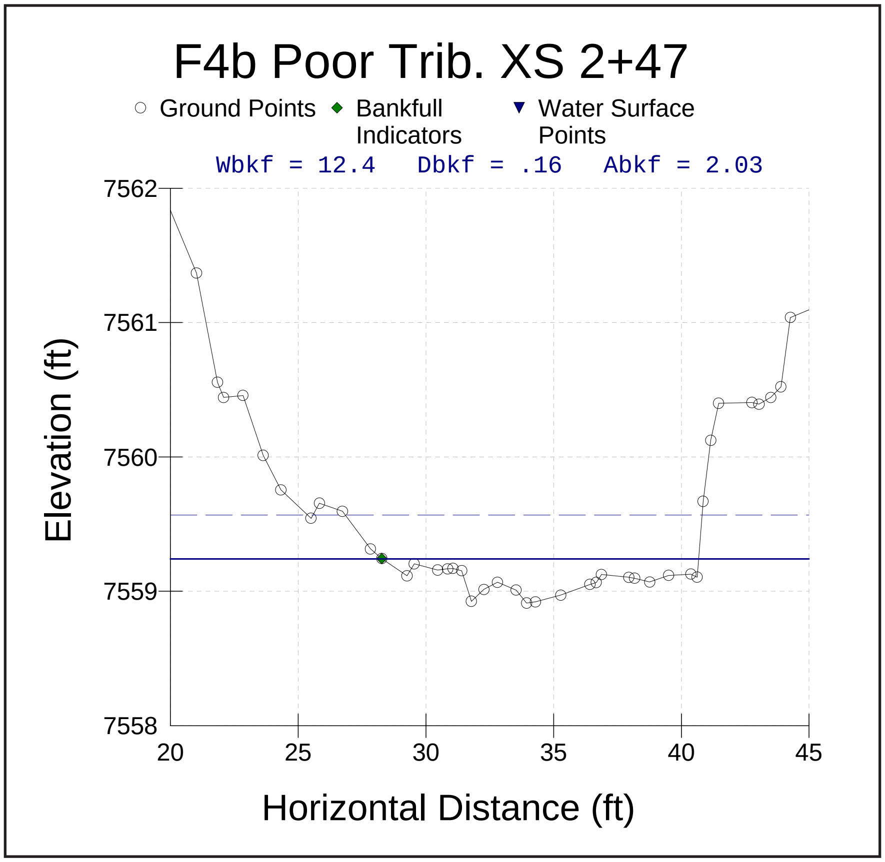
Longitudinal Profile (graph generated from RIVERMorph^{TM})



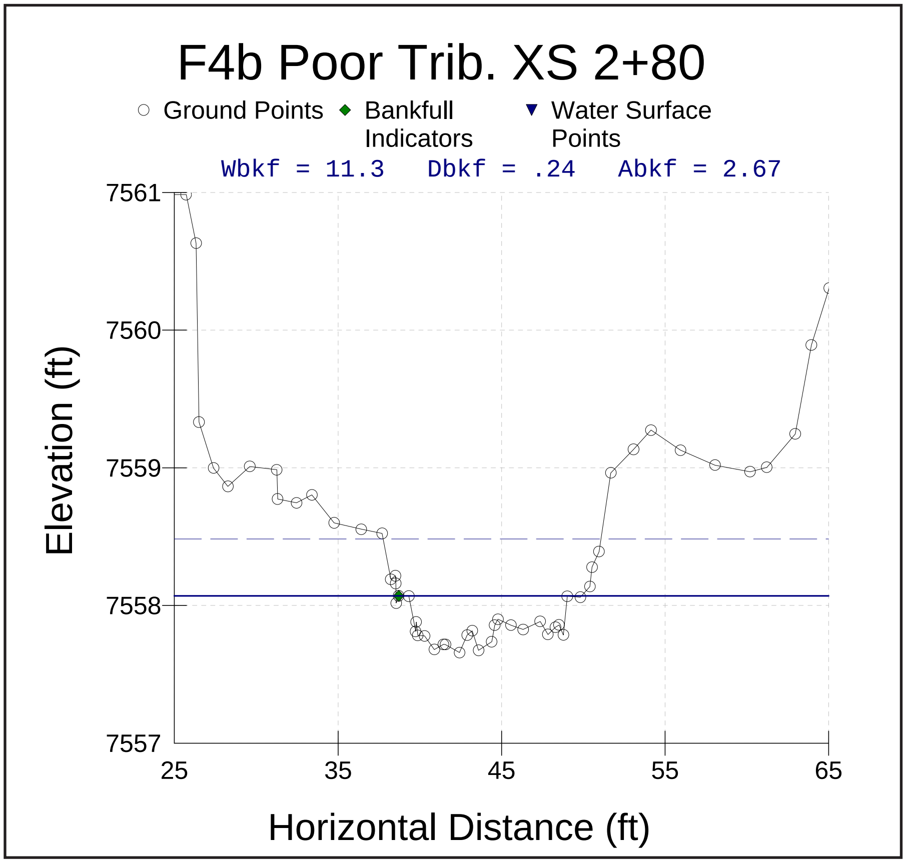
Riffle Cross-section 0+40.2 (graph generated from RIVERMorph^{TM})



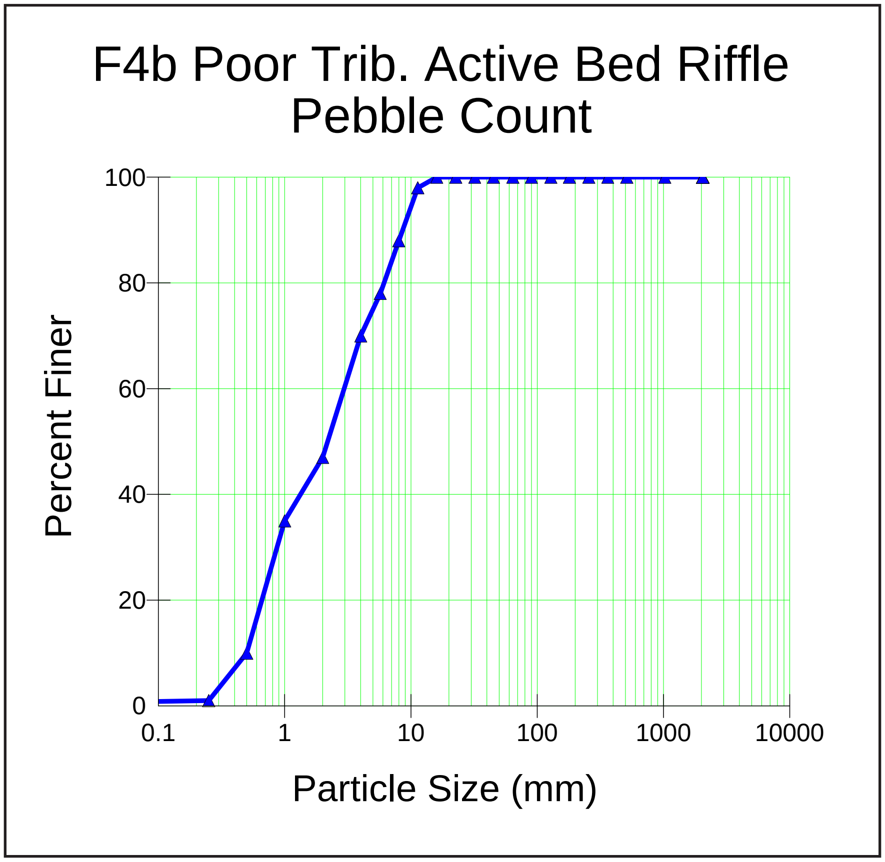
Riffle Cross-section 2+10.7 (graph generated from RIVERMorph^{TM})



Riffle Cross-section 2+47 (graph generated from RIVERMorph^{TM})



Representative Riffle Cross-Section 2+80 (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, F4b Poor Trib. Reach**			Location:	**XS 2+80, Pike N.F., Colorado**
Date:	**8/17/2010**	Stream Type:	**F4b**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**			HUC:	_ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _

INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	**2.67**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.24**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**11.35**	W_{bkf} (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**11.82**	W_p (ft)
D_{84} at Riffle	**7.1**	Dia. (mm)	D_{84} (mm) / 304.8	**0.02**	D_{84} (ft)
Bankfull SLOPE	**0.04**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.23**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**9.72**	R / D_{84}
Drainage Area	**1.5**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.539**	u* (ft/sec)

ESTIMATION METHODS		**Bankfull VELOCITY**		**Bankfull DISCHARGE**	
1. Friction Factor / Relative Roughness	$u = [\,2.83 + 5.66 * Log\,\{\,R / D_{84}\,\}\,]\,u^*$	**4.54**	ft / sec	**12.13**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8)	$u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.035**	**3.16**	ft / sec	**8.43**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9)	$u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.041**	**2.70**	ft / sec	**7.20**	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	$u = 1.49 * R^{2/3} * S^{1/2} / n$ $n = 0.39 * S^{0.38} * R^{-0.16}$ $n =$ **0.146**	**0.76**	ft / sec	**2.03**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)			ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)			ft / sec		cfs
4. Continuity Equations: a) Regional Curves **Return Period for Bankfull Discharge**	**u = Q / A** **Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data	**u = Q / A**		ft / sec		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 5-3. Level II stream classification.

Stream: **Trail Creek, F4b Poor Trib. Reach**

Basin: Drainage Area: **960** acres **1.5** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 2+80** Date: **08/17/2010**

Observers: **Rosgen *et al*.** Valley Type: **III**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**11.35**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.24**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**2.67**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**47.29**	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.	**0.41**	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.	**13.31**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.17**	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.	**2**	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.	**0.04**	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 **F4b** (See **Figure 2-14**)

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/17/2010** Valley Type: **III** Stream Type: **F4b**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*' **' ***	**Mean**	**Min**	**Max**		**Riffle Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Riffle Width (W_{bkf})	**12.83**	**11.35**	**14.89**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**2.44**	**2.03**	**2.93**
Mean Riffle Depth (d_{bkf})	**0.19**	**0.16**	**0.24**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**68.43**	**47.29**	**77.38**
Maximum Riffle Depth (d_{max})	**0.34**	**0.27**	**0.41**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	**1.75**	**1.59**	**2.06**
Width of Flood-Prone Area (W_{fpa})	**13.94**	**12.81**	**15.44**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.09**	**1.01**	**1.17**
Riffle Inner Berm Width (W_{ib})	**5.65**	**5.59**	**5.70**	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	**0.44**	**0.44**	**0.44**
Riffle Inner Berm Depth (d_{ib})	**0.09**	**0.08**	**0.09**	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	**0.44**	**0.42**	**0.47**
Riffle Inner Berm Area (A_{ib})	**0.48**	**0.45**	**0.51**	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	**0.20**	**0.18**	**0.21**
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	**66.61**	**63.33**	**69.88**					

Pool Dimensions*, **, ***

Pool Dimensions*' **' ***	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/17/2010** Valley Type: **III** Stream Type: **F4b**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.16**	ft/sec	Estimation Method	**"n" from FF/RR**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**8.43**	cfs	Drainage Area	**1.5**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**18.3**	**14.0**	**27.4**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.43**	**1.09**	**2.14**
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.0425**	ft/ft	Average Water Surface Slope (S)	**0.0410**	ft/ft	Sinuosity (S_{val} / S)	**1.04**
Stream Length (SL)	**304.3**	ft	Valley Length (VL)	**293.4**	ft	Sinuosity (SL / VL)	**1.04**

Low Bank Height (LBH)	start	**1.56**	ft	Max Bankfull Depth (d_{max})	start	**0.56**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start **2.8**
	end	**1.32**	ft		end	**0.45**	ft		end **2.9**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0690**	**0.0280**	**0.0880**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.6829**	**0.6829**	**2.1463**
Run Slope (S_{run})				ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)				ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)			
Glide Slope (S_g)				ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)			
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**0.34**	**0.27**	**0.41**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.740**	**1.403**	**2.130**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay		**0**		D_{16}		**0.62**			mm
% Sand		**47**		D_{35}		**1.00**			mm
% Gravel		**53**		D_{50}		**2.26**			mm
% Cobble		**0**		D_{84}		**7.08**			mm
% Boulder		**0**		D_{95}		**10.31**			mm
% Bedrock		**0**		D_{100}		**16.00**			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, F4b Poor Trib. Reach**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/16/2010**

Existing species composition: **Ponderosa Pine - 5% Burnt, Annual Grass/Forb, Cheatgrass**

Potential species composition: **Willow, Alder, Grass, Aspen**

	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**	**100%**
					100%
2. Understory	Shrub layer	▨	**0%**		
					100%
3. Ground level	Herbaceous	▨	**5%**	**Mullen** **Cheatgrass** **Ag Spic** **Annual grass** **Forbs**	
					100%
	Leaf or needle litter	▨	**5%**	**Remarks:** Condition, vigor and/or usage of existing reach:	
	Bare ground	▨	**90%**		
			Column total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, F4b Poor Trib.** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

List ALL COMBINATIONS that APPLY..............☞	**E2**	**E8**	**S2**	**S8**				

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, F4b Poor Trib. Reach**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen *et al* .**
Date: **8/16/2010**

Stream Size Category and Order ☞ **S-3(4)**

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 5-9. Meander patterns.

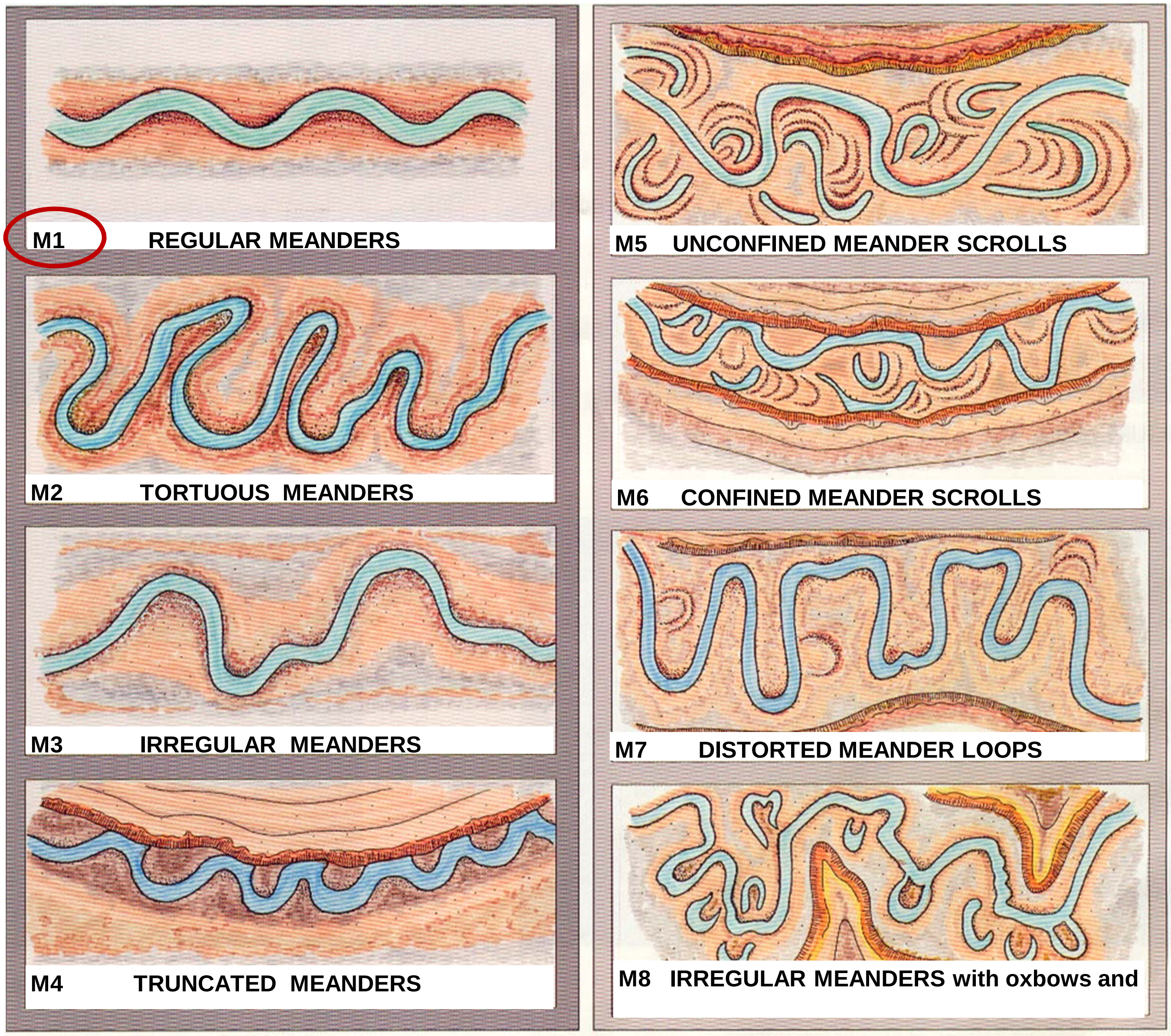
Meander Patterns

Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, CO**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

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 5-10. Depositional patterns.

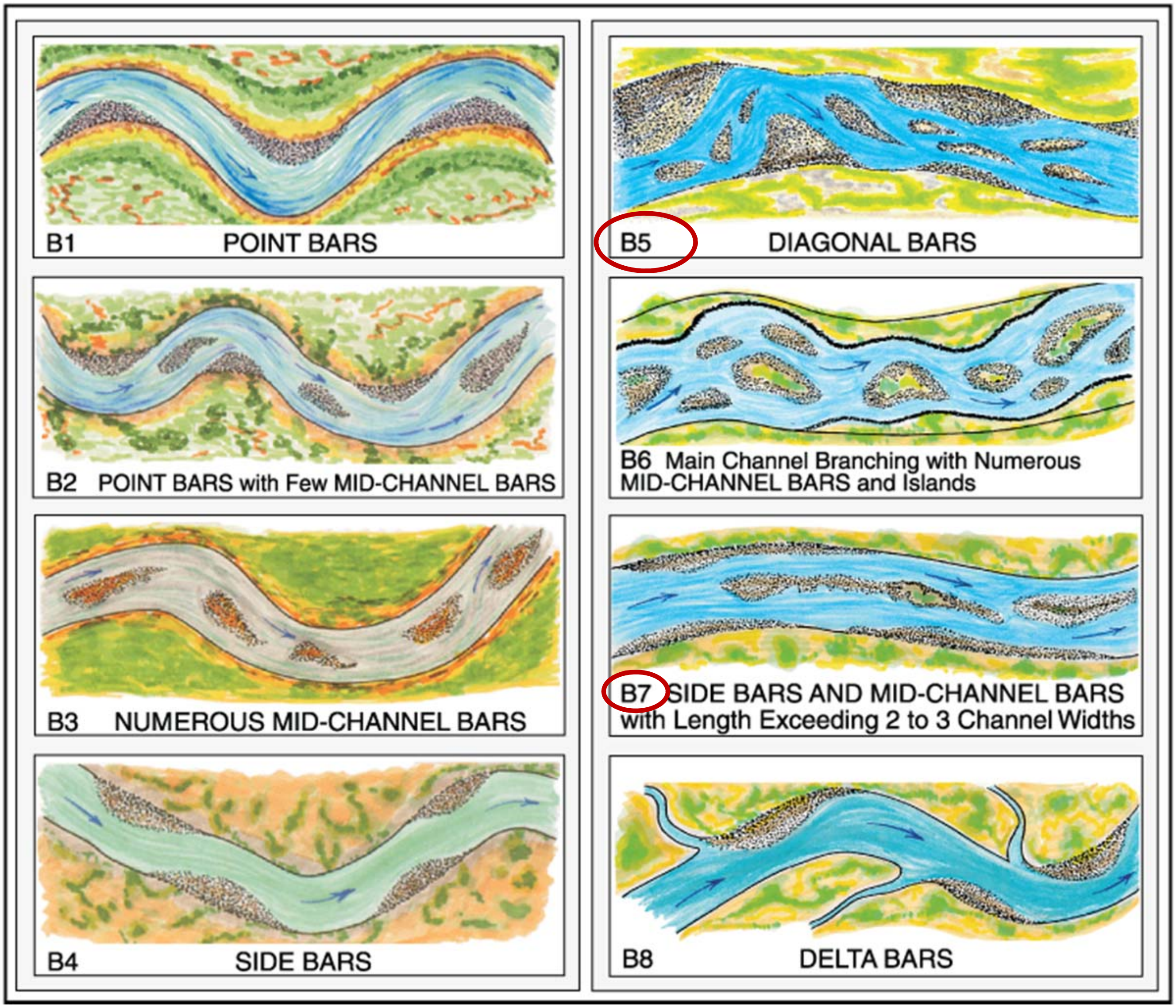
Depositional Patterns

Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

List ALL CATEGORIES that APPLY ☞	**B5**	**B7**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

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.	☐

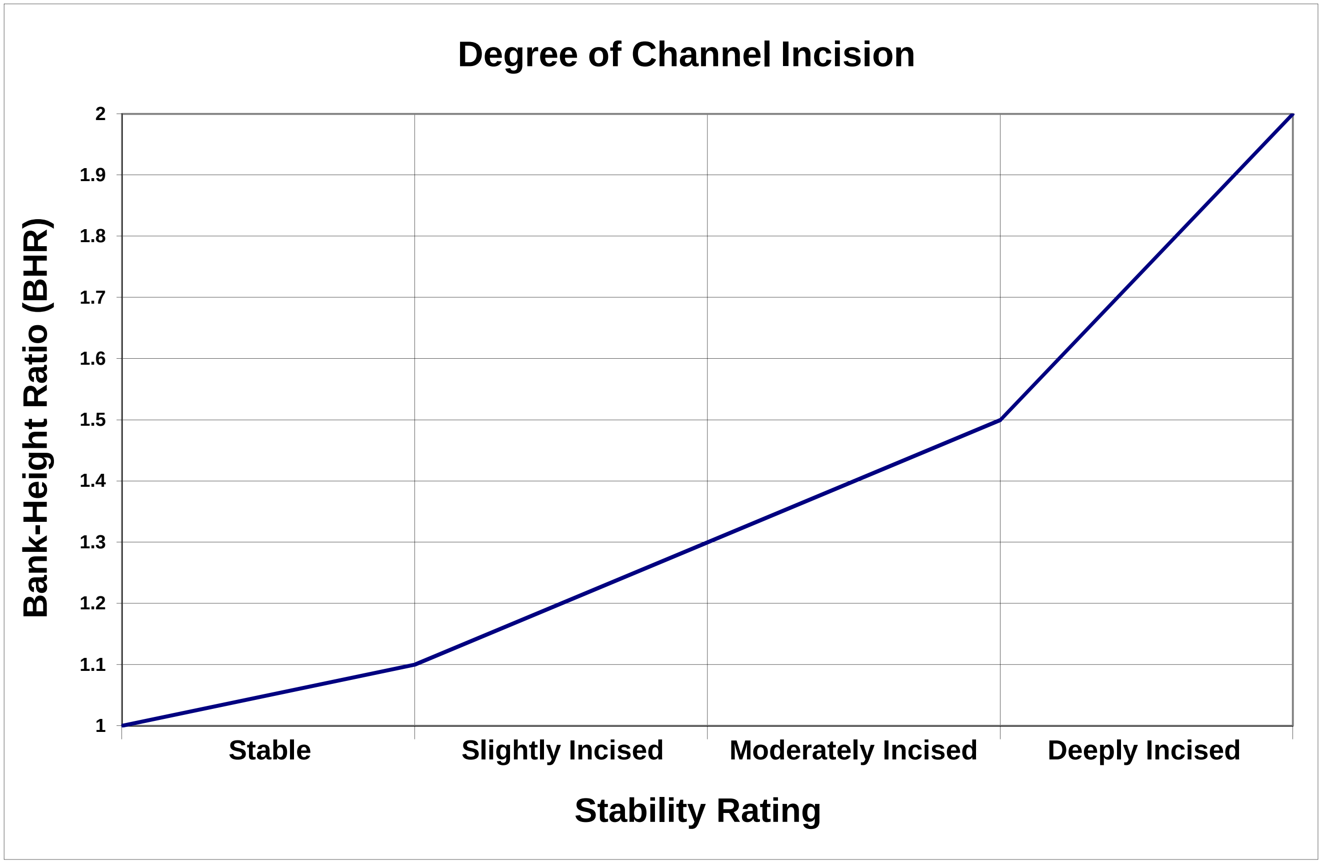
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height: **0.41**
Max Bankfull Depth: **0.41**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

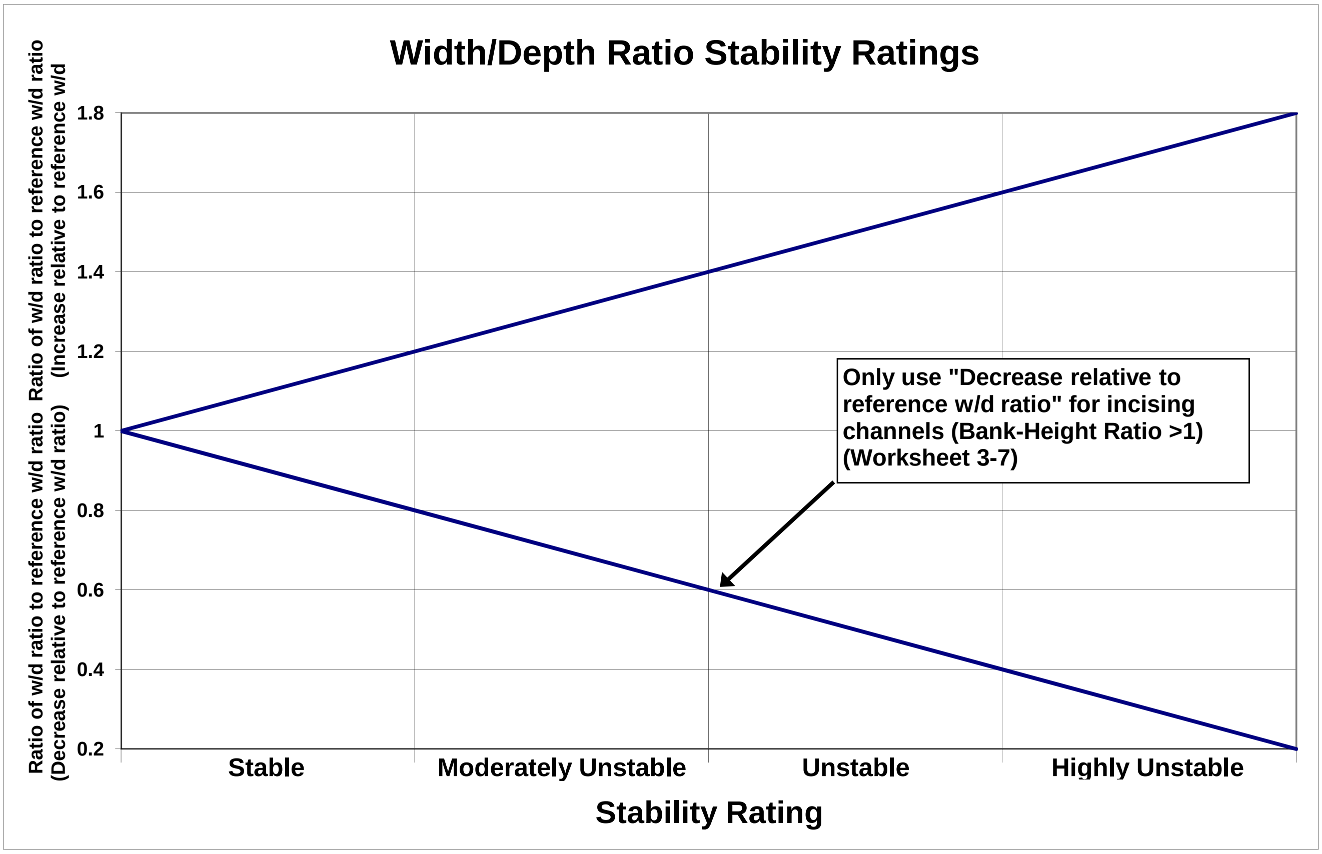
Width/Depth Ratio State

Existing Width/Depth Ratio: **47.29**

Reference Width/Depth Ratio: **12.57**

Ratio of existing W/d to reference W/d: **3.76**

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

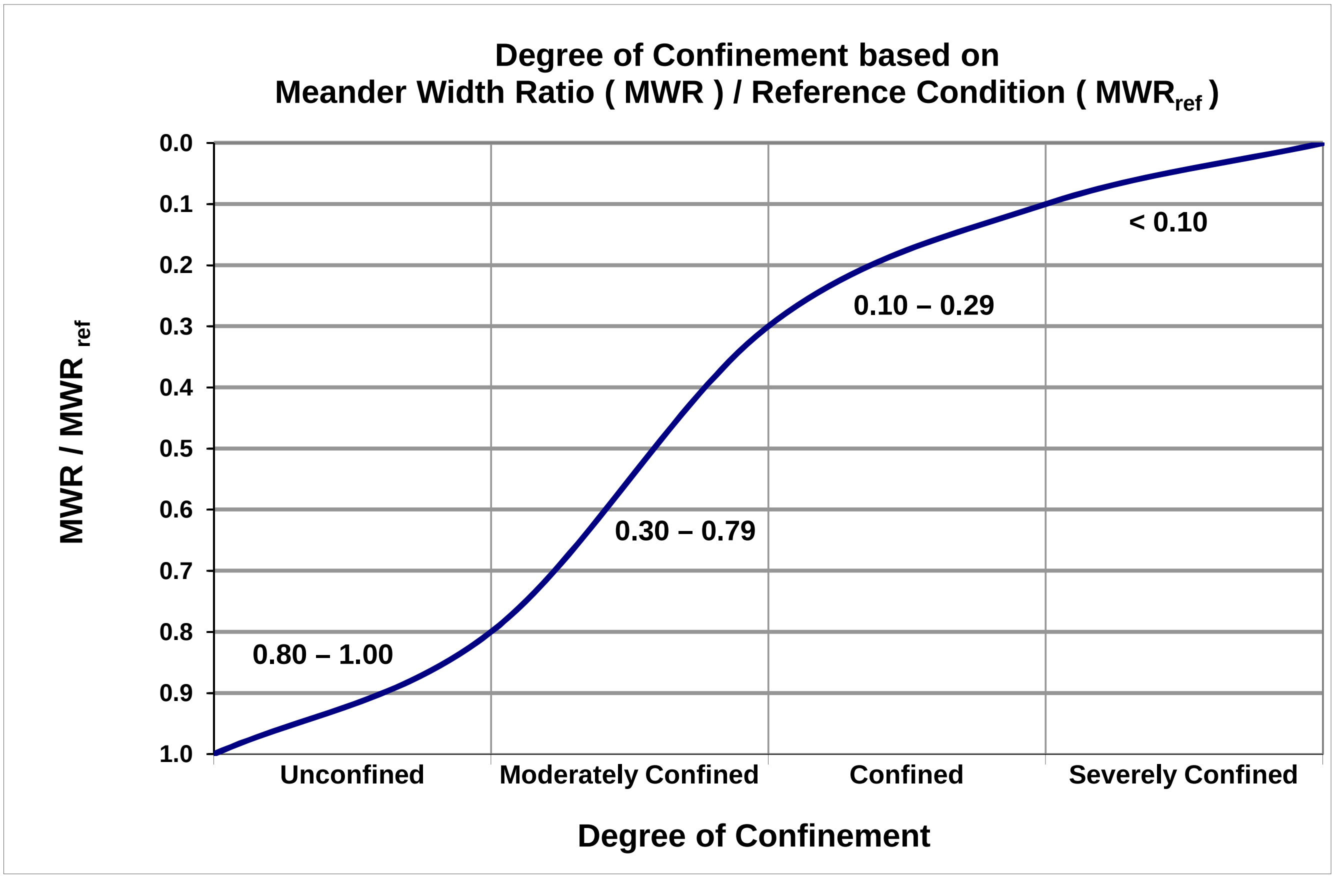
Degree of Confinement

Existing Meander Width Ratio (MWR): **1.43**

Reference Meander Width Ratio (MWR_{ref}): **2.7**

Ratio of MWR to MWR_{ref}: **0.53**

Degree of Confinement Stability Rating ☞ **Moderately Confined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, F4b Poor Trib. Reach **Location:** Pike National Forest, CO **Valley Type:** III **Observers:** Rosgen *et al*. **Date:** 8/17/2010

Location	Key	Category	Excellent Description	Rating	Good Description	Rating	Fair Description	Rating	Poor Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	[✓ 8]
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ 12]
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 4]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ 12]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	[✓ 4]
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 4]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	[✓ 16]
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	[✓ 16]
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	[✓ 4]
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ 8]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ 16]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	[✓ 24]
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	**0**	**Good total =**	**8**	**Fair total =**	**0**	**Poor total =**	**136**

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	[✓ B4]	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**144**
Existing stream type =	**F4b**
***Potential stream type =**	**B4**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

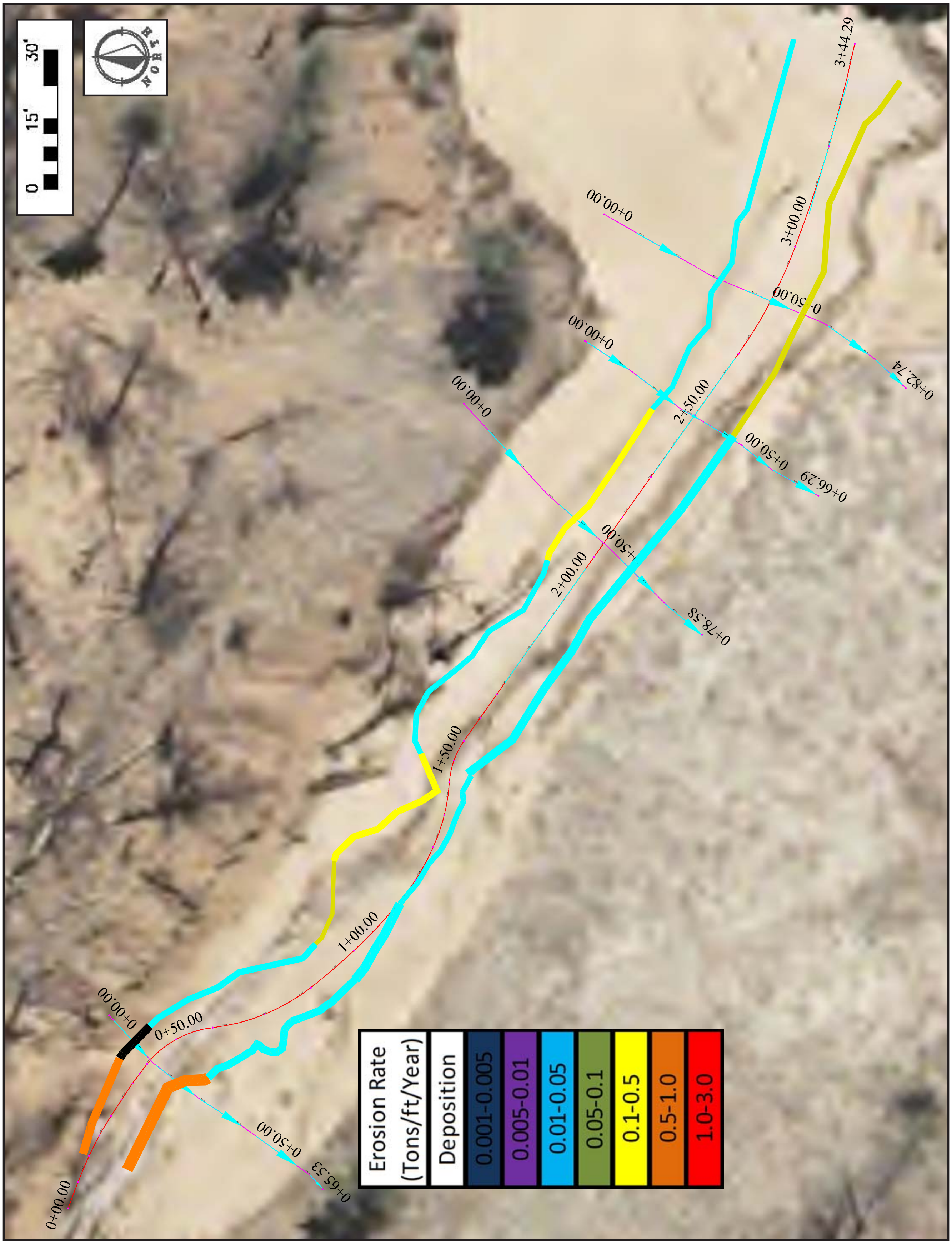
Stream: **Trail Creek, F4b Poor Trib. Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **337** Date: **8/16/2010**

Observers: **Rosgen *et al*.** Valley Type: **III** Stream Type: **F4b**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+10 - 0+62 R**	**Extreme**	**Very High**	**7.02692**	**52.0**	**2.7**	**986.58**	**0.91350**
2. **0+10 - 0+43 L**	**Extreme**	**Very High**	**7.02692**	**33.0**	**2.0**	**463.78**	**0.67667**
3. **0+63 - 0+90 L**	**Extreme**	**Low**	**0.41998**	**27.0**	**1.5**	**17.01**	**0.03033**
4. **0+62 - 0+93 R**	**Extreme**	**Low**	**0.41998**	**31.0**	**1.8**	**23.43**	**0.03640**
5. **0+93 - 0+118 R**	**Extreme**	**Low**	**0.41998**	**25.0**	**2.2**	**23.10**	**0.04449**
6. **0+90 - 0+118 L**	**Extreme**	**Moderate**	**1.07417**	**28.0**	**1.0**	**30.08**	**0.05172**
7. **0+118 - 0+157 L**	**Extreme**	**Very High**	**7.02692**	**39.0**	**1.6**	**438.48**	**0.54133**
8 **0+118 - 0+157 R**	**Extreme**	**Low**	**0.41998**	**39.0**	**1.3**	**21.29**	**0.02629**
9 **0+174 - 0+253 R**	**Extreme**	**Low**	**0.41998**	**59.0**	**2.0**	**49.56**	**0.04044**
10 **0+174 - 0+198 L**	**Extreme**	**Low**	**0.41998**	**24.0**	**1.3**	**13.10**	**0.02629**
11 **0+198 - 0+245 L**	**Extreme**	**Very High**	**7.02692**	**47.0**	**1.5**	**495.40**	**0.50750**
12 **0+253 - 0+344 R**	**Extreme**	**Moderate**	**1.07417**	**89.0**	**1.4**	**133.84**	**0.07241**
13 **0+245 - 0+344 L**	**Extreme**	**Low**	**0.41998**	**99.0**	**1.3**	**54.05**	**0.02629**
14							
15							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**2749.70**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**101.84**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**132.39**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.3929**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**8.43**	**0.0092**	**4.17**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**21.4**													
0.10%	**18.4**	**0.05%**	**0.09%**	**0.34**	**19.9**	**2.363**	**7.461**	**1.67**	**6.670**	**5.86**	**6.8**	**0.57**	**2.01**	**2.58**
0.25%	**15.9**	**0.08%**	**0.15%**	**0.55**	**17.2**	**2.036**	**5.232**	**1.01**	**4.809**	**4.22**	**9.4**	**0.55**	**2.31**	**2.87**
0.50%	**13.8**	**0.13%**	**0.25%**	**0.91**	**14.8**	**1.761**	**3.706**	**0.62**	**3.494**	**3.07**	**13.5**	**0.56**	**2.80**	**3.36**
0.75%	**11.7**	**0.13%**	**0.25%**	**0.91**	**12.8**	**1.513**	**2.592**	**0.37**	**2.502**	**2.20**	**11.6**	**0.34**	**2.01**	**2.34**
1%	**10.2**	**0.13%**	**0.25%**	**0.91**	**11.0**	**1.300**	**1.817**	**0.22**	**1.790**	**1.57**	**10.0**	**0.20**	**1.43**	**1.64**
1.5%	**8.7**	**0.25%**	**0.50%**	**1.83**	**9.4**	**1.120**	**1.289**	**0.14**	**1.289**	**1.13**	**17.2**	**0.25**	**2.07**	**2.32**
2%	**7.3**	**0.25%**	**0.50%**	**1.83**	**8.0**	**0.949**	**0.886**	**0.08**	**0.893**	**0.78**	**14.6**	**0.15**	**1.43**	**1.58**
3%	**6.1**	**0.50%**	**1.00%**	**3.65**	**6.7**	**0.795**	**0.600**	**0.05**	**0.602**	**0.53**	**24.5**	**0.17**	**1.93**	**2.09**
4%	**5.2**	**0.50%**	**1.00%**	**3.65**	**5.7**	**0.674**	**0.424**	**0.03**	**0.415**	**0.36**	**20.7**	**0.10**	**1.33**	**1.43**
5%	**4.7**	**0.50%**	**1.00%**	**3.65**	**4.9**	**0.587**	**0.322**	**0.02**	**0.304**	**0.27**	**18.1**	**0.07**	**0.97**	**1.04**
10%	**2.9**	**2.50%**	**5.00%**	**18.25**	**3.8**	**0.450**	**0.200**	**0.01**	**0.165**	**0.14**	**69.3**	**0.16**	**2.64**	**2.80**
20%	**1.6**	**5.00%**	**10.00%**	**36.50**	**2.3**	**0.269**	**0.103**	**0.00**	**0.045**	**0.04**	**82.6**	**0.10**	**1.46**	**1.55**
30%	**1.1**	**5.00%**	**10.00%**	**36.50**	**1.3**	**0.158**	**0.075**	**0.00**	**0.006**	**0.01**	**48.6**	**0.04**	**0.21**	**0.25**
40%	**0.8**	**5.00%**	**10.00%**	**36.50**	**0.9**	**0.108**	**0.068**	**0.00**	**0.000**	**0.00**	**33.2**	**0.03**	**0.00**	**0.03**
50%	**0.6**	**5.00%**	**10.00%**	**36.50**	**0.7**	**0.079**	**0.066**	**0.00**	**0.000**	**0.00**	**24.3**	**0.02**	**0.00**	**0.02**
60%	**0.4**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.061**	**0.065**	**0.00**	**0.000**	**0.00**	**18.6**	**0.01**	**0.00**	**0.01**
70%	**0.4**	**5.00%**	**10.00%**	**36.50**	**0.4**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**14.6**	**0.01**	**0.00**	**0.01**
80%	**0.3**	**5.00%**	**10.00%**	**36.50**	**0.3**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**12.1**	**0.01**	**0.00**	**0.01**
90%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.3**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**9.7**	**0.01**	**0.00**	**0.01**
100%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**4.9**	**0.00**	**0.00**	**0.00**
									Annual Totals:		**464.4** (cfs) **921.2** (acre-ft)	**3.3** (tons/yr)	**22.6** (tons/yr)	**25.9** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Poor" Pagosa	$y = 0.07176+1.02176x^{2.3772}$	8.43	0.0923	153.71
2. Suspended Sediment	"Poor" Pagosa	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	24.6													
0.10%	21.6	0.05%	0.09%	0.34	23.1	2.739	36.866	353.25	11.280	99.20	7.9	121.20	34.03	155.23
0.25%	19.1	0.08%	0.15%	0.55	20.3	2.412	23.192	195.70	8.357	73.49	11.1	107.14	40.24	147.38
0.50%	16.9	0.13%	0.25%	0.91	18.0	2.137	14.921	111.54	6.283	55.26	16.4	101.78	50.42	152.20
0.75%	14.9	0.13%	0.25%	0.91	15.9	1.889	9.542	63.06	4.706	41.39	14.5	57.54	37.77	95.31
1%	13.3	0.13%	0.25%	0.91	14.1	1.676	6.191	36.30	3.558	31.29	12.9	33.12	28.55	61.67
1.5%	11.8	0.25%	0.50%	1.83	12.6	1.494	4.097	21.41	2.723	23.95	23.0	39.07	43.70	82.77
2%	10.4	0.25%	0.50%	1.83	11.1	1.317	2.623	12.09	2.038	17.92	20.3	22.06	32.71	54.77
3%	9.2	0.50%	1.00%	3.65	9.8	1.160	1.687	6.85	1.527	13.43	35.7	25.00	49.02	74.01
4%	8.1	0.50%	1.00%	3.65	8.6	1.024	1.105	3.96	1.154	10.15	31.5	14.46	37.04	51.50
5%	7.1	0.50%	1.00%	3.65	7.6	0.903	0.732	2.31	0.872	7.67	27.8	8.44	28.01	36.44
10%	4.5	2.50%	5.00%	18.25	5.8	0.689	0.335	0.81	0.493	4.34	106.0	14.73	79.20	93.93
20%	1.9	5.00%	10.00%	36.50	3.2	0.376	0.125	0.16	0.172	1.51	115.6	5.98	55.05	61.03
30%	1.1	5.00%	10.00%	36.50	1.5	0.175	0.100	0.06	0.088	0.77	53.8	2.24	28.23	30.48
40%	0.8	5.00%	10.00%	36.50	0.9	0.109	0.099	0.04	0.077	0.68	33.5	1.38	24.72	26.10
50%	0.6	5.00%	10.00%	36.50	0.7	0.079	0.099	0.03	0.074	0.65	24.3	1.00	23.82	24.82
60%	0.4	5.00%	10.00%	36.50	0.5	0.061	0.099	0.02	0.073	0.64	18.6	0.76	23.45	24.22
70%	0.4	5.00%	10.00%	36.50	0.4	0.047	0.099	0.02	0.072	0.64	14.6	0.60	23.27	23.87
80%	0.3	5.00%	10.00%	36.50	0.3	0.039	0.099	0.01	0.072	0.64	12.1	0.50	23.18	23.68
90%	0.2	5.00%	10.00%	36.50	0.3	0.032	0.099	0.01	0.072	0.63	9.7	0.40	23.12	23.52
100%	0.0	5.00%	10.00%	36.50	0.1	0.016	0.099	0.01	0.072	0.63	4.9	0.20	23.05	23.25
									Annual Totals:		594.4 (cfs) 1,179.0 (acre-ft)	557.6 (tons/yr)	708.6 (tons/yr)	1,266.2 (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/14/10**

Observers: **S=.04, Q=8, 6.8, Bed.=.2031, S.Sand=76.85** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.04**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.22**	**0.13**	**0.18**	**3.01**	**0.06**	**0.83**	**0.0400**	**0.15**	**0.32**	**0.11**	**10%**	**36.50**	**0.65**	**0.00**	**23.73**	**0.00**	**23.73**
80.00%	**0.31**	**0.27**	**0.25**	**3.20**	**0.08**	**0.96**	**0.0400**	**0.19**	**0.67**	**0.21**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
70.00%	**0.35**	**0.33**	**0.29**	**3.28**	**0.09**	**1.02**	**0.0400**	**0.22**	**0.82**	**0.25**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
60.00%	**0.44**	**0.40**	**0.33**	**3.37**	**0.10**	**1.08**	**0.0400**	**0.24**	**1.00**	**0.30**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
50.00%	**0.58**	**0.51**	**0.39**	**3.51**	**0.11**	**1.18**	**0.0400**	**0.28**	**1.27**	**0.36**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
40.00%	**0.75**	**0.67**	**0.48**	**3.72**	**0.13**	**1.33**	**0.0400**	**0.32**	**1.67**	**0.45**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
30.00%	**1.08**	**0.92**	**0.60**	**3.96**	**0.15**	**1.51**	**0.0400**	**0.38**	**2.30**	**0.58**	**10%**	**36.50**	**0.69**	**0.02**	**25.18**	**0.73**	**25.91**
20.00%	**1.87**	**1.48**	**0.81**	**4.21**	**0.19**	**1.76**	**0.0400**	**0.47**	**3.69**	**0.88**	**10%**	**36.50**	**0.78**	**0.03**	**28.47**	**1.09**	**29.56**
10.00%	**4.47**	**3.17**	**1.37**	**4.80**	**0.29**	**2.30**	**0.0400**	**0.70**	**7.91**	**1.65**	**10%**	**36.50**	**1.64**	**0.09**	**59.86**	**3.28**	**63.14**
5.00%	**7.15**	**5.81**	**2.07**	**5.39**	**0.38**	**2.79**	**0.0400**	**0.93**	**14.50**	**2.69**	**5%**	**18.25**	**4.84**	**0.46**	**88.33**	**8.39**	**96.72**
4.00%	**8.07**	**7.61**															
3.00%	**9.20**	**8.64**															
2.00%	**10.36**	**9.78**															
1.50%	**11.84**	**11.10**															
1.00%	**13.33**	**12.59**															
0.75%	**14.92**	**14.13**															
0.50%	**16.93**	**15.93**															
0.25%	**19.09**	**18.01**															
0.10%	**21.56**	**20.33**															
0.0060%	**24.60**	**23.08**															
										Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):					**344.2**	**15.3**	**359.5**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, F4b Poor Trib, XS 2+80** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/14/10**

Observers: **S=.04, Q=8, 6.8, Bed.=.2031, S.Sand=76.85** Stream Type: **F4b** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.04**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.22**	**0.13**	**0.14**	**3.07**	**0.05**	**1.07**	**0.0400**	**0.11**	**0.32**	**0.10**	**10%**	**36.50**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
80.00%	**0.31**	**0.27**	**0.22**	**3.73**	**0.06**	**1.15**	**0.0400**	**0.14**	**0.67**	**0.18**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
70.00%	**0.35**	**0.33**	**0.26**	**4.02**	**0.06**	**1.18**	**0.0400**	**0.16**	**0.82**	**0.20**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
60.00%	**0.44**	**0.40**	**0.30**	**4.35**	**0.07**	**1.21**	**0.0400**	**0.17**	**1.00**	**0.23**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
50.00%	**0.58**	**0.51**	**0.36**	**4.87**	**0.07**	**1.27**	**0.0400**	**0.18**	**1.27**	**0.26**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
40.00%	**0.75**	**0.67**	**0.45**	**5.62**	**0.08**	**1.35**	**0.0400**	**0.19**	**1.67**	**0.30**	**10%**	**36.50**	**0.65**	**0.01**	**23.73**	**0.36**	**24.09**
30.00%	**1.08**	**0.92**	**0.60**	**6.80**	**0.09**	**1.48**	**0.0400**	**0.21**	**2.30**	**0.34**	**10%**	**36.50**	**0.65**	**0.02**	**23.73**	**0.73**	**24.46**
20.00%	**1.87**	**1.48**	**0.83**	**7.84**	**0.11**	**1.68**	**0.0400**	**0.26**	**3.69**	**0.47**	**10%**	**36.50**	**0.65**	**0.03**	**23.73**	**1.09**	**24.82**
10.00%	**4.47**	**3.17**	**1.40**	**9.03**	**0.16**	**2.18**	**0.0400**	**0.37**	**7.91**	**0.88**	**10%**	**36.50**	**0.78**	**0.07**	**28.47**	**2.56**	**31.03**
5.00%	**7.15**	**5.81**	**2.07**	**9.60**	**0.22**	**2.72**	**0.0400**	**0.52**	**14.50**	**1.51**	**5%**	**18.25**	**1.47**	**0.15**	**26.83**	**2.74**	**29.57**
4.00%	**8.07**	**7.61**															
3.00%	**9.20**	**8.64**															
2.00%	**10.36**	**9.78**															
1.50%	**11.84**	**11.10**															
1.00%	**13.33**	**12.59**															
0.75%	**14.92**	**14.13**															
0.50%	**16.93**	**15.93**															
0.25%	**19.09**	**18.01**															
0.10%	**21.56**	**20.33**															
0.0060%	**24.60**	**23.08**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**221.4**	**8.9**	**230.3**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**344.2**	**15.3**	**359.5**
Difference in sediment transport capacity (tons/yr) (+ or -):	**-122.8**	**-6.4**	**-129.2**
Stability evaluation: Aggradation, Degradation or Stable:	**Aggradation, > 35% Reduction in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, F4b Poor Trib. Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

Enter Required Information for Existing Condition

2.3	D_{50}	Riffle bed material D_{50} (mm)			
	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.05	D_{max}	Largest particle from **Bed Material** (ft)	**16**	**(mm)**	304.8 mm/ft
0.04	S	Existing bankfull water surface slope (ft/ft)			
0.24	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

0.599		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 **43**	CO **105**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **0.21**	CO **0.043**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.08**	CO **0.02**	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 **0.0140**	CO **0.0029**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, F4b Poor Trib.** Stream Type: **F4b**

Location: **Pike National Forest, CO** Valley Type: **III**

Observers: **Rosgen *et al*.** Date: **8/16/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☑ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **Trail Creek, F4b Poor Trib. Reach** Stream Type: **F4b**
Location: **Pike National Forest, Colorado** Valley Type: **III**
Observers: **Rosgen *et al*.** Date: **8/16/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**8**
	(2)	**(4)**	**(6)**	**3.76** [✓ **(8)**]	
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2	B4, B8	B3	**B5**, B6, **B7**	**4**
	(1)	**(2)**	**(3)**	**B5, B7** [✓ **(4)**]	
3 **Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4		M2, M5, M6, M7, M8		**1**
	M1 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**8**
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**2**
	(1)	[✓ **(2)**]	**(3)**	**(4)**	
				Total Points	**23**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☑

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, F4b Poor Trib. Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**8**
	(2)	**(4)**	**(6)**	**≈ 40%** [✓ **(8)**]	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**8**
	(2)	**(4)**	**(6)**	**3.8** [✓ **(8)**]	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**6**
	(2)	**(4)**	**G to F** [✓ **(6)**]	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, B4	B3, **B5**	B6, **B7**, B8	**4**
	(1)	**(2)**	**(3)**	**B5, B7** [✓ **(4)**]	
6 **Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**29**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, F4b Poor Trib. Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-22)**	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) (Worksheet 5-20)**	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 5-12)**	1.00 – 1.10 **1.00** **[✓ (2)]**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**1**
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00 **(1)**	0.30 – 0.79 **0.53** **[✓ (2)]**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**2**
				Total Points	**15**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, F4b Poor Trib. Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) [✓ **(6)**]	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**6**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* [✓ **(8)**]	**8**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* [✓ **(4)**]	*Moderately Incised* **(6)**	*Degradation* **(8)**	**4**
				Total Points	**24**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☑

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, F4b Poor Trib. Reach**	Stream Type:	**F4b**
Location:	**Pike National Forest, Colorado**	Valley Type:	**III**
Observers:	**Rosgen *et al*.**	Date:	**8/16/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	***Stable***	**1**	**4**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**[✓ 4]**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	***No Deposition***	**1**	**3**
	Mod. Deposition	**2**	
	Excess Deposition	**[✓ 3]**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	***Not Incised***	**1**	**2**
	Slightly Incised	**[✓ 2]**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 5-28)	***No Increase***	**1**	**4.0**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**[✓ 4]**	
5 Pfankuch Channel Stability (Worksheet 5-15)	***Good: Stable***	**1**	**4.0**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**[✓ 4]**	
		Total Points	**17**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☑

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, F4b Poor Trib. Reach**					Location: **Pike National Forest, Colorado**				
Observers:	**Rosgen *et al*.**		Date: **8/16/2010**			Stream Type: **F4b**		Valley Type: **III**		
Channel Dimension (XS 2+80)	Mean Bankfull Depth (ft):	**0.24**	Bankfull Width (ft):	**11.35**	Cross-Sectional Area (ft^2):	**2.67**	Width of Flood-Prone Area (ft):	**13.31**	Entrenchment Ratio:	**1.17**
Channel Pattern	Mean: Range:	λ/W_{bkf}:		L_m/W_{bkf}:		R_c/W_{bkf}:	MWR:	**1.43** **1.09-2.14**	Sinuosity:	**1.04**
River Profile & Bed Features	Check: ☑ Riffle/Pool		☐ Step/Pool		☐ Plane Bed	☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed		
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope	
		0.57	**N/A**		**1.31**	**n/a**		**N/A**	Valley: **0.0425**	Water Surface: **0.041**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:			Poten.tial Composition/Density:			Remarks: Condition, Vigor & Usage of Existing Reach:		
		5% p. pine, burnt, annual grass			**willow, alder, grass, aspen**			**burned area that has not fully recovered**		
	Flow Regime:	**E2, E8, S2, S8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**M1**	Depositional Patterns:	**B5, B7**	Debris/Channel Blockages:	**D2**
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):			**144 (Poor)**		
	Width/depth Ratio (W/d):	**47.3**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**3.76**	W/d Ratio State Stability Rating:	**Highly Unstable**		
	Meander Width Ratio (MWR):	**1.43**	Reference MWR_{ref}:	**2.7**	Degree of confinement (MWR / MWR_{ref}):	**0.53**	MWR / MWR_{ref} Stability Rating:	**Moderately Confined**		
Bank Erosion Summary	Length of Reach Studied (ft):	**337**	Annual Streambank Erosion Rate: **132.39** (tons/yr)	**0.39** (tons/yr/ft)	Curve Used: **Colorado**	Remarks: **F cutting through an alluvial fan**				
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity		Remarks: ≈ **40% Reduction in Transport**					
Entrainment/ Competence	Largest Particle from **Bed Material** (mm):	**16**	$\tau =$ **0.599**	$\tau^* =$ **N/A**	Existing Depth:	**0.24**	Required Depth: **0.08**	Existing Slope: **0.041**	Required Slope:	**0.014**
Successional Stage Shift	D → G → [✓ F] → B → →				Existing Stream State (Type):	**F4b**	Potential Stream State (Type):	**B4**		
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☑ *Highly Unstable*	Remarks/causes: **High Banks, Poor Veg.**					
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes: **High W/d Ratio**					
Vertical Stability (Degradation)	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes: **Highly Mobile Bed**					
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☑ *Extensive*	Remarks/causes: **Both Banks Eroding**					
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☐ *High*	☑ *Very High*	Remarks/causes: **Hayman Fire - unveg banks, pikes peak granite - highly erosive, F cutting through an alluvial fan**					

Appendix C15

G4 Stream Type

Poor Stability Reach

Table of Contents

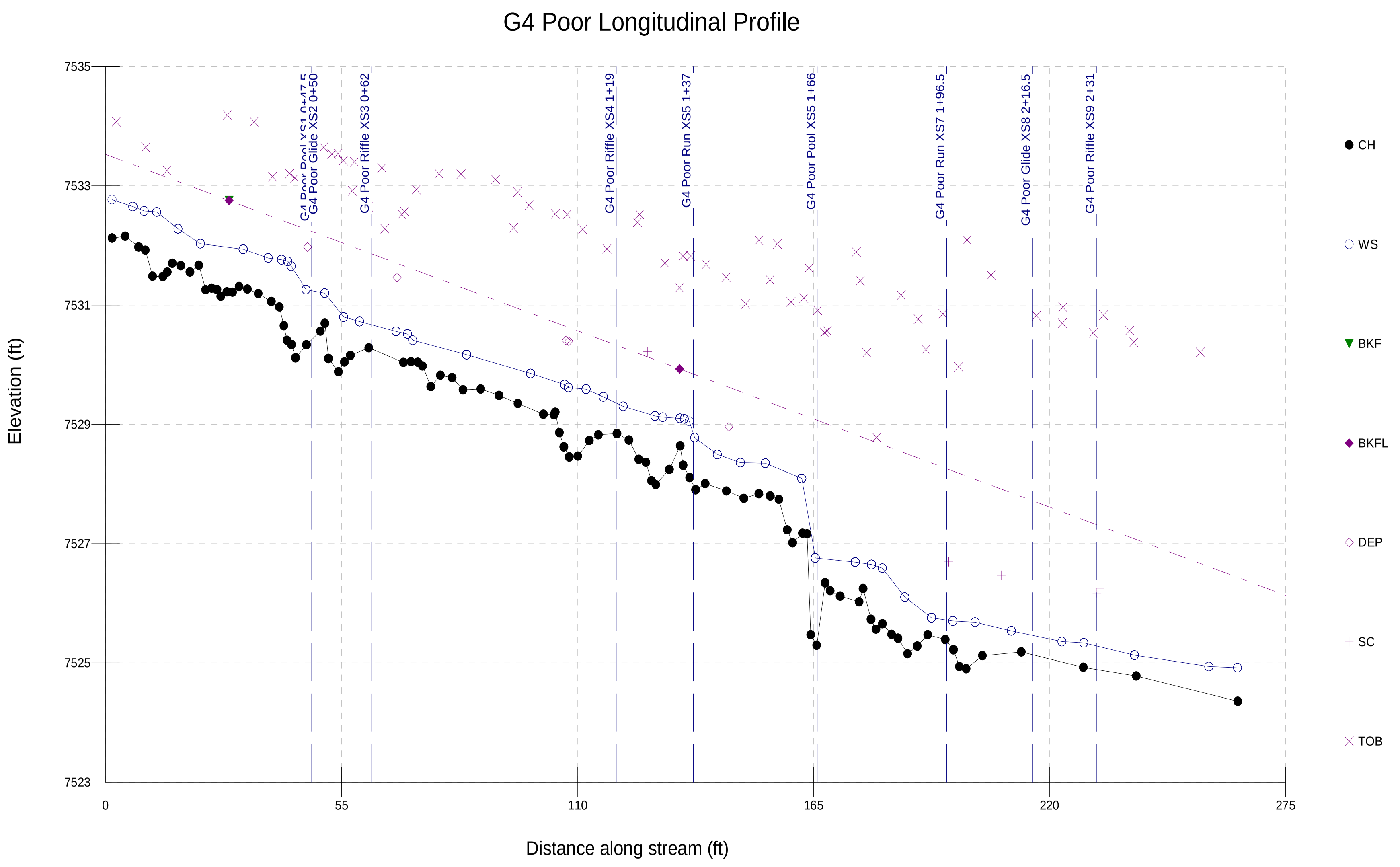
Appendix C15: G5 Poor Reach

G4 Poor Reach Location & Overview

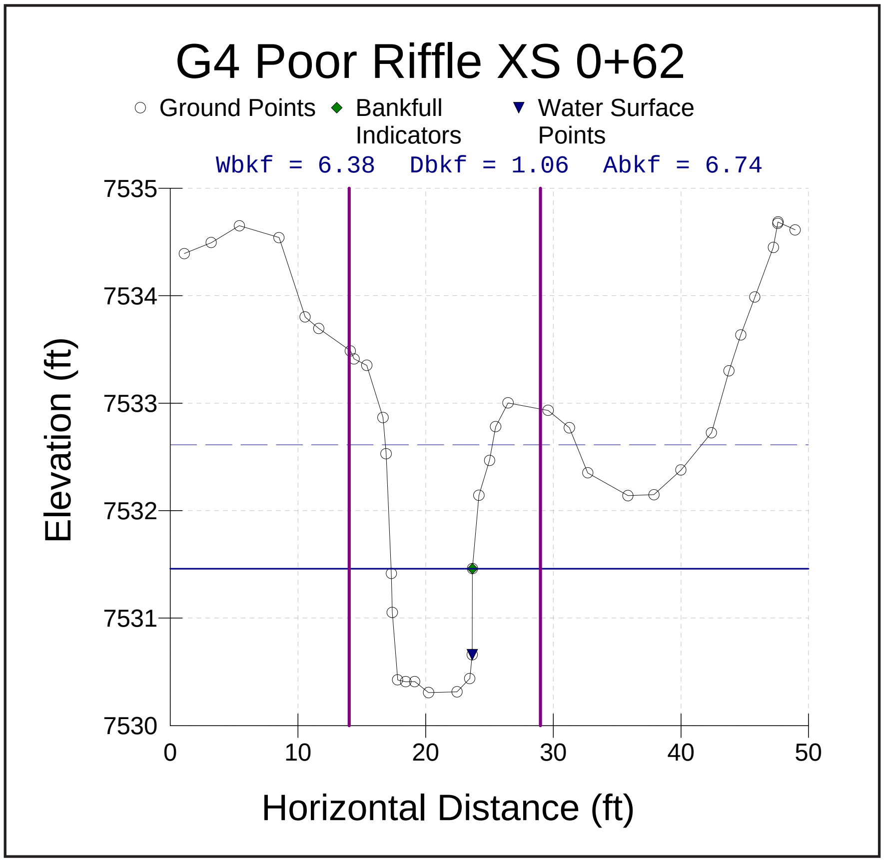
The G4 Poor representative reach is a perennial stream located in the upper Trail Creek Watershed (**Figure C-2**). The stream is entrenched with evident bank erosion and is actively downcutting in previously deposited sediment as depicted in the photograph. This channel had previously been a more stable C4 stream type in this terraced, alluvial Valley Type VIIIc. However, excess sediment deposition and subsequent downcutting converted this stream type to a G4. The stream has apparently not recovered from past floods and high sediment supply impacts. The width/depth ratio is trending to shift to an F4 stream type indicated by the width/depth ratio of *13.9* due to channel enlargement. This reach has a poor recovery potential if left in its present state. The potential stable stream type in the current valley type is a B4; thus POWERSED was used to determine streambed stability. The results approximated severe degradation rates of *17,922 tons/yr* of downcutting through previously deposited material. The stability rating is "Poor" due to a Pfankuch stability rating of 138 ("Poor") and the extreme streambank erosion rate of *0.658 tons/yr/ft* compared to the B4 reference rate of *0.0048 tons/yr/ft* (an increase of two orders of magnitude). The sediment supply rating is *Very High* due to the excess streambank erosion rates compared to the B4 reference and the channel degradation. The "Poor" rating indicates an extremely high potential increase in flow-related sediment compared to the same sized-B4 stream type reference. The WRENSS model resulted in a water yield increase due to the fire from *3,333 acre-ft* to *6,066 acre-ft*, representing a total increase of *2,733* acre-ft. The corresponding bedload increased from *45 tons/yr* to *7,562 tons/yr* and the suspended sediment increased from *92 tons/yr* to *13,373 tons/yr*, representing a total increase in sediment of *20,799 tons/yr*. This enormous and disproportionate sediment yield reflects the sediment yield increases due to the increased flows in a severely unstable reach.

The following graphs and summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability conditions responsible for the overall "Poor" rating.

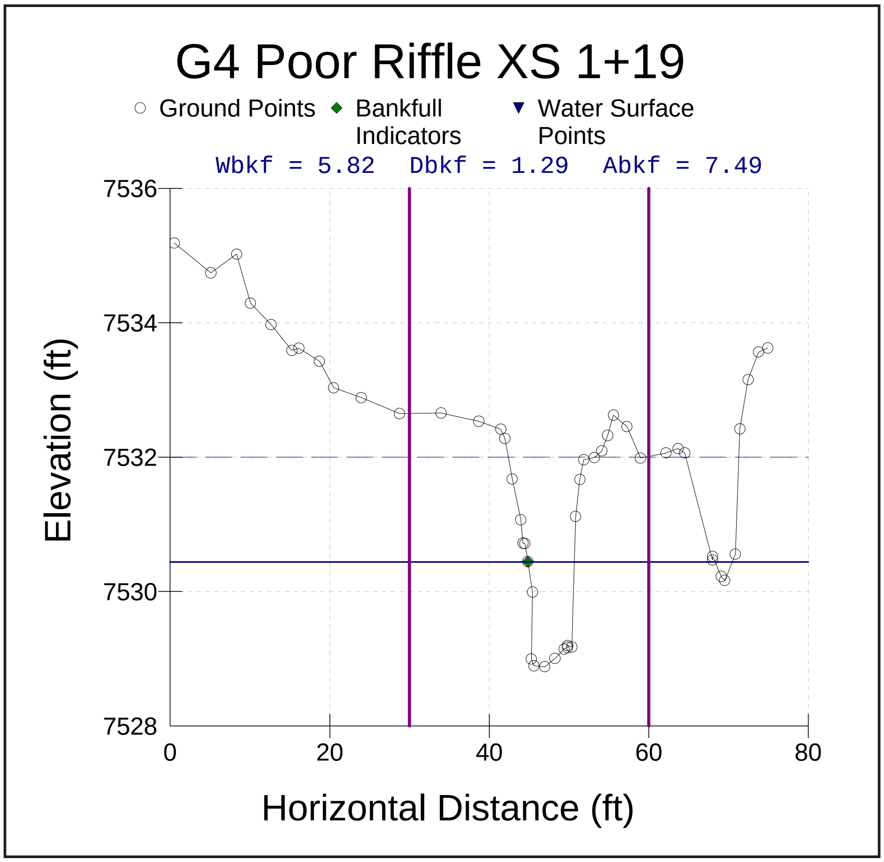
Survey Summary



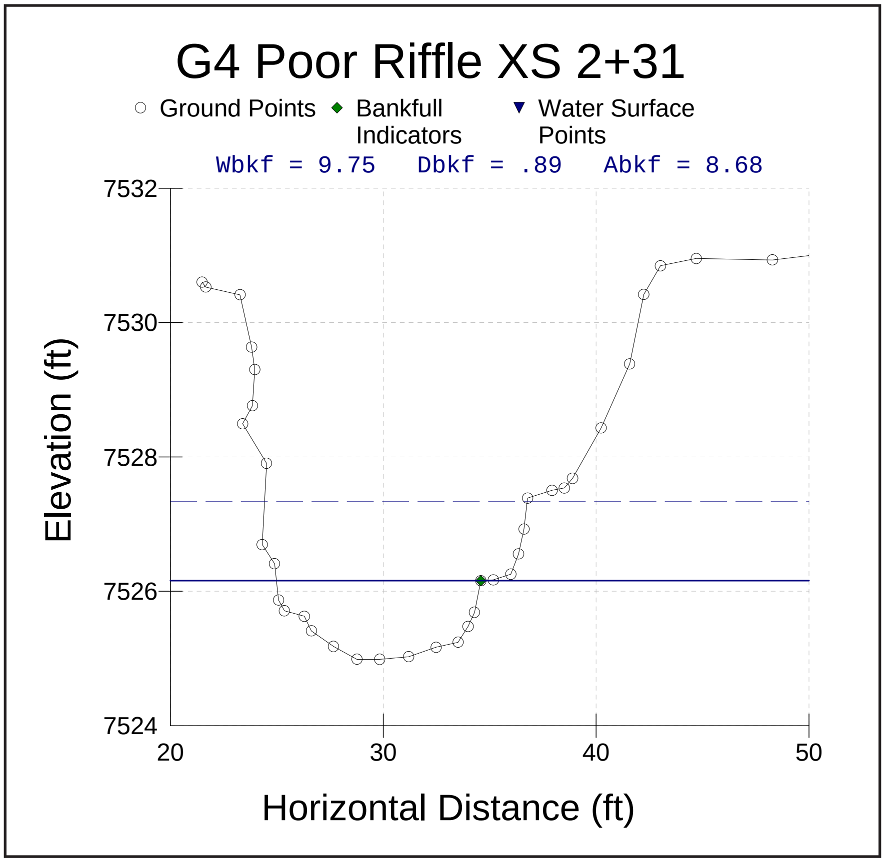
Longitudinal Profile (graph generated from RIVERMorph^{TM})



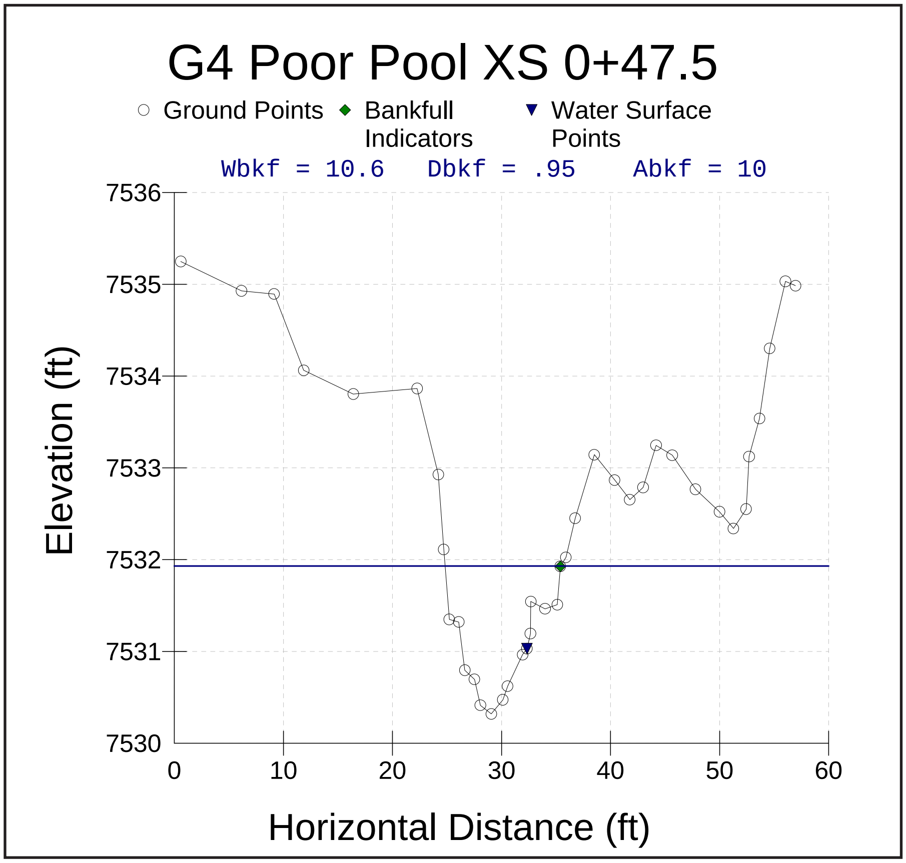
Riffle Cross-section 0+62 (graph generated from RIVERMorph^{TM})



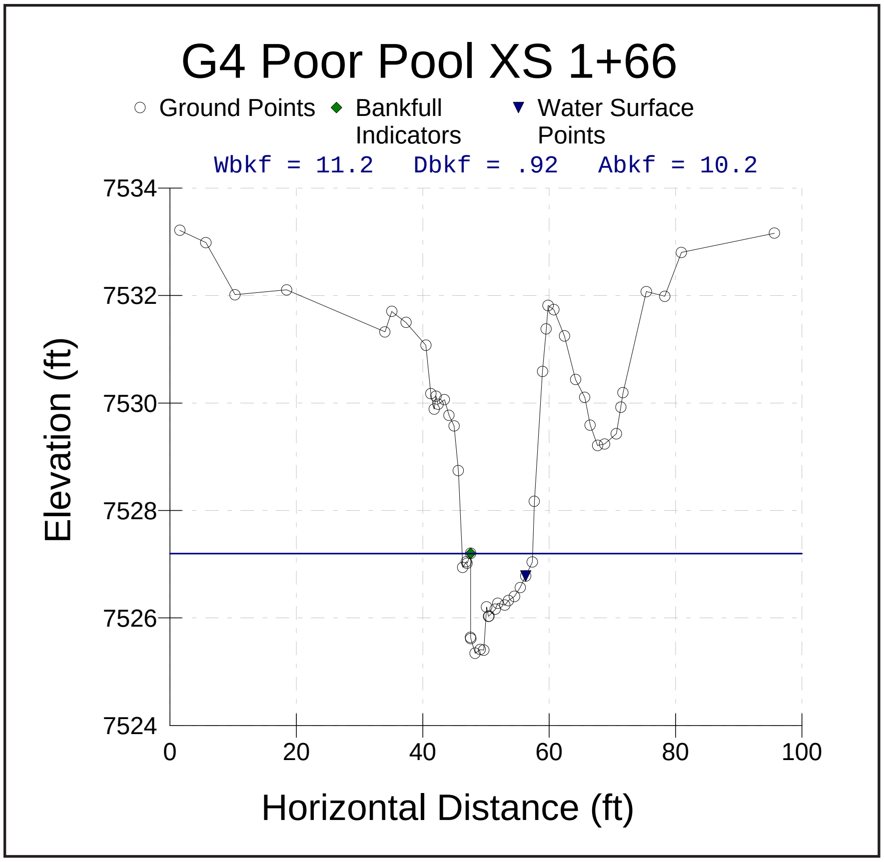
Riffle Cross-section 1+19 (graph generated from RIVERMorph^{TM})



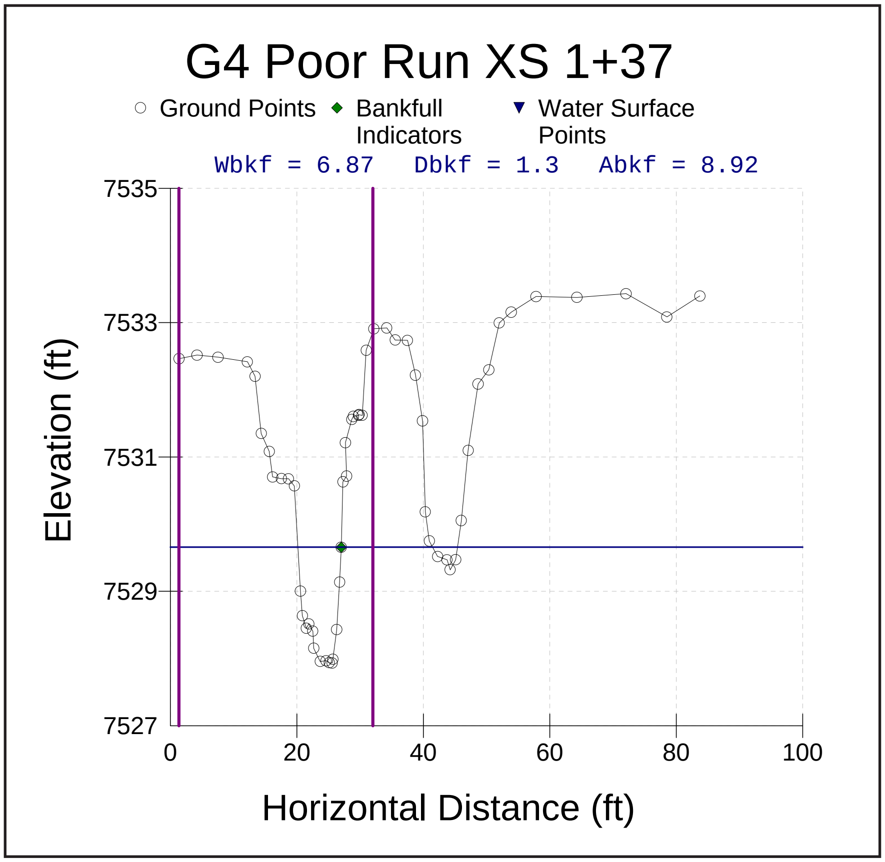
Riffle Cross-section 2+31 (graph generated from RIVERMorph^{TM})



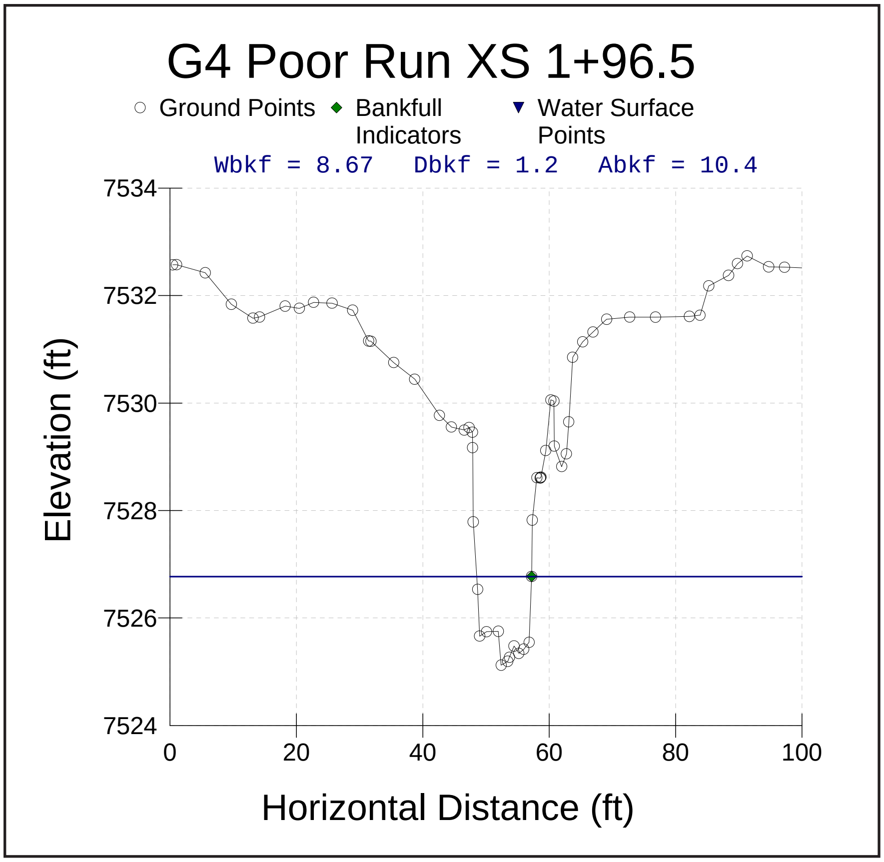
Pool Cross-Section 0+47.5 (graph generated from RIVERMorph^{TM})



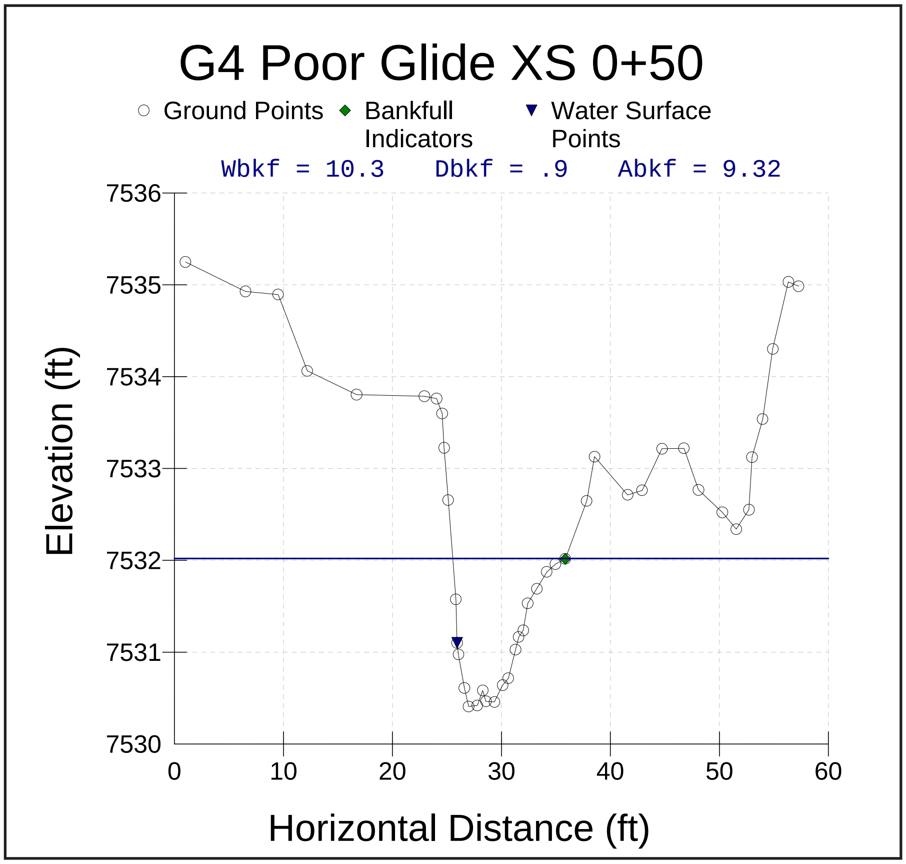
Pool Cross-section 1+66 (graph generated from RIVERMorph^{TM})



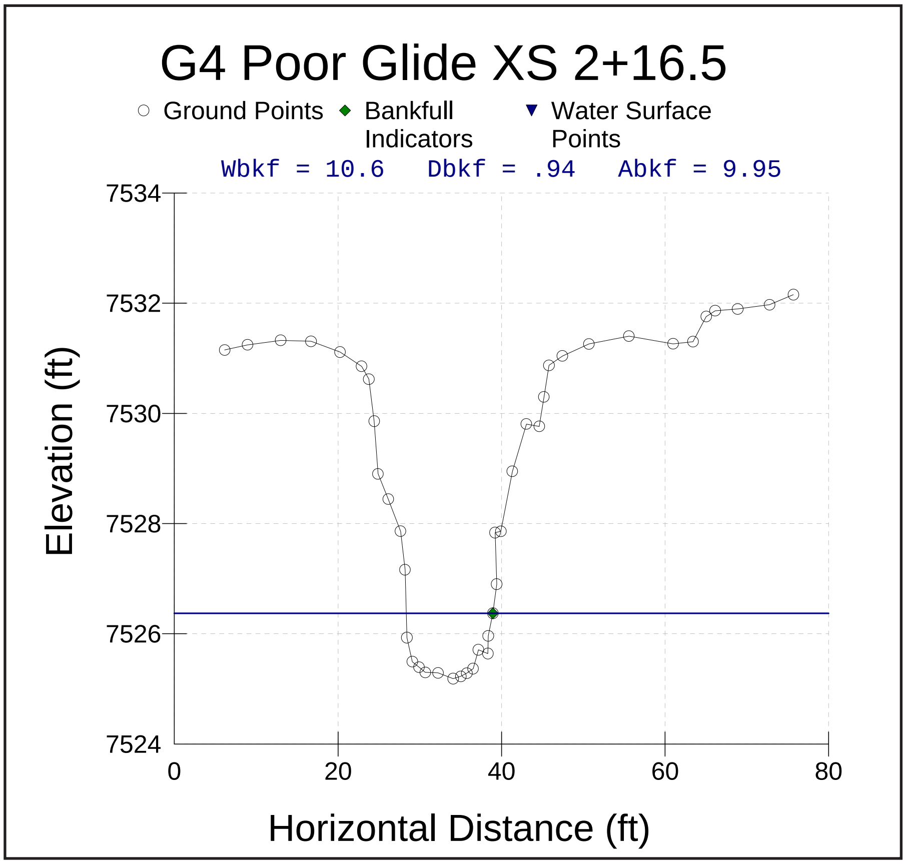
Run Cross-section 1+37 (graph generated from RIVERMorph^{TM})



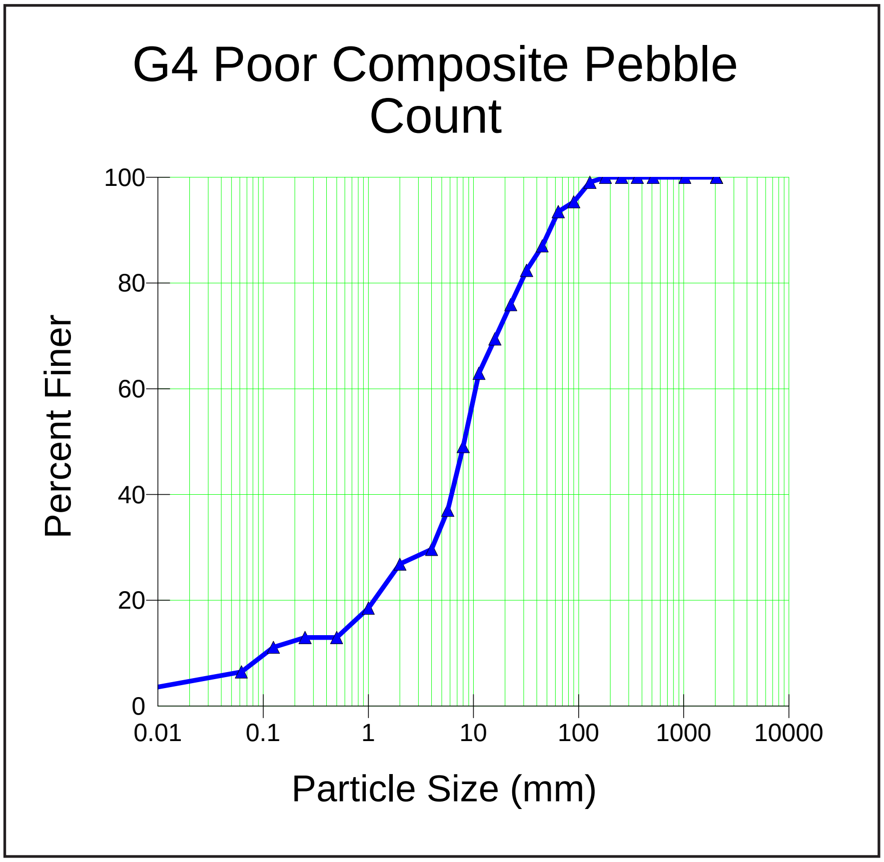
Run Cross-section 1+96.5 (graph generated from RIVERMorph™)



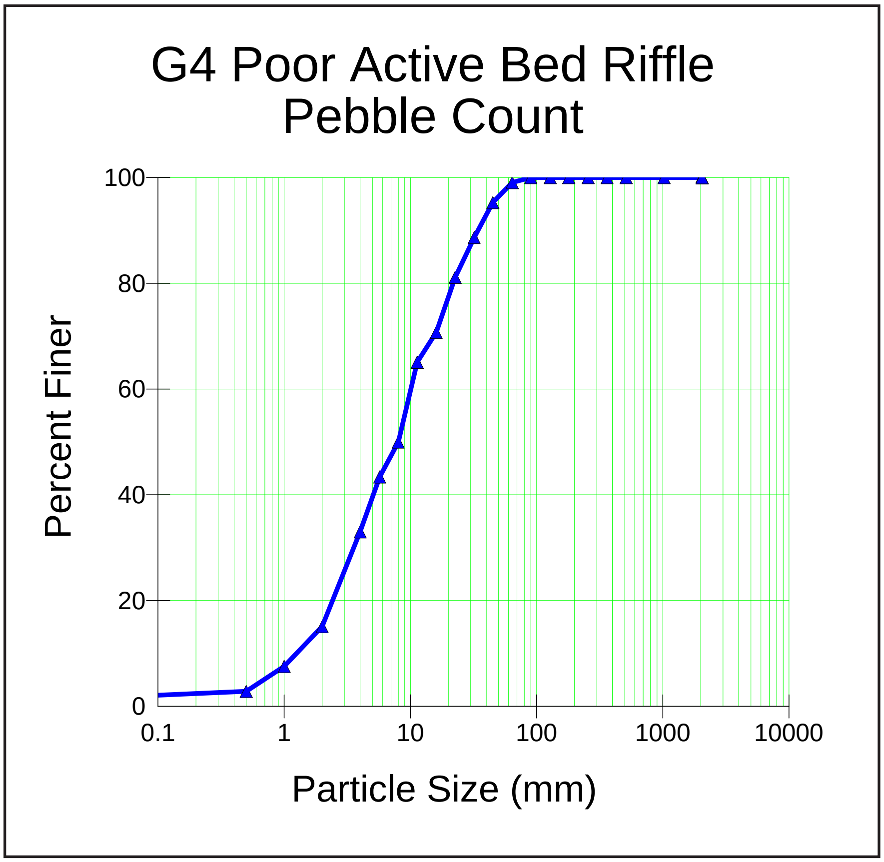
Glide Cross-Section 0+50 (graph generated from RIVERMorph™)



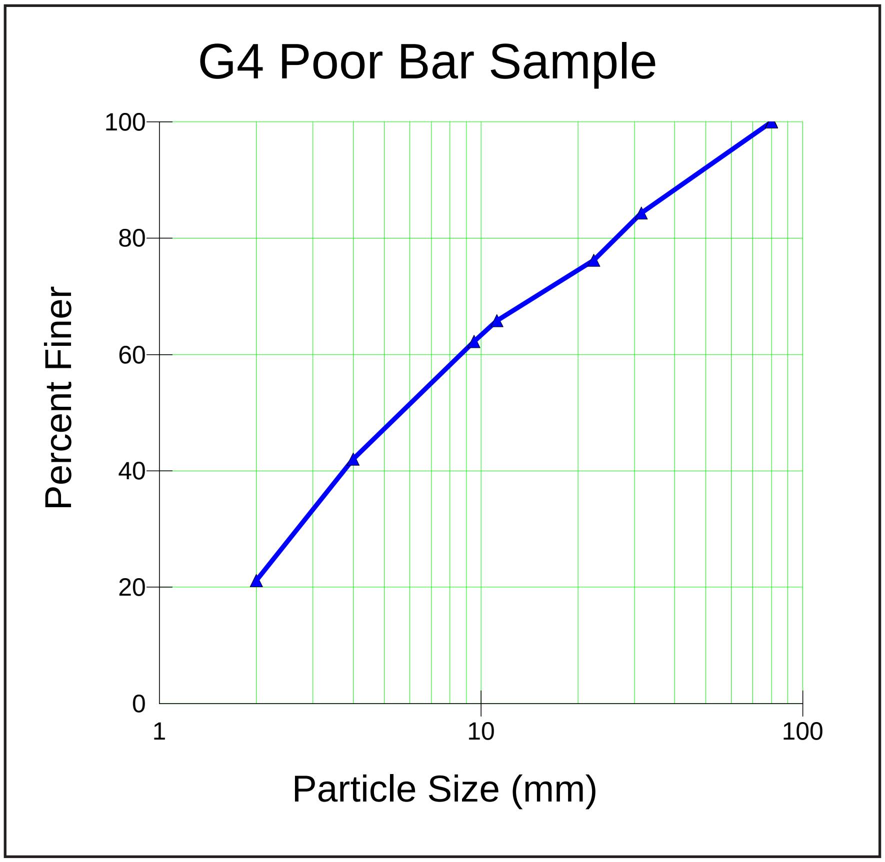
Glide Cross-Section 2+16.5 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, G4 Poor Reach**			Location:	**Riffle XS 2+31, Pike N.F., Colorado**
Date:	**8/18/2010**	Stream Type:	**G4**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**			HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**8.68**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.89**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**9.75**	**W_{bkf}** (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**10.50**	**W_p** (ft)
D_{84} at Riffle	**26.2**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.09**	**D_{84}** (ft)
Bankfull SLOPE	**0.0258**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.83**	**R** (ft)
Gravitational Acceleration	**32.2**	**g** (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**9.62**	**R / D_{84}**
Drainage Area	**15.9**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.829**	**u*** (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**6.96**	ft / sec	**60.38**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.035**	**6.02**	ft / sec	**52.28**	cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **b) Manning's *n* from Stream Type** (Fig. 5-9) $n =$ **0.06**	**3.51**	ft / sec	**30.50**	cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **c) Manning's *n* from Jarrett (USGS):** $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.100**	**2.10**	ft / sec	**18.27**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ______ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, G4 Poor Reach**

Basin: Drainage Area: **10176** acres **15.9** mi^2

Location: **XS 2+31, Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Lat =39.13425 Long=105.16711** Date: **8/18/2010**

Observers: **B. Kasun *et al* .** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**9.75**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.89**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**8.68**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**10.95**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.17**	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.	**12.35**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.17**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**8**	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.	**0.0258**	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 (S_{val} / S).	**1.05**	

Stream Type **G4** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, G4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **B. Kasun *et al*.** Date: **8/18/2010** Valley Type: **VIII** Stream Type: **G4**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	6.38	5.82	9.75	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	7.64	6.74	8.68
Mean Riffle Depth (d_{bkf})	1.08	0.89	1.29	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	7.16	4.51	10.96
Maximum Riffle Depth (d_{max})	1.29	1.15	1.56	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.203	1.085	1.315
Width of Flood-Prone Area (W_{fpa})	10.03	8.41	12.35	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.36	1.17	1.32
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	9.6	8.6	10.6	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.500	1.340	1.660
Mean Pool Depth (d_{bkfp})	0.81	0.67	0.95	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.750	0.620	0.880
Pool Cross-Sectional Area (A_{bkfp})	7.9	5.7	10.0	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.031	0.749	1.313
Maximum Pool Depth (d_{maxp})	1.51	1.40	1.61	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	1.398	1.296	1.491
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})	9.7	8.7	10.8	ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.527	1.359	1.694
Mean Run Depth (d_{bkfr})	1.69	1.65	1.73	ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.565	1.528	1.602
Run Cross-Sectional Area (A_{bkfr})	10.0	9.6	10.4	ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.313	1.259	1.366
Maximum Run Depth (d_{maxr})	1.69	1.65	1.73	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.565	1.528	1.602
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	5.7	5.3	6.2	ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	10.5	10.3	10.6	ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.639	1.621	1.658
Mean Glide Depth (d_{bkfg})	1.40	1.18	1.61	ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	1.296	1.093	1.491
Glide Cross-Sectional Area (A_{bkfg})	9.6	9.3	10.0	ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.262	1.217	1.302
Maximum Glide Depth (d_{maxg})	1.40	1.18	1.61	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.296	1.093	1.491
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	7.5	8.7	6.6	ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})			
Glide Inner Berm Width (W_{ibg})				ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})			
Glide Inner Berm Depth (d_{ibg})				ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})			
Glide Inner Berm Area (A_{ibg})				ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})			

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, G4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **B. Kasun *et al*.** Date: **8/18/2010** Valley Type: **VIII** Stream Type: **G4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**3.5**	ft/sec	Estimation Method	**"n" by Stream Type**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**30.3**	cfs	Drainage Area	**15.9**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**14.6**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**2.29**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)	**4.6**	**1.3**	**9.1**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**0.72**	**0.20**	**1.43**
Individual Pool Length (L_p)	**7.8**	**4.1**	**11.4**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.22**	**0.64**	**1.79**
Pool to Pool Spacing (P_s)	**163.0**	**7.6**	**24.2**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**25.55**	**1.19**	**3.79**

Channel Profile

Valley Slope (S_{val})	**0.0270**	ft/ft	Average Water Surface Slope (S)	**0.0258**	ft/ft	Sinuosity (S_{val} / S)	**1.05**
Stream Length (SL)	**232.0**	ft	Valley Length (VL)	**222.0**	ft	Sinuosity (SL / VL)	**1.05**

Low Bank Height (LBH)	start	**2.00**	ft	Max Bankfull Depth (d_{max})	start	**1.10**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.8**
	end	**2.50**	ft		end	**1.10**	ft		end	**2.3**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0240**	**0.0150**	**0.0370**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**0.9302**	**0.5814**	**1.4341**
Run Slope (S_{run})	**0.0690**	**0.0180**	**0.1110**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**2.6744**	**0.6977**	**4.3023**
Pool Slope (S_p)	**0.0130**	**0.0060**	**0.0200**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.5039**	**0.2326**	**0.7752**
Glide Slope (S_g)	**0.0240**	**0.0060**	**0.0620**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.9302**	**0.2326**	**2.4031**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.29**	**1.15**	**1.56**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.194**	**1.065**	**1.444**
Max Run Depth (d_{maxr})	**1.73**	**1.65**	**1.96**	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**1.602**	**1.528**	**1.815**
Max Pool Depth (d_{maxp})	**1.51**	**1.40**	**1.61**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**1.398**	**1.296**	**1.491**
Max Glide Depth (d_{maxg})	**1.40**	**1.18**	**1.61**	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.296**	**1.093**	**1.491**
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**6**	**0**	**0**	D_{16}	**1.0**	**2.0**	**0.0**		mm
% Sand	**20**	**15**	**21**	D_{35}	**5.0**	**4.0**	**3.0**		mm
% Gravel	**67**	**84**	**75**	D_{50}	**8.0**	**8.0**	**6.0**		mm
% Cobble	**6**	**1**	**4**	D_{84}	**36.0**	**26.0**	**31.0**		mm
% Boulder				D_{95}	**85.0**	**44.0**	**65.0**		mm
% Bedrock				D_{100}	**180.0**	**90.0**	**80.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, G4 Poor Reach**

Location: **Pike National Forest, Colorado**

Observers: **B. Kasun *et al*.**

Reference reach ☐

Disturbed (impacted reach) ☒

Date: **8/18/2010**

Existing species composition: **Willow**

Potential species composition: **Willow, Salex, Alder**

Riparian cover categories		**Percent aerial cover***	**Percent of site coverage****	**Species composition**	**Percent of total species composition**
1. Overstory	Canopy layer	**0%**	**0%**		
					100%
2. Understory	Shrub layer	▨	**15%**	**Willows, 2 BroadleafSp.**	**100%**
					100%
3. Ground level	Herbaceous	▨	**35%**	**Horseweed**	**65%**
				Phacella	**5%**
				Grasses	**20%**
				Invasives (Mullen)	**10%**
				Carex	**17%**
					100%
	Leaf or needle litter	▨	**20%**		
	Bare ground	▨	**30%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, G4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **B. Kasun *et al*.** Date: **8/18/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, G4 Poor Reach**
Location: **Pike National Forest, Colorado**
Observers: **B. Kasun *et al* .**
Date: **8/18/2010**

Stream Size Category and Order ☞ **S-3(4)**

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).

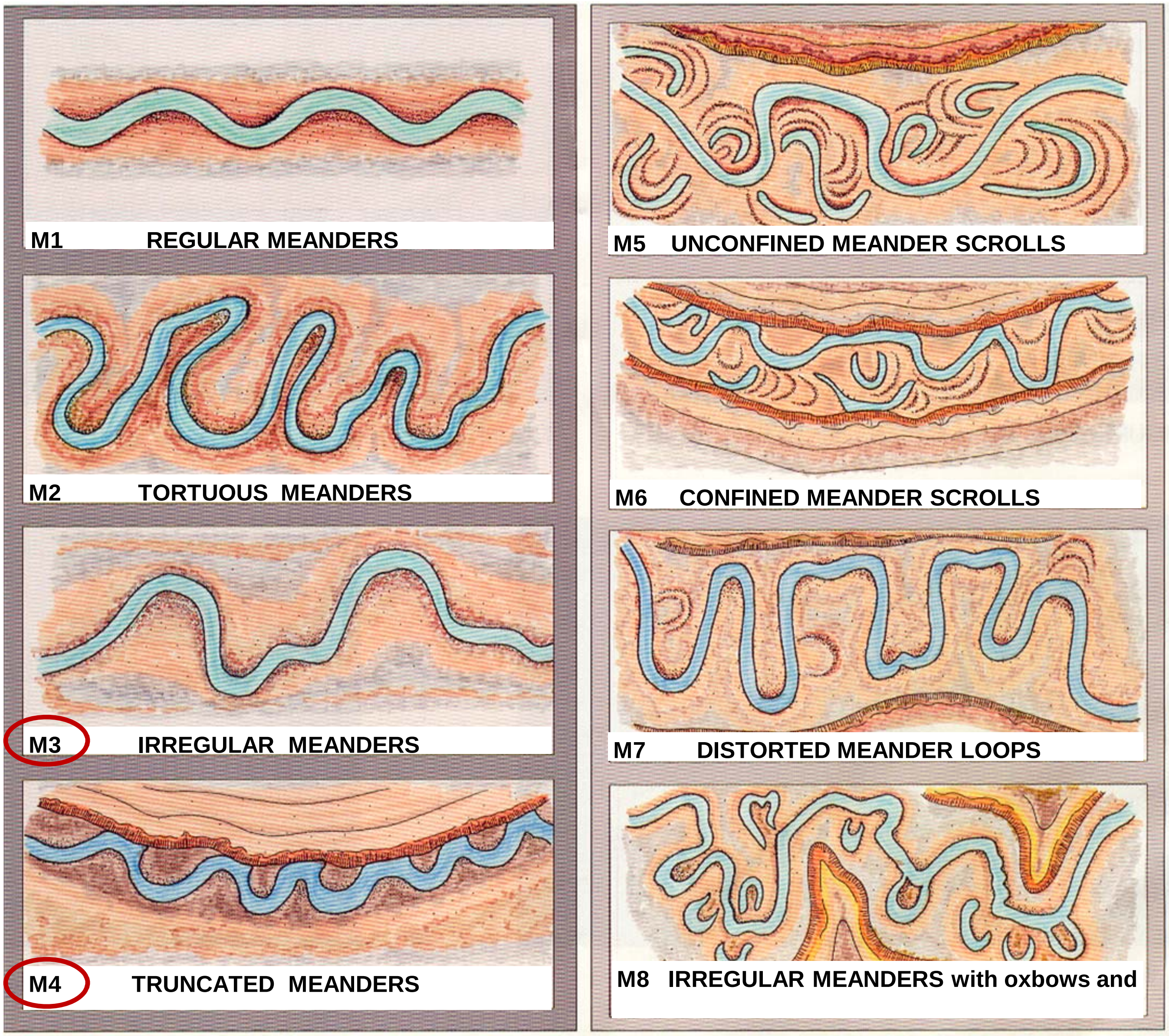
Worksheet 5-9. Meander patterns.

Meander Patterns

Stream:	**Trail Creek, G4 Poor Reach**	Location:	**Pike National Forest, CO**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

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

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



Worksheet 5-10. Depositional patterns.

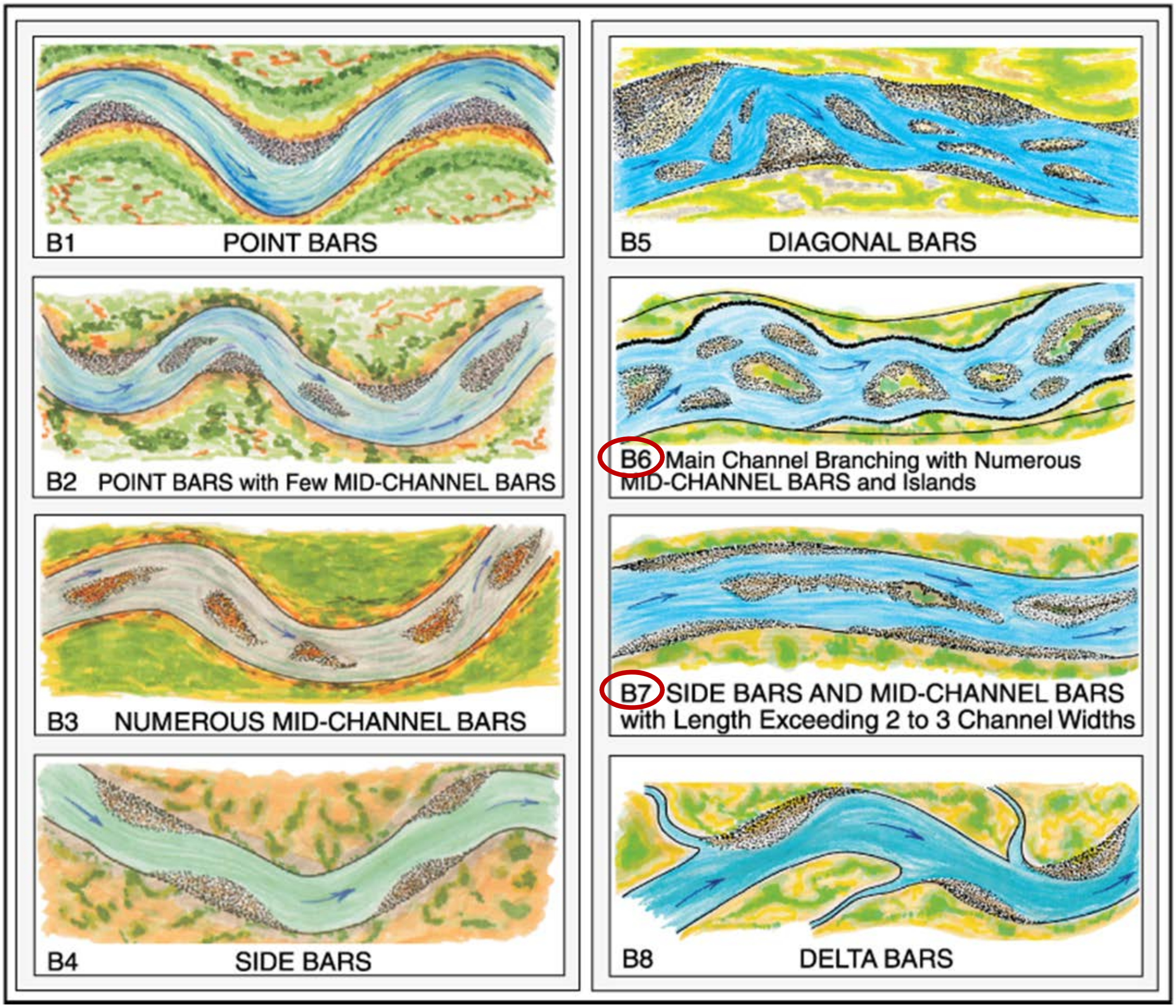
Depositional Patterns

Stream: **Trail Creek, G4 Poor Reach** Location: **Pike National Forest, Colorado**

Observers: **B. Kasun *et al*.** Date: **8/18/2010**

List ALL CATEGORIES that APPLY ☞	**B6**	**B7**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream:	**Trail Creek, G4 Poor Reach**	Location:	**Pike National Forest, Colorado**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

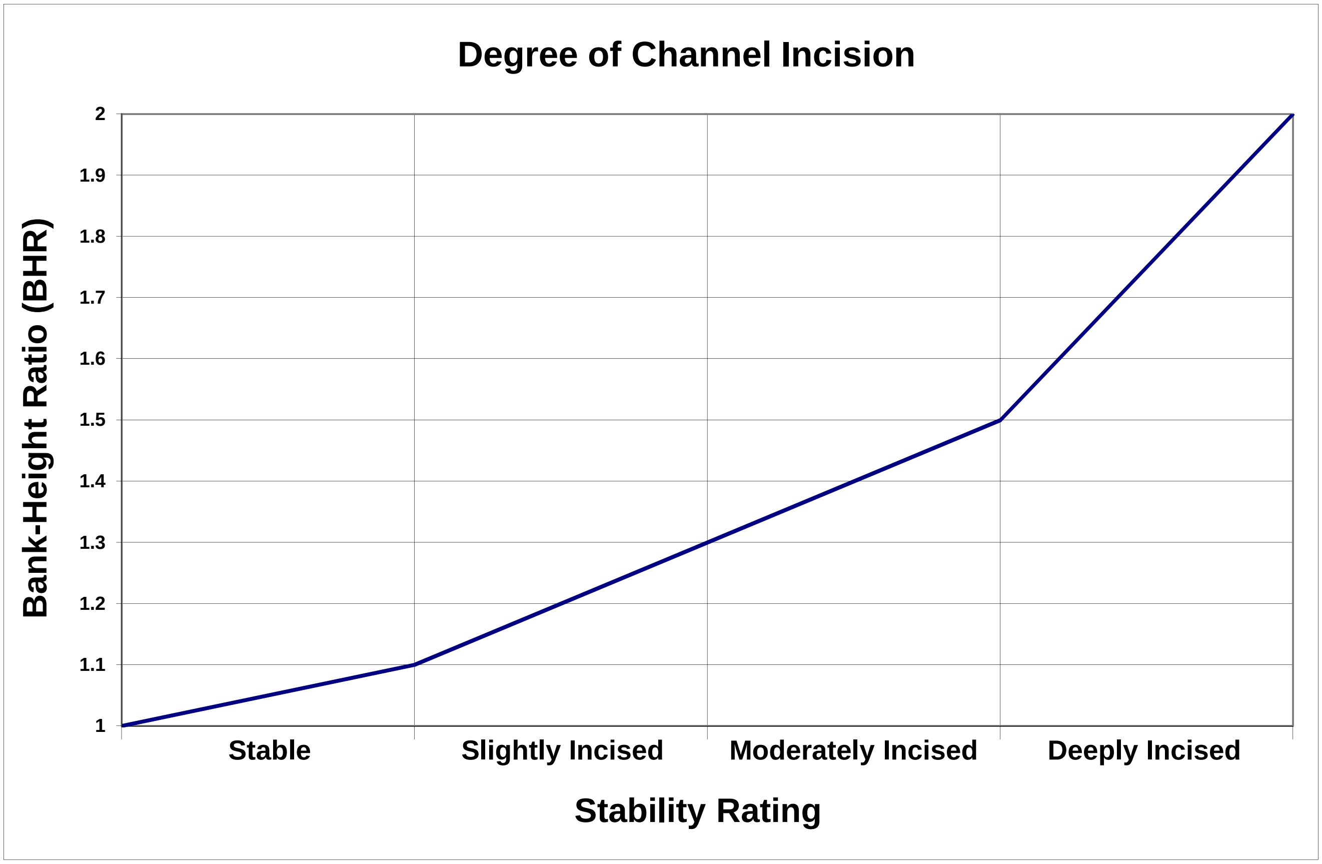
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris 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 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**2.5**	Bank-Height Ratio:	**1.7**
Max Bankfull Depth:	**1.5**		

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



Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

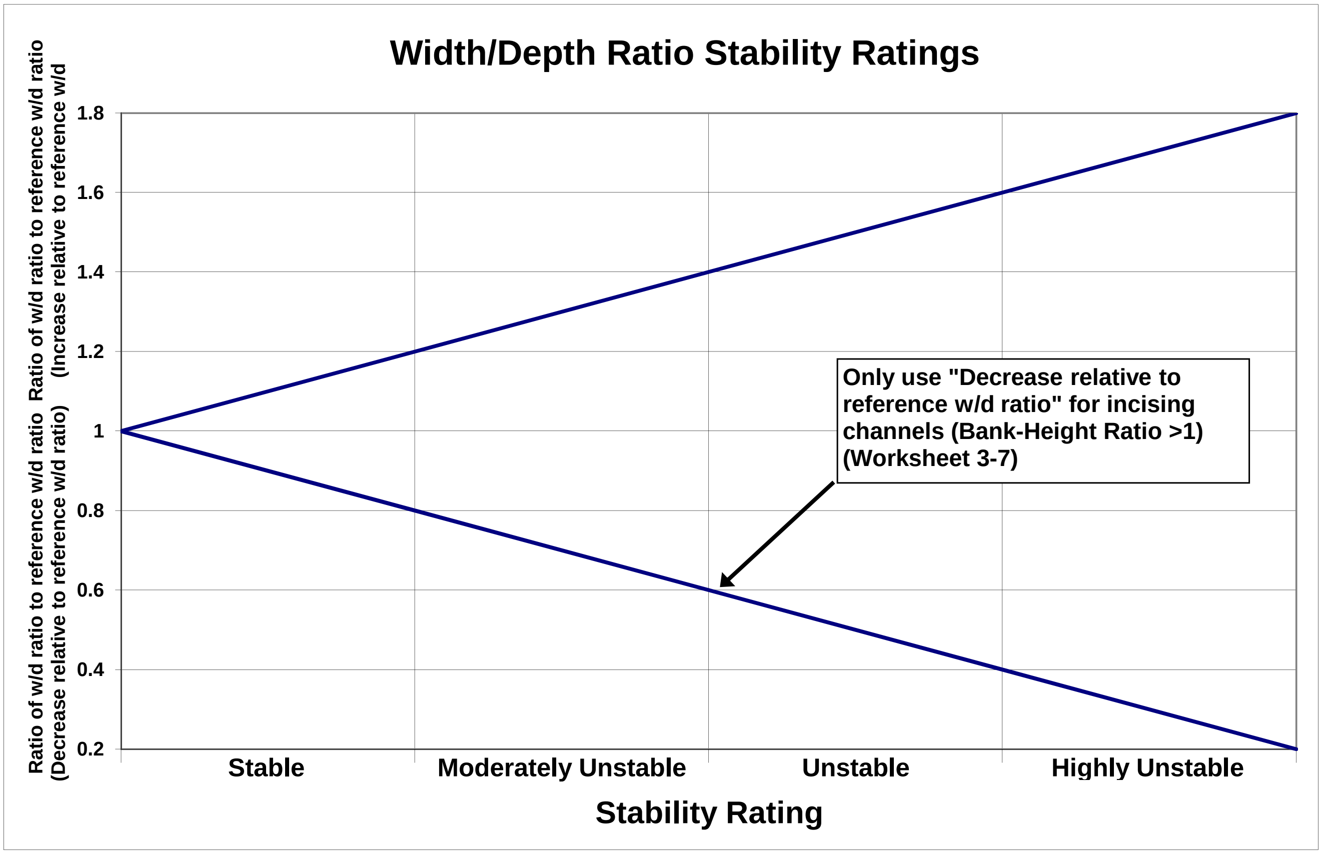
Existing Width/Depth Ratio: **6***

Reference Width/Depth Ratio: **12.57**

*Riffle XS 0+62

Ratio of existing W/d to reference W/d: **0.48**

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

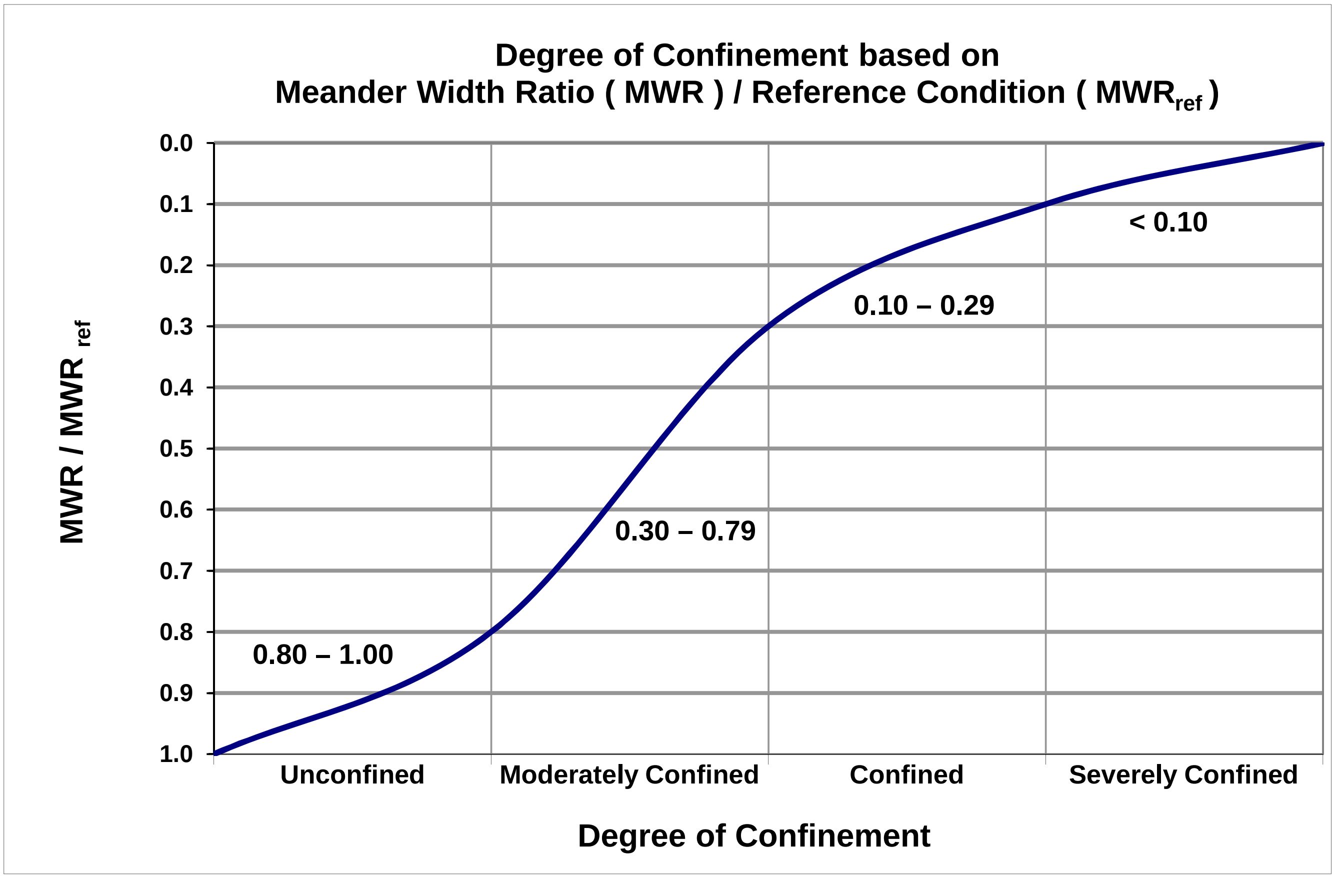
Degree of Confinement

Existing Meander Width Ratio (MWR): **1.8**

Reference Meander Width Ratio (MWR_{ref}): **3.7**

Ratio of MWR to MWR_{ref}: **0.49**

Degree of Confinement Stability Rating ☞ **Mod. Confined**



Degree of Confinement based on Meander Width Ratio (MWR) / Reference Condition (MWR_{ref})

Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, G4 Poor Reach **Location: Pike National Forest, CO** **Valley Type: VIII** **Observers: B. Kasun *et al*.** **Date: 8/18/2010**

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	[✓ 8]
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	[✓ 12]
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 4]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	[✓ 12]
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	[✓ 6]	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	[✓ 12]	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	[✓ 16]
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	[✓ 3]	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ 8]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ 16]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	[✓ 24]
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	**1**	**Good total =**	**4**	**Fair total =**	**21**	**Poor total =**	**112**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**[✓ B4]**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	**138**
Existing stream type =	**G4**
***Potential stream type =**	**B4**
Modified channel stability rating =	**Poor**

*Rating is adjusted to potential stream type, not existing.

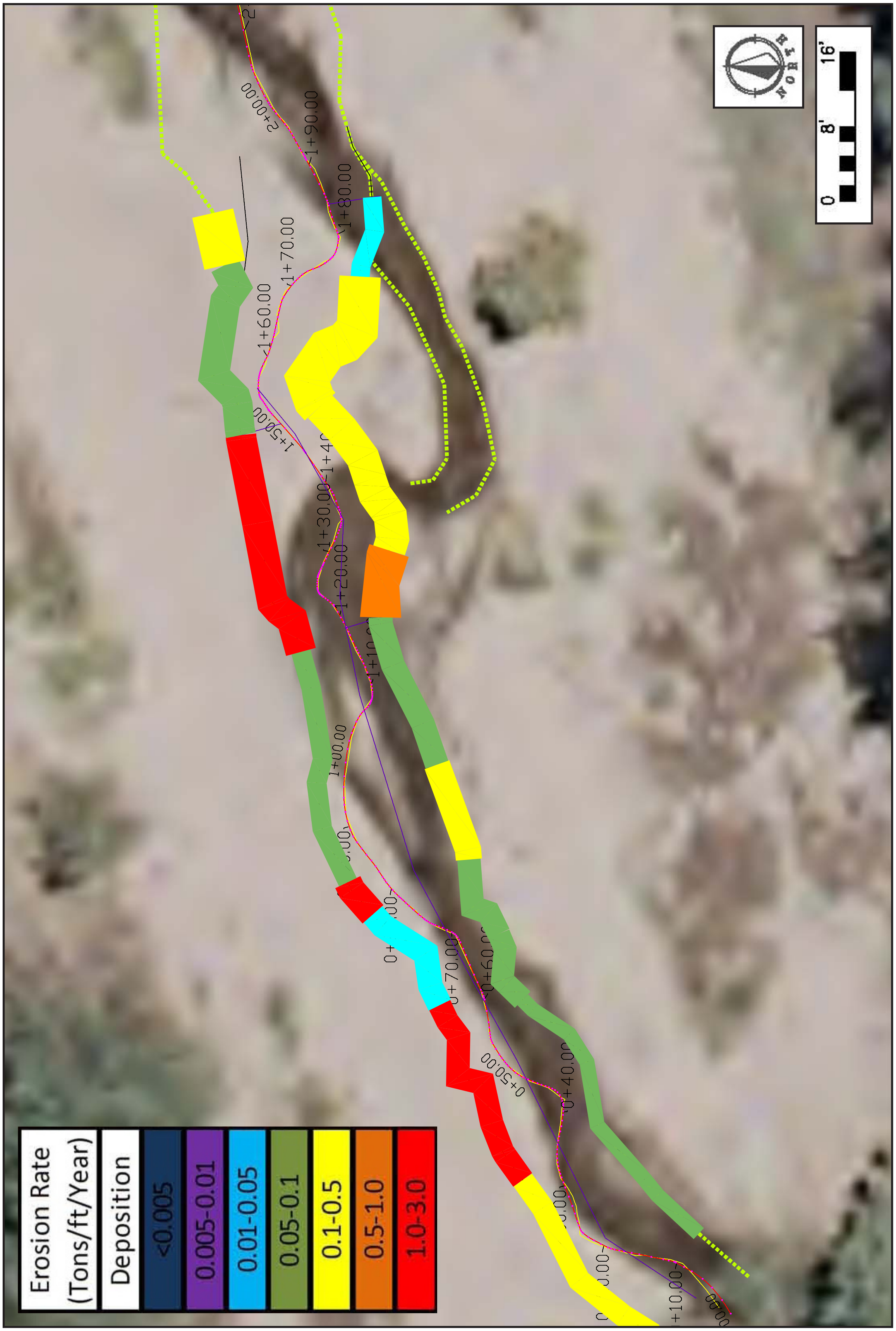
BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, G4 Poor Reach** Location: **Pike National Forest, Colorado**
Graph Used: **Colorado** Total Stream Length (ft): **184** Date: **8/18/2010**
Observers: **B. Kasun *et al*.** Valley Type: **VIII** Stream Type: **G4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+00-57R**	**High**	**High**	**0.57533**	**57.0**	**2.0**	**65.59**	**0.05540**
2. **0+00-34L**	**Very High**	**Very High**	**0.87205**	**34.0**	**3.0**	**88.95**	**0.12596**
3. **0+34-63L**	**Extreme**	**Very High**	**7.02692**	**29.0**	**3.1**	**631.72**	**1.04883**
4. **0+63-80L**	**Moderate**	**Low**	**0.15287**	**17.0**	**3.3**	**8.58**	**0.02429**
5. **0+80-84L**	**Extreme**	**Very High**	**7.02692**	**4.0**	**3.7**	**104.00**	**1.25183**
6. **0+57-67R**	**Moderate**	**High**	**0.42031**	**10.0**	**3.0**	**12.61**	**0.06071**
7. **0+67-78R**	**Moderate**	**High**	**0.42031**	**11.0**	**3.1**	**14.33**	**0.06273**
8 **0+84-118L**	**Very High**	**High**	**0.57533**	**34.0**	**2.6**	**50.86**	**0.07202**
9 **0+78-93R**	**Extreme**	**Extreme**	**2.76027**	**15.0**	**3.5**	**144.91**	**0.46516**
10 **0+93-118R**	**High**	**Moderate**	**0.37957**	**25.0**	**3.2**	**30.37**	**0.05848**
11 **118-150L**	**Extreme**	**Very High**	**7.02692**	**32.0**	**4.1**	**921.93**	**1.38717**
12 **118-131R**	**Extreme**	**Extreme**	**2.76027**	**13.0**	**4.5**	**161.48**	**0.59806**
13 **131-150R**	**High**	**Very High**	**0.87205**	**19.0**	**4.4**	**72.90**	**0.18475**
14 **150-174R**	**Extreme**	**Moderate**	**1.07417**	**24.0**	**5.5**	**141.79**	**0.28446**
15 **150-174L**	**High**	**Moderate**	**0.37957**	**24.0**	**4.0**	**36.44**	**0.07310**
16 **174-184L**	**Extreme**	**Low**	**0.41998**	**10.0**	**5.6**	**23.52**	**0.11324**
17 **174-184R**	**Very High**	**Low**	**0.25042**	**10.0**	**2.5**	**6.26**	**0.03014**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**2516.23**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**93.19**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**121.15**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.6584**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	30.5	0.0182	31.70
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	77.6													
0.10%	66.6	0.05%	0.09%	0.34	72.1	2.363	7.461	46.03	6.670	11.59	24.7	15.79	3.98	19.77
0.25%	57.6	0.08%	0.15%	0.55	62.1	2.036	5.232	27.81	4.809	8.35	34.0	15.22	4.57	19.80
0.50%	49.8	0.13%	0.25%	0.91	53.7	1.761	3.706	17.04	3.494	6.07	49.0	15.54	5.54	21.08
0.75%	42.5	0.13%	0.25%	0.91	46.1	1.513	2.592	10.24	2.502	4.35	42.1	9.34	3.97	13.31
1%	36.8	0.13%	0.25%	0.91	39.6	1.300	1.817	6.17	1.790	3.11	36.2	5.63	2.84	8.46
1.5%	31.6	0.25%	0.50%	1.83	34.2	1.120	1.289	3.77	1.289	2.24	62.3	6.88	4.09	10.97
2%	26.3	0.25%	0.50%	1.83	28.9	0.949	0.886	2.19	0.893	1.55	52.8	4.01	2.83	6.84
3%	22.2	0.50%	1.00%	3.65	24.2	0.795	0.600	1.25	0.602	1.05	88.5	4.55	3.82	8.36
4%	18.9	0.50%	1.00%	3.65	20.6	0.674	0.424	0.75	0.415	0.72	75.0	2.72	2.63	5.36
5%	16.9	0.50%	1.00%	3.65	17.9	0.587	0.322	0.49	0.304	0.53	65.4	1.80	1.93	3.73
10%	10.6	2.50%	5.00%	18.25	13.7	0.450	0.200	0.24	0.165	0.29	250.6	4.29	5.23	9.52
20%	5.8	5.00%	10.00%	36.50	8.2	0.269	0.103	0.07	0.045	0.08	298.9	2.63	2.88	5.51
30%	3.9	5.00%	10.00%	36.50	4.8	0.158	0.075	0.03	0.006	0.01	175.8	1.12	0.41	1.53
40%	2.7	5.00%	10.00%	36.50	3.3	0.108	0.068	0.02	0.000	0.00	120.2	0.70	0.00	0.70
50%	2.1	5.00%	10.00%	36.50	2.4	0.079	0.066	0.01	0.000	0.00	87.9	0.49	0.00	0.49
60%	1.6	5.00%	10.00%	36.50	1.8	0.061	0.065	0.01	0.000	0.00	67.4	0.37	0.00	0.37
70%	1.3	5.00%	10.00%	36.50	1.4	0.047	0.064	0.01	0.000	0.00	52.8	0.29	0.00	0.29
80%	1.1	5.00%	10.00%	36.50	1.2	0.039	0.064	0.01	0.000	0.00	44.0	0.24	0.00	0.24
90%	0.8	5.00%	10.00%	36.50	1.0	0.032	0.064	0.01	0.000	0.00	35.2	0.19	0.00	0.19
100%	0.2	5.00%	10.00%	36.50	0.5	0.016	0.064	0.00	0.000	0.00	17.6	0.10	0.00	0.10
									Annual Totals:		1,680.3 (cfs) 3,332.9 (acre-ft)	91.9 (tons/yr)	44.7 (tons/yr)	136.6 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Poor" Pagosa**	$y = 0.07176+1.02176x^{2.3772}$	**30.5**	**0.4699**	**223.46**
2. Suspended Sediment	**"Poor" Pagosa**	$y = 0.0989+0.9213x^{3.659}$			

From Dimensional 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)
Percentage of Time	Daily Mean Discharge	Mid-Ordinate	Time Increment (percent)	Time Increment (days)	Mid-Ordinate Streamflow	Dimensionless Streamflow	Dimensionless Suspended Sediment Discharge	Suspended Sediment Discharge	Dimensionless Bedload Discharge	Bedload Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	111.2													
0.10%	100.2	0.05%	0.09%	0.34	105.7	3.465	86.989	5546.02	19.669	880.48	36.3	1902.84	302.09	2204.93
0.25%	91.2	0.08%	0.15%	0.55	95.7	3.138	60.560	3496.68	15.555	696.33	52.4	1914.43	381.24	2295.67
0.50%	83.4	0.13%	0.25%	0.91	87.3	2.862	43.307	2281.18	12.519	560.42	79.7	2081.58	511.38	2592.96
0.75%	76.1	0.13%	0.25%	0.91	79.7	2.615	31.126	1497.67	10.110	452.55	72.8	1366.62	412.95	1779.57
1%	70.4	0.13%	0.25%	0.91	73.2	2.401	22.827	1008.77	8.272	370.28	66.8	920.51	337.88	1258.39
1.5%	64.7	0.25%	0.50%	1.83	67.5	2.214	16.983	691.95	6.832	305.82	123.2	1262.80	558.12	1820.92
2%	59.0	0.25%	0.50%	1.83	61.8	2.027	12.331	460.06	5.555	248.65	112.9	839.62	453.79	1293.41
3%	54.8	0.50%	1.00%	3.65	56.9	1.866	9.122	313.18	4.571	204.63	207.7	1143.10	746.90	1890.00
4%	48.9	0.50%	1.00%	3.65	51.9	1.701	6.534	204.51	3.684	164.91	189.4	746.46	601.91	1348.38
5%	43.3	0.50%	1.00%	3.65	46.1	1.511	4.275	118.89	2.799	125.31	168.3	433.96	457.38	891.34
10%	26.9	2.50%	5.00%	18.25	35.1	1.150	1.637	34.66	1.497	67.03	640.4	632.60	1223.33	1855.93
20%	8.6	5.00%	10.00%	36.50	17.8	0.583	0.227	2.43	0.355	15.89	648.9	88.76	579.91	668.67
30%	4.0	5.00%	10.00%	36.50	6.3	0.208	0.102	0.39	0.096	4.30	231.3	14.21	157.08	171.29
40%	2.7	5.00%	10.00%	36.50	3.4	0.111	0.099	0.20	0.077	3.46	123.6	7.40	126.23	133.63
50%	2.1	5.00%	10.00%	36.50	2.4	0.079	0.099	0.14	0.074	3.32	87.9	5.25	121.25	126.50
60%	1.6	5.00%	10.00%	36.50	1.8	0.061	0.099	0.11	0.073	3.27	67.4	4.02	119.37	123.40
70%	1.3	5.00%	10.00%	36.50	1.4	0.047	0.099	0.09	0.072	3.24	52.8	3.15	118.44	121.58
80%	1.1	5.00%	10.00%	36.50	1.2	0.039	0.099	0.07	0.072	3.23	44.0	2.62	118.02	120.64
90%	0.8	5.00%	10.00%	36.50	1.0	0.032	0.099	0.06	0.072	3.22	35.2	2.10	117.70	119.80
100%	0.2	5.00%	10.00%	36.50	0.5	0.016	0.099	0.03	0.072	3.21	17.6	1.05	117.34	118.39
									Annual Totals:		**3,058.2** (cfs) **6,066.0** (acre-ft)	**13,373** (tons/yr)	**7,562** (tons/yr)	**20,935** (tons/yr)

POWERSED Model – Sediment Transport Capacity

Worksheet 20a. Sediment transport prediction representing the upstream supply up to bankfull for bedload and suspended sand sediment.

Stream: **Trail Creek, Upstream Existing Sediment Supply** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/14/10**

Observers: **S=.0258, Q=31, 24.25, Bed.=1.0337, S.Sand=111.73** Stream Type: **G4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.16**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.80**	**0.48**	**0.38**	**4.37**	**0.09**	**1.08**	**0.0258**	**0.14**	**0.77**	**0.18**	**10%**	**36.50**	**3.20**	**0.01**	**116.80**	**0.36**	**117.16**
80.00%	**1.12**	**0.96**	**0.64**	**5.09**	**0.13**	**1.44**	**0.0258**	**0.20**	**1.55**	**0.30**	**10%**	**36.50**	**3.20**	**0.03**	**116.80**	**1.09**	**117.89**
70.00%	**1.28**	**1.20**	**0.75**	**5.32**	**0.14**	**1.56**	**0.0258**	**0.23**	**1.93**	**0.36**	**10%**	**36.50**	**3.24**	**0.04**	**118.26**	**1.46**	**119.72**
60.00%	**1.61**	**1.45**	**0.84**	**5.45**	**0.15**	**1.65**	**0.0258**	**0.25**	**2.33**	**0.43**	**10%**	**36.50**	**3.24**	**0.04**	**118.26**	**1.46**	**119.72**
50.00%	**2.09**	**1.85**	**0.99**	**5.67**	**0.17**	**1.79**	**0.0258**	**0.28**	**2.98**	**0.53**	**10%**	**36.50**	**3.24**	**0.06**	**118.26**	**2.19**	**120.45**
40.00%	**2.73**	**2.41**	**1.20**	**5.98**	**0.20**	**1.98**	**0.0258**	**0.32**	**3.88**	**0.65**	**10%**	**36.50**	**3.33**	**0.07**	**121.55**	**2.56**	**124.11**
30.00%	**4.04**	**3.39**	**1.50**	**6.27**	**0.24**	**2.21**	**0.0258**	**0.38**	**5.46**	**0.87**	**10%**	**36.50**	**3.46**	**0.10**	**126.29**	**3.65**	**129.94**
20.00%	**8.63**	**6.34**	**2.28**	**6.90**	**0.33**	**2.75**	**0.0258**	**0.52**	**10.21**	**1.48**	**10%**	**36.50**	**4.23**	**0.19**	**154.40**	**6.94**	**161.34**
10.00%	**26.93**	**17.78**	**4.60**	**8.30**	**0.55**	**3.85**	**0.0258**	**0.87**	**28.62**	**3.45**	**10%**	**36.50**	**15.38**	**1.18**	**561.37**	**43.07**	**604.44**
5.00%	**43.25**	**35.09**	**9.48**	**18.37**	**0.52**	**3.69**	**0.0258**	**0.81**	**56.49**	**3.08**	**5%**	**18.25**	**64.45**	**16.40**	**1176.21**	**299.30**	**1475.51**
4.00%	**48.95**	**46.10**															
3.00%	**54.82**	**51.89**															
2.00%	**58.99**	**56.91**															
1.50%	**64.69**	**61.84**															
1.00%	**70.38**	**67.54**															
0.75%	**76.12**	**73.25**															
0.50%	**83.39**	**79.76**															
0.25%	**91.23**	**87.31**															
0.10%	**100.18**	**95.71**															
0.0060%	**111.17**	**105.68**															
											Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):				**2728.2**	**362.1**	**3090.3**

Worksheet 20b. Sediment transport prediction for the existing condition reach compared to the upstream sediment supply to assess bed stability.

Stream: **Trail Creek, G4 Poor, Riffle XS3 0+62** Location: **Pike National Forest, Colorado (Used "POOR" Curves)** Date: **08/14/10**

Observers: **S=.0258, Q=31, 24.25, Bed.=1.0337, S.Sand=111.73** Stream Type: **G4** Valley Type: **VIII** Gage Station #: **Used Post-Fire Dimensionless F-D C.**

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)
100.00%	**0.16**										**0%**				**0.00**	**0.00**	**0.00**
90.00%	**0.80**	**0.48**	**0.42**	**4.40**	**0.10**	**1.03**	**0.0258**	**0.15**	**0.77**	**0.17**	**10%**	**36.50**	**0.00**	**0.01**	**0.00**	**0.36**	**0.36**
80.00%	**1.12**	**0.96**	**0.70**	**5.25**	**0.13**	**1.29**	**0.0258**	**0.21**	**1.55**	**0.30**	**10%**	**36.50**	**3.20**	**0.03**	**116.80**	**1.09**	**117.89**
70.00%	**1.28**	**1.20**	**0.83**	**5.68**	**0.15**	**1.42**	**0.0258**	**0.23**	**1.93**	**0.34**	**10%**	**36.50**	**3.24**	**0.04**	**118.26**	**1.46**	**119.72**
60.00%	**1.61**	**1.45**	**0.93**	**5.78**	**0.16**	**1.51**	**0.0258**	**0.25**	**2.33**	**0.40**	**10%**	**36.50**	**3.24**	**0.04**	**118.26**	**1.46**	**119.72**
50.00%	**2.09**	**1.85**	**1.08**	**5.82**	**0.19**	**1.65**	**0.0258**	**0.29**	**2.98**	**0.51**	**10%**	**36.50**	**3.24**	**0.06**	**118.26**	**2.19**	**120.45**
40.00%	**2.73**	**2.41**	**1.28**	**5.87**	**0.22**	**1.83**	**0.0258**	**0.34**	**3.88**	**0.66**	**10%**	**36.50**	**3.33**	**0.07**	**121.55**	**2.56**	**124.11**
30.00%	**4.04**	**3.39**	**1.59**	**5.94**	**0.27**	**2.10**	**0.0258**	**0.42**	**5.46**	**0.92**	**10%**	**36.50**	**3.50**	**0.10**	**127.75**	**3.65**	**131.40**
20.00%	**8.63**	**6.34**	**2.37**	**6.07**	**0.39**	**2.65**	**0.0258**	**0.59**	**10.21**	**1.68**	**10%**	**36.50**	**5.36**	**0.22**	**195.64**	**8.03**	**203.67**
10.00%	**26.93**	**17.78**	**4.62**	**6.29**	**0.73**	**3.84**	**0.0258**	**1.03**	**28.62**	**4.55**	**10%**	**36.50**	**164.98**	**35.31**	**6021.77**	**1288.82**	**7310.59**
5.00%	**43.25**	**35.09**	**7.27**	**6.47**	**1.12**	**4.82**	**0.0258**	**1.44**	**56.49**	**8.73**	**5%**	**18.25**	**366.55**	**332.90**	**6689.54**	**6075.42**	**12764.96**
4.00%	**48.95**	**46.10**															
3.00%	**54.82**	**51.89**															
2.00%	**58.99**	**56.91**															
1.50%	**64.69**	**61.84**															
1.00%	**70.38**	**67.54**															
0.75%	**76.12**	**73.25**															
0.50%	**83.39**	**79.76**															
0.25%	**91.23**	**87.31**															
0.10%	**100.18**	**95.71**															
0.0060%	**111.17**	**105.68**															

Notes:

Total annual sediment yield (bedload and suspended sand bed-material load) (tons/yr):	**13627.8**	**7385.0**	**21012.9**
Upstream total annual sediment supply (tons/yr) (**Worksheet 5-20a**):	**2728.2**	**362.1**	**3090.3**
Difference in sediment transport capacity (tons/yr) (+ or -):	**10899.6**	**7022.9**	**17922.6**
Stability evaluation: Aggradation, Degradation or Stable:	**Degradation, ≈ 72% Increase in Transport**		

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

Enter Required Information for Existing Condition

8.0	D_{50}	Riffle bed material D_{50} (mm)			
6.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.26	D_{max}	Largest particle from bar sample (ft)	**80**	**(mm)**	304.8 mm/ft
0.0258	S	Existing bankfull water surface slope (ft/ft)			
0.89	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.33	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
10.00	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

1.433		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 **99**	CO **190**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.01**	CO **0.4**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.63**	CO **0.25**	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 **0.0182**	CO **0.0072**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, G4 Poor Reach** Stream Type: **G4**
Location: **Pike National Forest, CO** Valley Type: **VIII**
Observers: **B. Kasun *et al*.** Date: **8/18/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☑ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

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 5-13)**	< 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, **B6, B7** **B6, B7** [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	M1, **M3, M4** **M3, M4** [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex [✓ **(8)**]	**8**
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0 **(1)**	0.3 – 0.79 [✓ **(2)**]	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**2**
				Total Points	**17**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☐	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☑	***Highly Unstable*** **> 21** ☐	

Worksheet 5-26. Vertical stability − aggradation.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

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 5-22)**	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) (Worksheet 5-20)**	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 5-13)**	< 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**2**
4 **Stream Succession States (Worksheet 5-24)**	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) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 5-10)**	B1 **(1)**	B2, B4 **(2)**	B3, B5 **(3)**	**B6**, **B7**, B8 **B6, B7** [✓ **(4)**]	**4**
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, **D3** **D3** [✓ **(1)**]	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**1**
				Total Points	**13**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

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 5-22)**	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	**8**
	(2)	**(4)**	**(6)**	**[✓ (8)]**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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	**8**
	(2)	**(4)**	**(6)**	**[✓ (8)]**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	**[✓ (8)]**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**8**
	(2)	**(4)**	**(6)**	**[✓ (8)]**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**2**
	(1)	**[✓ (2)]**	**(3)**	**(4)**	
				Total Points	**34**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☑

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

	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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **(2)**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **[✓ (8)]**	**8**
2	**Lateral Stability (Worksheet 5-25)**	*Stable* **(2)**	*Moderately Unstable* **(4)**	*Unstable* **[✓ (6)]**	*Highly Unstable* **(8)**	**6**
3	**Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **[✓ (2)]**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4	**Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **(2)**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **[✓ (8)]**	**8**
					Total Points	**24**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☑

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, G4 Poor Reach**	Stream Type:	**G4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**B. Kasun *et al*.**	Date:	**8/18/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	**1**	**3**
	Mod. Unstable	**2**	
	Unstable	**[✓ 3]**	
	Highly Unstable	**4**	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	**[✓ 1]**	**1**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	**1**	**4**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**[✓ 4]**	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	**1**	**4**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**[✓ 4]**	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	**1**	**4**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**[✓ 4]**	
		Total Points	**16**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **> 15** ☑

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, G4 Poor Reach**					Location:	**Pike National Forest, Colorado**				
Observers:	**B. Kasun *et al*.**			Date:	**8/18/2010**		Stream Type:	**G4**	Valley Type:	**VIII**	
Channel Dimension (Riffle XS 2+31)	Mean Bankfull Depth (ft):	**0.89**	Bankfull Width (ft):	**9.75**	Cross-Sectional Area (ft^2):	**8.68**	Width of Flood-Prone Area (ft):	**12.35**	Entrenchment Ratio:	**1.27**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**1.82**	Sinuosity:	**1.05**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☑ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence		☐ Dunes/Antidunes/Smooth Bed					
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope		
		1.29	**1.51**		**1.32**	**1.54**		**2.03**	Valley: **0.027**	Water Surface: **0.0259**	
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:		Potential Composition/Density:		Remarks: Condition, Vigor & Usage of Existing Reach:					
		Willow100% 2 B.leaf Sp.		**Salix, Alder/100%**		**Sprouts w/good vigor**					
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**M3, M4**	Depositional Patterns:	**B6, B7**	Channel Blockages:	**D3**	
	Degree of Incision (Bank-Height Ratio):	**1.7**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**138 (Poor)**					
	Width/depth Ratio (W/d):	**6.02**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**0.48**	W/d Ratio State Stability Rating:	**Unstable**			
	Meander Width Ratio (MWR):	**1.82**	Reference MWR_{ref}:	**3.7**	Degree of confinement (MWR / MWR_{ref}):	**0.52**	MWR / MWR_{ref} Stability Rating:	**Moderately Confined**			
Bank Erosion Summary	Length of Reach Studied (ft):	**184**	Annual Streambank Erosion Rate:	**121.15** (tons/yr)	**0.6584** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:	**Fire effects**		
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☑ Excess Capacity			Remarks:	**Transitioning from F to G to B potential**				
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**80**	$\tau =$	**1.769**	$\tau^* =$	**N/A**	Existing Depth:	**0.89**	Required Depth:	**0.63**	Existing Slope: **0.027** Required Slope: **0.018**
Successional Stage Shift	**C → D → G → F → [✓ G] → B4**						Existing Stream State (Type):	**G4**	Potential Stream State (Type):	**B4**	
Lateral Stability	☐ *Stable*	☐ *Mod. Unstable*	☑ *Unstable*	☐ *Highly Unstable*		Remarks/causes:	**little veg recovery, very erosive soils**				
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*		Remarks/causes:	**little veg recovery, very erosive soils**				
Vertical Stability (Degradation)	☐ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☑ *Degradation*		Remarks/causes:	**little veg recovery, very erosive soils**				
Channel Enlargement	☐ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☑ *Extensive*		Remarks/causes:	**little veg recovery, very erosive soils**				
Sediment Supply (Channel Source)	☐ *Low*	☐ *Moderate*	☐ *High*	☑ *Very High*		Remarks/causes:	**little veg recovery, very erosive soils**				

Appendix C16

A4a+ Stream Type

Reference Reach

Table of Contents

Appendix C16: A4a+ Reference Reach

A4a+ Reference Reach Location & Overview

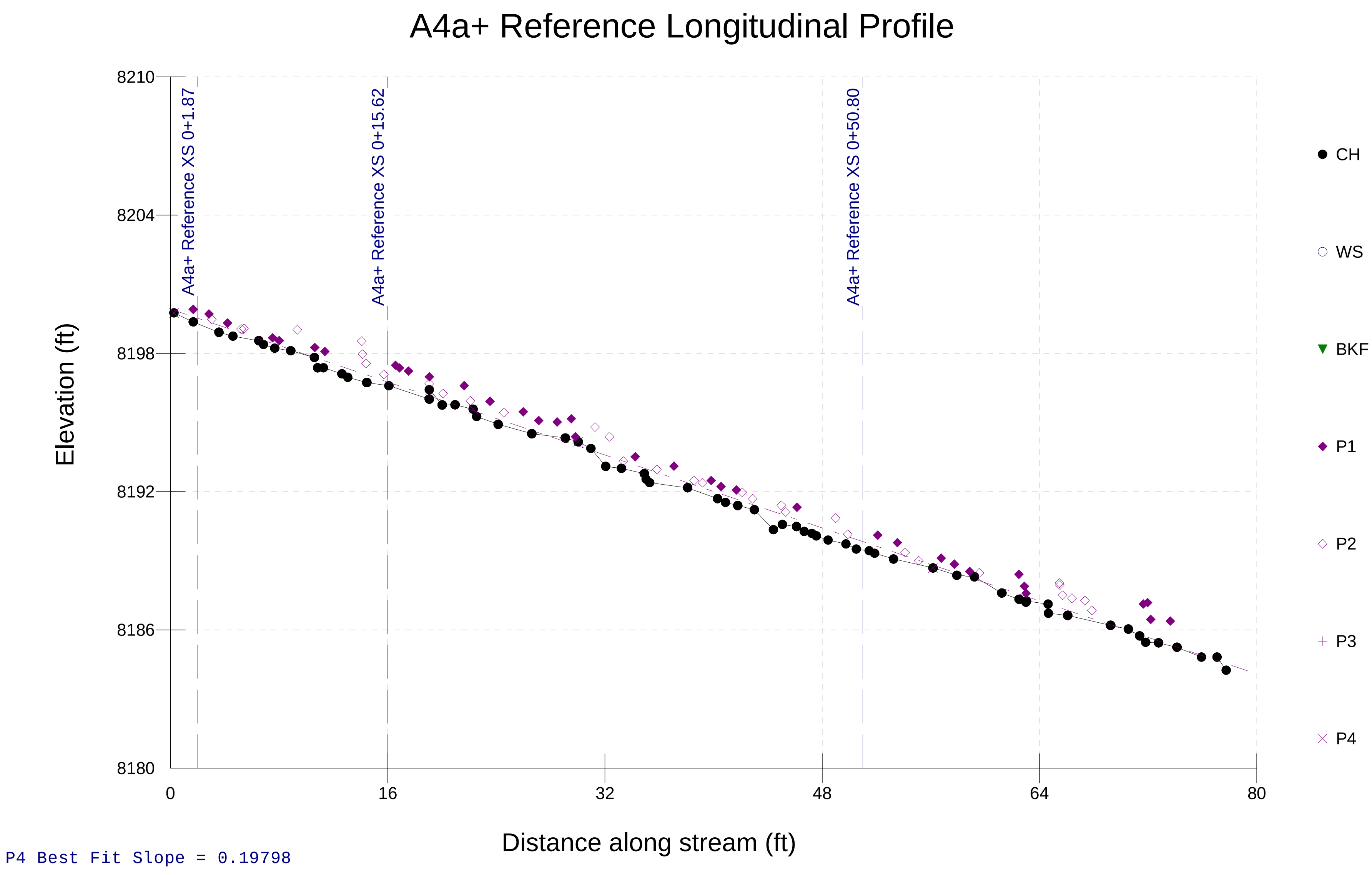
The A4a+ reference reach is in a Valley Type I and is typical of a channel comprising of gravel-cobble and sand materials. The channel bed and banks are potentially erodible, but due to the vegetation condition, this reference reach shows little sediment yield from this 1st order channel. Bed features are generally dominated by step/pool and cascades. The channel is ephemeral and is associated with a stable bed and banks and a high sediment transport capacity. There is little sediment storage and very low to negligible streambank erosion.

Typical of A4a+ stream types, the channel is entrenched and has a low width/depth ratio with a relatively straight pattern with a sinuosity less than 1.1. The channel is also laterally contained or confined (meander width ratio around 2 or less). Little channel source sediment is generated from this stream type during high runoff events due to the good riparian vegetation. The predicted streambank erosion rate of *0.0017 tons/yr/ft* represents a geologic, yet acceptable rate of erosion for these soil and stream types (**Worksheet 5-18**).

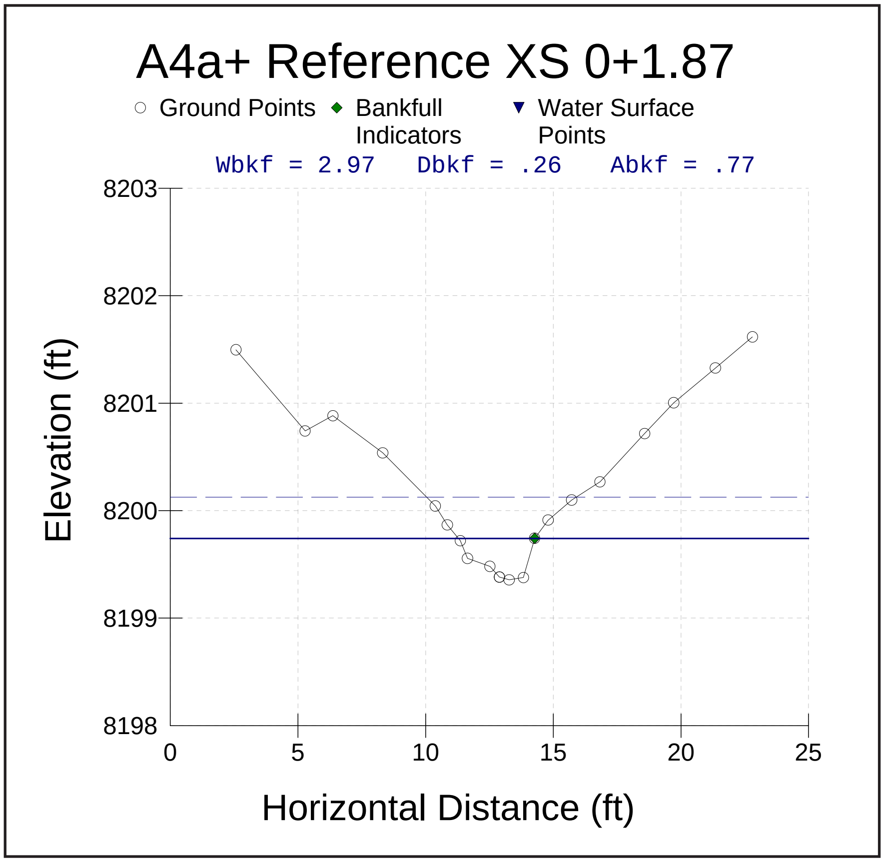
The location of this reach is shown in **Figure C-2**, and the photograph depicts the stable characteristics of this stream type. Although the fire burned the riparian, aspen and perennial bunch grasses are colonizing the site. There is little to no evidence of active channel-source sediment from this stream type. Such stream types are mapped where they occur by sub-watershed as shown in **Appendix D**.

The details of the dimension, pattern, profile and materials are summarized. The POWERSED model was not run on this reference reach as the bed is obviously stable. The following summary worksheets provide the detail of the morphology, hydraulics, stability, and streambank erosion rates for this reference reach. In the situation where impaired A4a+ stream types are located, an alternative for mitigation and sediment reduction is to use the data from the stable form to extrapolate for potential implementation of natural channel design.

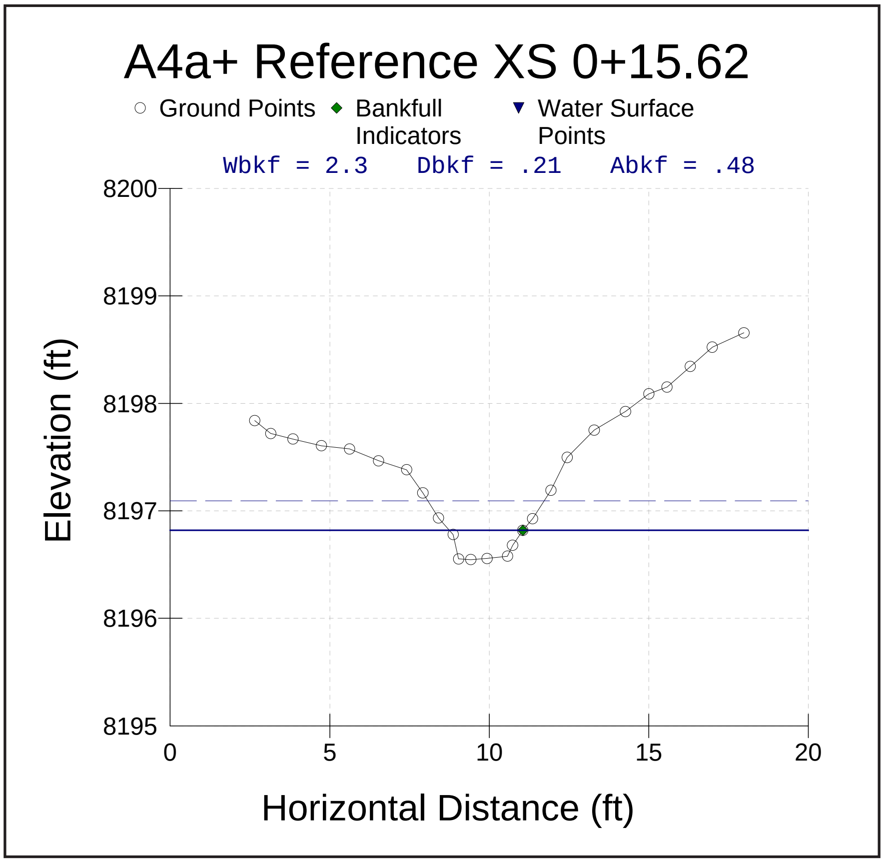
Survey Summary



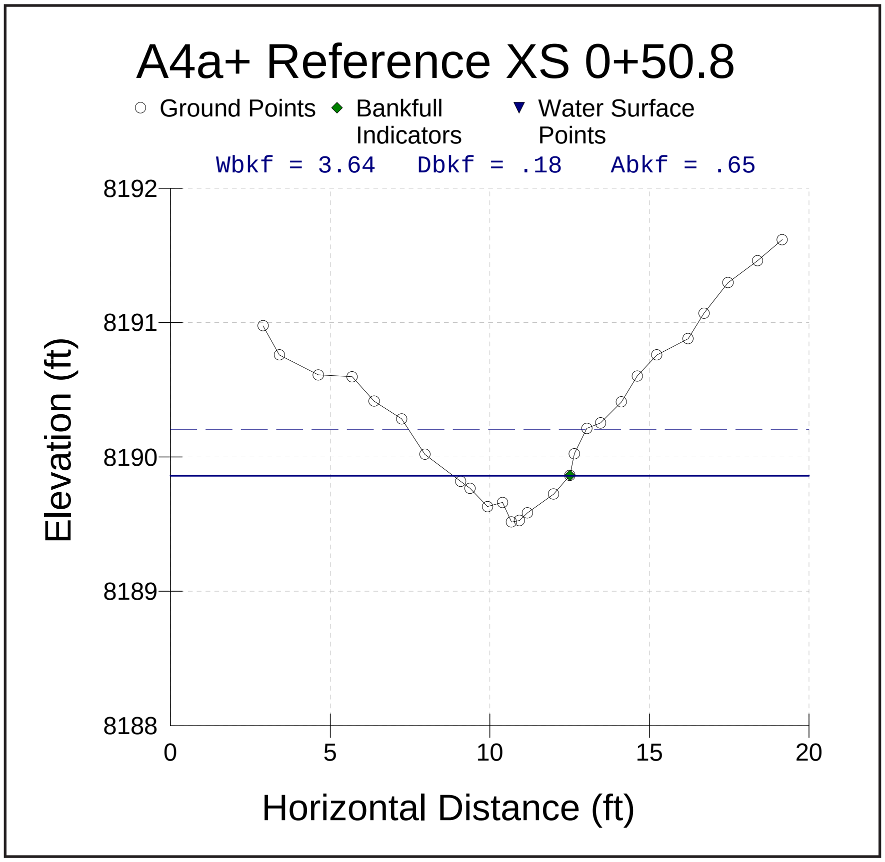
Longitudinal Profile (graph generated from RIVERMorph^{TM})



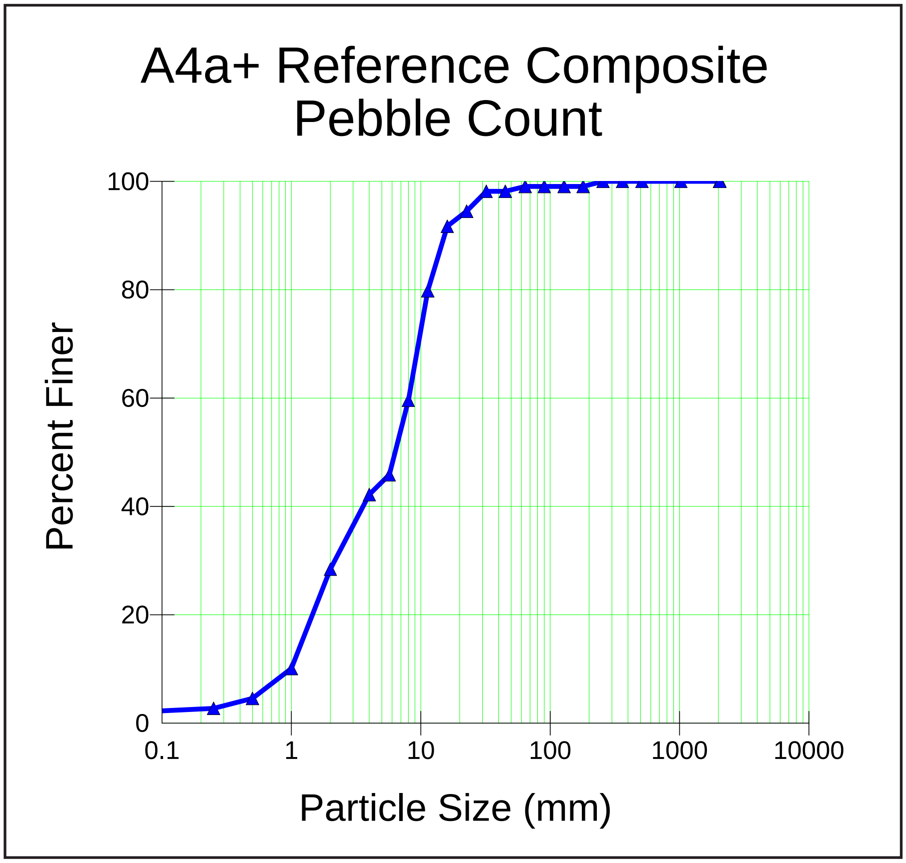
Cross-section 0+1.87 (graph generated from RIVERMorph^{TM})



Representative Cross-section 0+15.62 (graph generated from RIVERMorph^{TM})



Cross-section 0+50.8 (graph generated from RIVERMorph™)



Composite Pebble Count (graph generated from RIVERMorph™)

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, A4a+ Reference**			Location:	**XS 0+15.62, Pike N.F., Colorado**
Date:	**9/3/2010**	Stream Type:	**A4a+**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**			HUC:	__ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**0.48**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.21**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**2.30**	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**2.72**	W_p (ft)
D_{84} at Riffle	**13.0**	Dia. (mm)	D_{84} (mm) / 304.8	**0.04**	D_{84} (ft)
Bankfull SLOPE	**0.198**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.18**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**4.16**	R / D_{84}
Drainage Area	**0.002**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**1.061**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**6.72**	ft / sec	**3.23**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.0285**	**7.32**	ft / sec	**3.52**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$		ft / sec		cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.278** **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	**0.75**	ft / sec	**0.36**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q = ____ year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, A4a+ Reference Reach**

Basin: Drainage Area: acres **0.002** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+15.62** Date: **09/03/10**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**2.30**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A / W_{bkf}$).	**0.21**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**0.48**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**10.95**	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.	**0.27**	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.	**3.65**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.59**	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.	**6.39**	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.	**0.198**	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 **A4a+** (See **Figure 2-14**)

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, A4a+ Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010** Valley Type: **I** Stream Type: **A4a+**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**3.0**	**2.3**	**3.6**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**0.6**	**0.5**	**0.8**
Mean Riffle Depth (d_{bkf})	**0.22**	**0.18**	**0.26**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**11.19**	**10.95**	**11.42**
Maximum Riffle Depth (d_{max})	**0.33**	**0.27**	**0.39**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	**1.558**	**1.286**	**1.889**
Width of Flood-Prone Area (W_{fpa})	**5.0**	**3.7**	**5.9**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**1.55**	**1.53**	**1.6**
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream:	**Trail Creek, A4a+ Reference Reach**			Location:	**Pike National Forest, Colorado**		
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**	Valley Type:	**I**	Stream Type:	**A4a+**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**0.75**	ft/sec	Estimation Method	**Manning's n from Jarrett**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**0.36**	cfs	Drainage Area	**0.002**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**4.5**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**1.52**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.220**	ft/ft	Average Water Surface Slope (S)	**0.198**	ft/ft	Sinuosity (S_{val} / S)	**1.11**
Stream Length (SL)		ft	Valley Length (VL)		ft	Sinuosity (SL / VL)	

Low Bank Height (LBH)	start		ft	Max Bankfull Depth (d_{max})	start		ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	
	end		ft		end		ft		end	

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.1980**			ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.0000**		
Run Slope (S_{run})				ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)				ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)			
Glide Slope (S_g)				ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)			
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**0.38**	**0.27**	**0.49**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.520**	**1.080**	**1.960**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0**			D_{16}	**1.32**				mm
% Sand	**28.44**			D_{35}	**2.95**				mm
% Gravel	**70.64**			D_{50}	**6.39**				mm
% Cobble	**0.92**			D_{84}	**12.95**				mm
% Boulder	**0**			D_{95}	**23.88**				mm
% Bedrock	**0**			D_{100}	**255.99**				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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, A4a+ Reference Reach**

Location: **Pike NF**

Observers: **Chavez, Kasun & Gallagher**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **9/3/2010**

Existing species composition: **Aspen, Forb/Grass**

Potential species composition: **Same but without Invasive Species & with Ponderosa Pine**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**25%**	**25%**	**Aspen**	**100%**
					100%
2. Understory	Shrub layer	▨	**15%**	**Raspberry**	**80%**
				Rose	**10%**
				Ribes	**10%**
					100%
3. Ground level	Herbaceous	▨	**25%**	**Forbs (senecio, aster, scarlet gilia, mullen)**	**65%**
				Grasses	**35%**
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**30%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Sediment from hillslope delivery - lots of rilling on south aspect

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, A4a+ Reference** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL COMBINATIONS that APPLY..............☞	**E1**	**E2**	**E8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, A4a+ Reference Reach**
Location: **Pike National Forest, Colorado**
Observers: **Chavez, Kasun & Gallagher**
Date: **9/3/2010**

Stream Size Category and Order ☞ **S-2(1)**

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 5-9. Meander patterns.

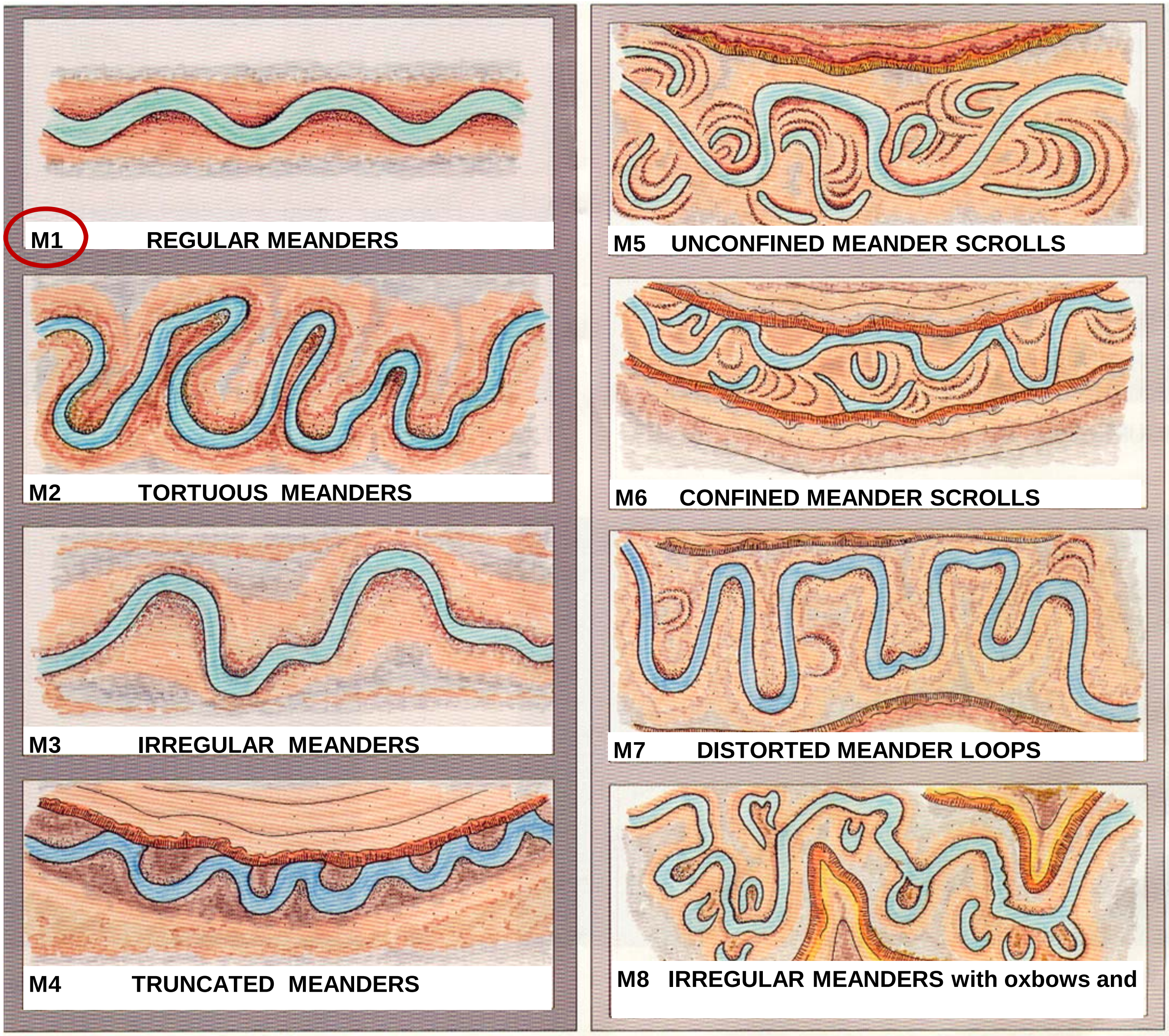
Meander Patterns

Stream: **Trail Creek, A4a+ Reference Reach** Location: **Pike National Forest, CO**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL CATEGORIES that APPLY ☞	**M1**				

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



Worksheet 5-10. Depositional patterns.

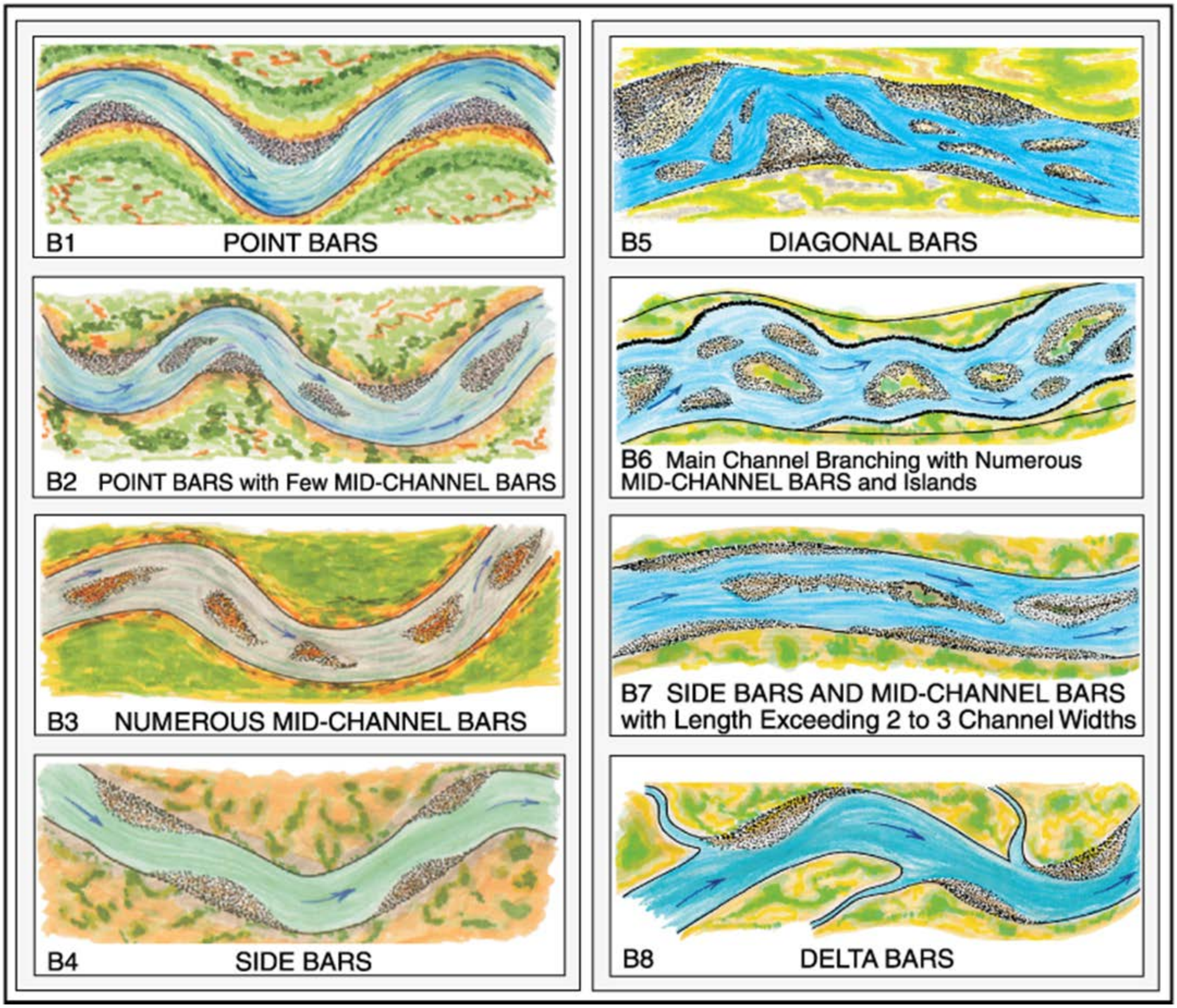
Depositional Patterns

Stream: **Trail Creek, A4a+ Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

List ALL CATEGORIES that APPLY ☞	**None**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages		
Stream: **Trail Creek, A4a+ Reference Reach**	Location: **Pike National Forest, Colorado**	
Observers: **Chavez, Kasun & Gallagher**	Date: **9/3/2010**	
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 5-12. Degree of channel incision.

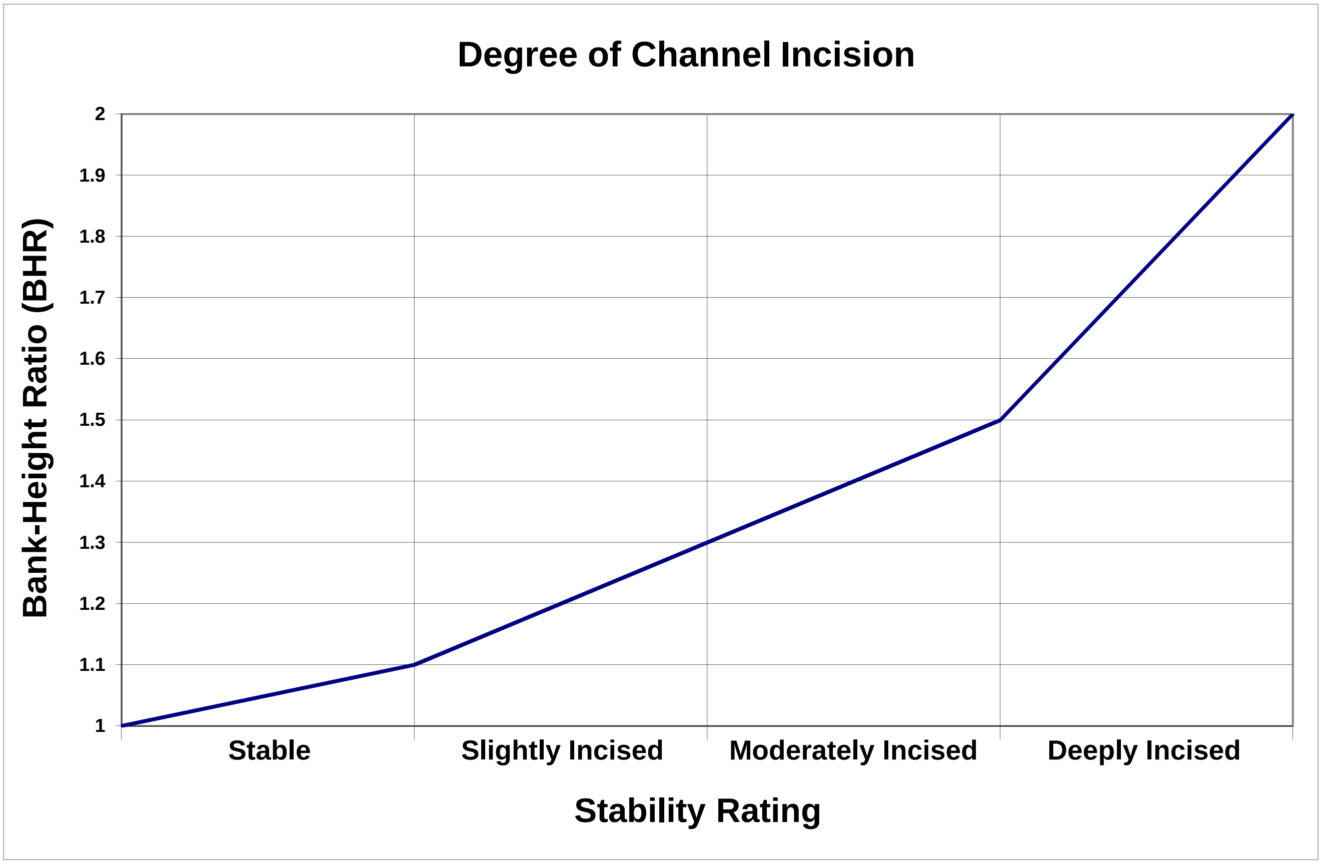
Degree of Channel Incision

Low Bank Height: **0.6**

Max Bankfull Depth: **0.2**

Bank-Height Ratio: **3.0**

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

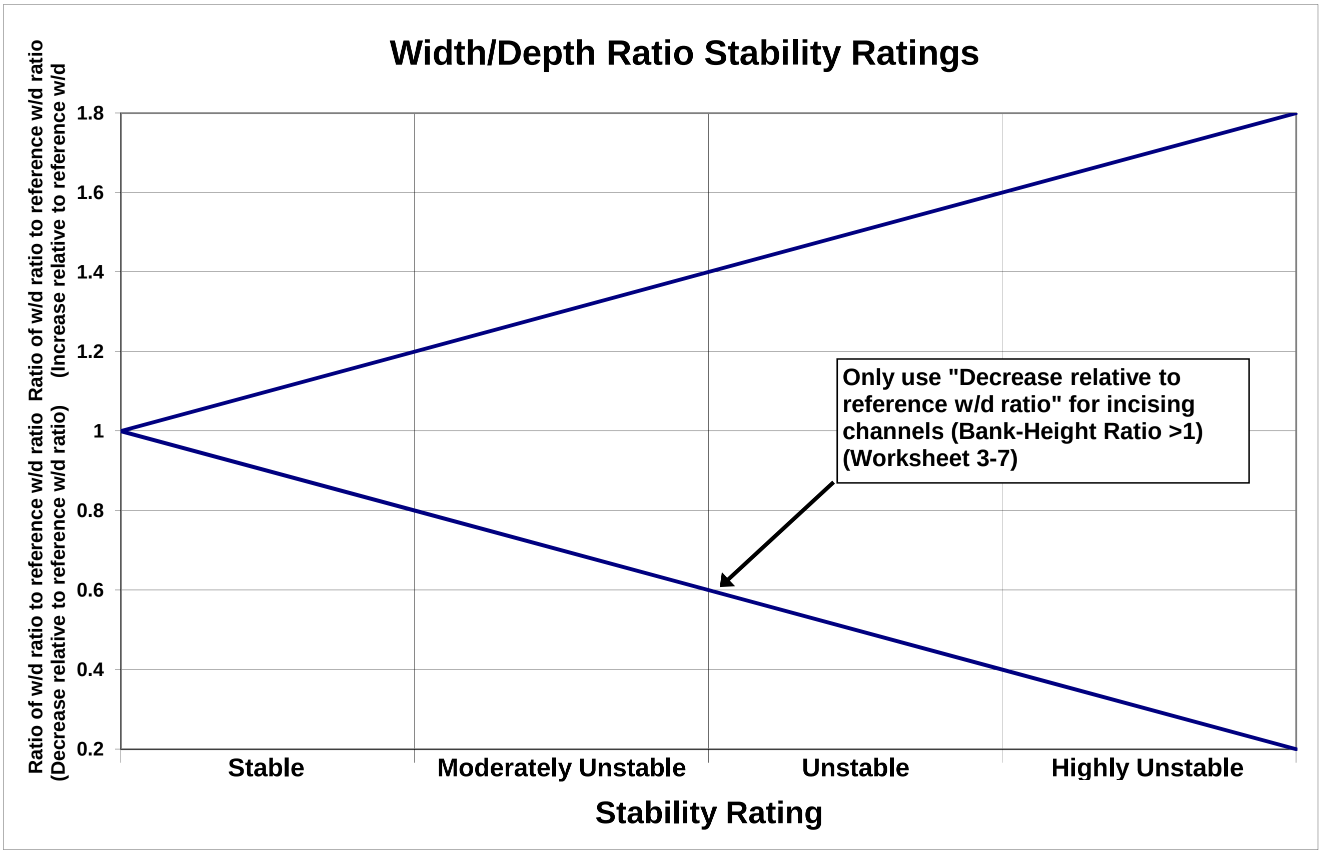


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	10.95	Ratio of existing W/d to reference W/d:	1.00
Reference Width/Depth Ratio:	10.95		

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

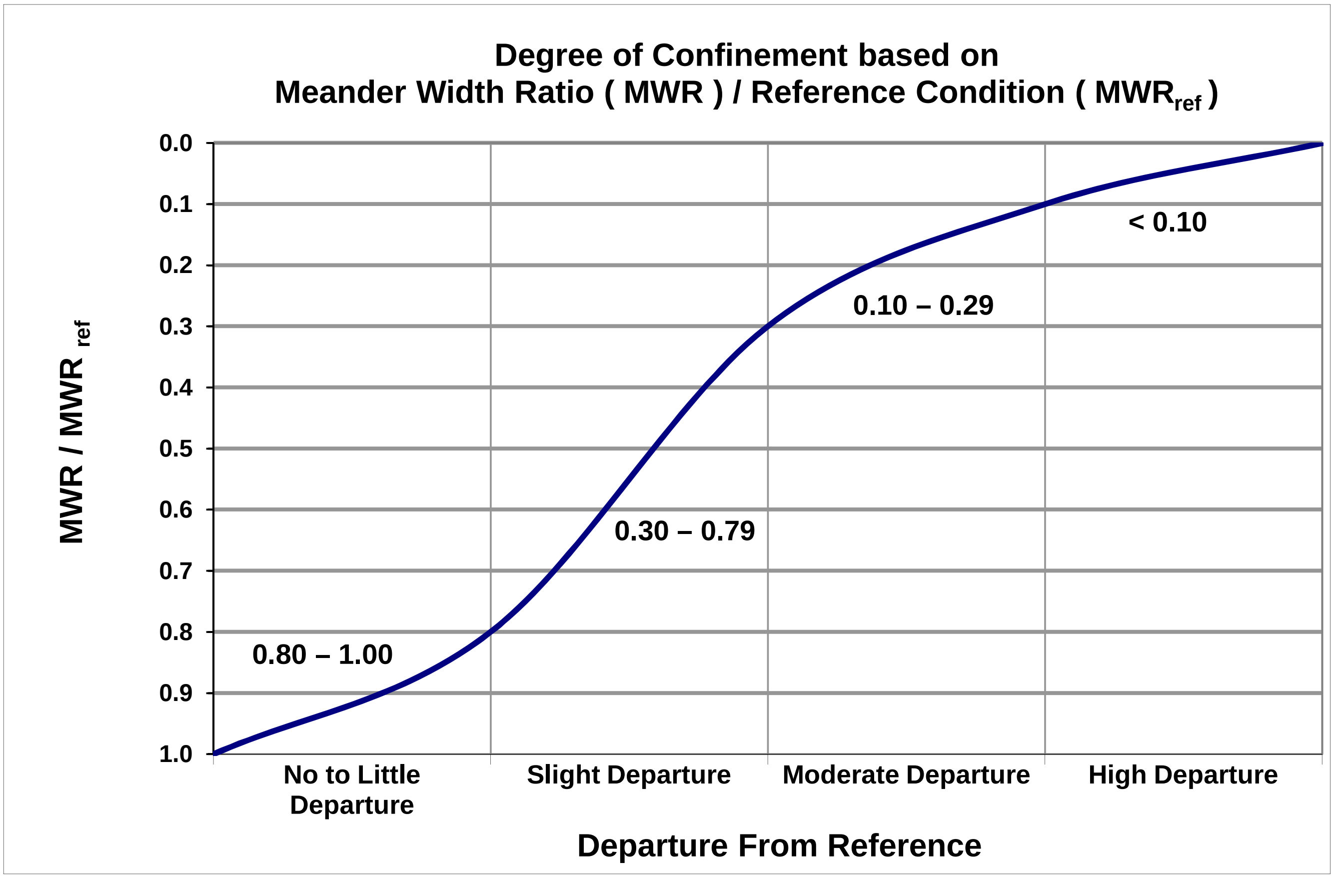


Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**1.52**	Ratio of MWR to MWR$_{ref}$:	**1.00**
Reference Meander Width Ratio (MWR$_{ref}$):	**1.52**		

Degree of Confinement Stability Rating ☞ **No Departure**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, A4a+ Reference **Location:** Pike National Forest **Valley Type:** I **Observers:** Chavez, Kasun & Gallagher **Date:** 9/3/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	[✓ 2]	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	[✓ 6]	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	[✓ 9]	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	[✓ 2]	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 2]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	[✓ 4]	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	[✓ 8]	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	[✓ 8]
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	[✓ 16]
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	[✓ 12]	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	**10**	**Good total =**	**30**	**Fair total =**	**9**	**Poor total =**	**40**

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	**89**
Existing stream type =	**A4a+**
***Potential stream type =**	**A4a+**
Modified channel stability rating =	**Good**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trail Creek, A4a+ Reference Reach** Location: **Pike National Forest, Colorado**

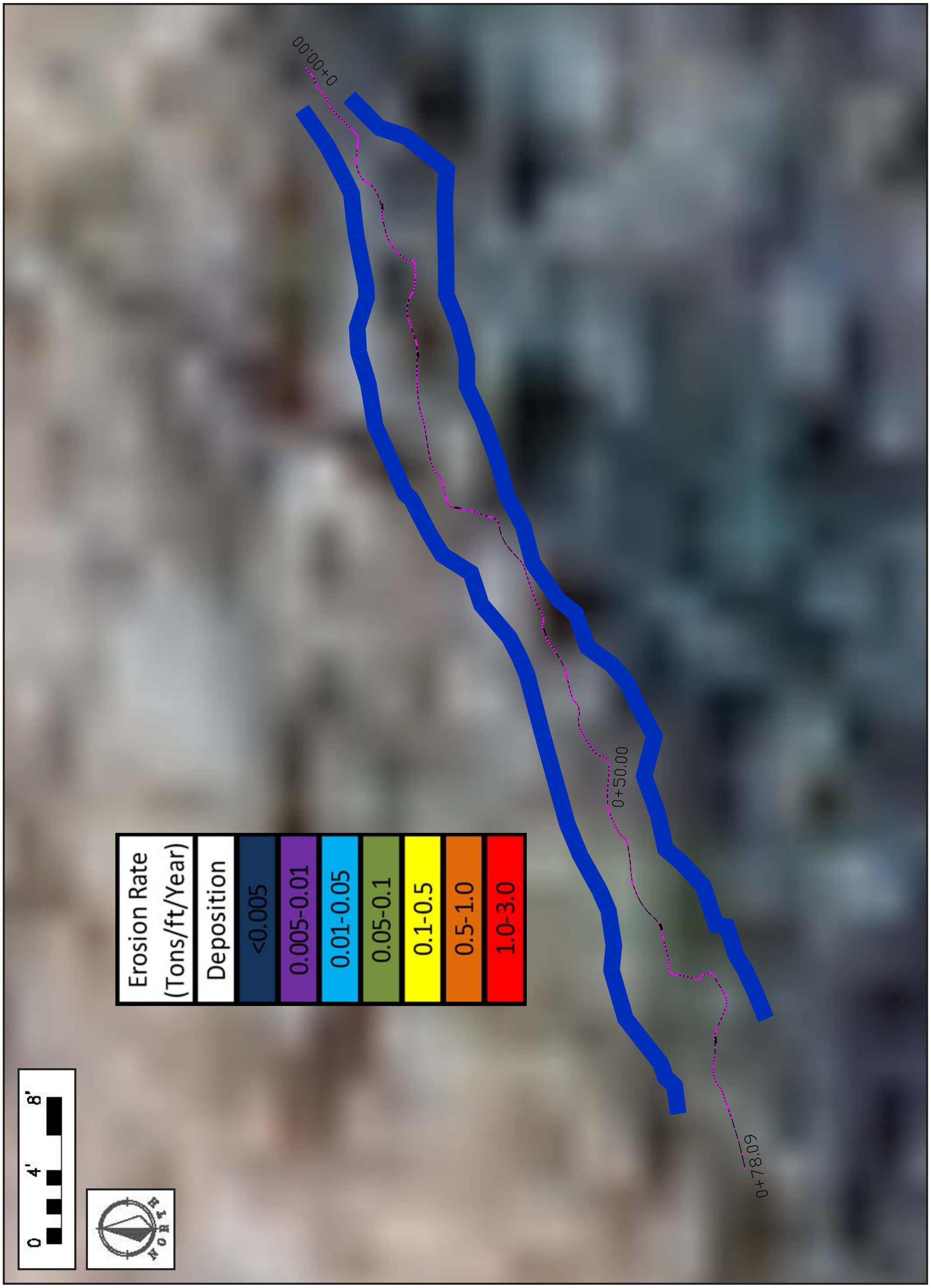
Graph Used: **Colorado** Total Stream Length (ft): **70** Date: **9/3/2010**

Observers: **Chavez, Kasun & Gallagher** Valley Type: **I** Stream Type: **A4a+**

(1) Station (ft)	(2) BEHI rating (Worksheet 5-16) (adjective)	(3) NBS rating (Worksheet 5-17) (adjective)	(4) Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. L 0+00 to 0+70	Low	Low	0.03566	70.0	0.5	1.25	0.00086
2. R 0+00 to 0+70	Low	Low	0.03566	70.0	0.5	1.25	0.00086
3.							
4.							
5.							
6.							
7.							
8							
9							
10							
11							
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total Erosion (ft^3/yr)	2.50
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	Total Erosion (yds^3/yr)	0.09
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	Total Erosion (tons/yr)	0.12
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	Total Erosion (tons/yr/ft)	0.0017

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**0.36**	**0.0013617**	**0.01405947**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	0.9													
0.10%	0.8	0.05%	0.09%	0.34	0.9	2.363	7.461	0.00	6.670	0.87	0.3	0.00	0.30	0.30
0.25%	0.7	0.08%	0.15%	0.55	0.7	2.036	5.232	0.00	4.809	0.62	0.4	0.00	0.34	0.34
0.50%	0.6	0.13%	0.25%	0.91	0.6	1.761	3.706	0.00	3.494	0.45	0.6	0.00	0.41	0.41
0.75%	0.5	0.13%	0.25%	0.91	0.5	1.513	2.592	0.00	2.502	0.32	0.5	0.00	0.30	0.30
1%	0.4	0.13%	0.25%	0.91	0.5	1.300	1.817	0.00	1.790	0.23	0.4	0.00	0.21	0.21
1.5%	0.4	0.25%	0.50%	1.83	0.4	1.120	1.289	0.00	1.289	0.17	0.7	0.00	0.31	0.31
2%	0.3	0.25%	0.50%	1.83	0.3	0.949	0.886	0.00	0.893	0.12	0.6	0.00	0.21	0.21
3%	0.3	0.50%	1.00%	3.65	0.3	0.795	0.600	0.00	0.602	0.08	1.0	0.00	0.28	0.28
4%	0.2	0.50%	1.00%	3.65	0.2	0.674	0.424	0.00	0.415	0.05	0.9	0.00	0.20	0.20
5%	0.2	0.50%	1.00%	3.65	0.2	0.587	0.322	0.00	0.304	0.04	0.8	0.00	0.14	0.14
10%	0.1	2.50%	5.00%	18.25	0.2	0.450	0.200	0.00	0.165	0.02	3.0	0.00	0.39	0.39
20%	0.1	5.00%	10.00%	36.50	0.1	0.269	0.103	0.00	0.045	0.01	3.5	0.00	0.22	0.22
30%	0.0	5.00%	10.00%	36.50	0.1	0.158	0.075	0.00	0.006	0.00	2.1	0.00	0.03	0.03
40%	0.0	5.00%	10.00%	36.50	0.0	0.108	0.068	0.00	0.000	0.00	1.4	0.00	0.00	0.00
50%	0.0	5.00%	10.00%	36.50	0.0	0.079	0.066	0.00	0.000	0.00	1.0	0.00	0.00	0.00
60%	0.0	5.00%	10.00%	36.50	0.0	0.061	0.065	0.00	0.000	0.00	0.8	0.00	0.00	0.00
70%	0.0	5.00%	10.00%	36.50	0.0	0.047	0.064	0.00	0.000	0.00	0.6	0.00	0.00	0.00
80%	0.0	5.00%	10.00%	36.50	0.0	0.039	0.064	0.00	0.000	0.00	0.5	0.00	0.00	0.00
90%	0.0	5.00%	10.00%	36.50	0.0	0.032	0.064	0.00	0.000	0.00	0.4	0.00	0.00	0.00
100%	0.0	5.00%	10.00%	36.50	0.0	0.016	0.064	0.00	0.000	0.00	0.2	0.00	0.00	0.00
									Annual Totals:		**19.8** (cfs) **39.3** (acre-ft)	**0.0** (tons/yr)	**3.3** (tons/yr)	**3.3** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**0.36**	**0.0013617**	**0.01405947**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**0.9**													
0.10%	**0.8**	**0.05%**	**0.09%**	**0.34**	**0.9**	**2.383**	**7.614**	**0.00**	**6.796**	**0.88**	**0.3**	**0.00**	**0.30**	**0.30**
0.25%	**0.7**	**0.08%**	**0.15%**	**0.55**	**0.7**	**2.056**	**5.356**	**0.00**	**4.914**	**0.64**	**0.4**	**0.00**	**0.35**	**0.35**
0.50%	**0.6**	**0.13%**	**0.25%**	**0.91**	**0.6**	**1.781**	**3.807**	**0.00**	**3.582**	**0.46**	**0.6**	**0.00**	**0.42**	**0.42**
0.75%	**0.5**	**0.13%**	**0.25%**	**0.91**	**0.6**	**1.533**	**2.673**	**0.00**	**2.576**	**0.33**	**0.5**	**0.00**	**0.30**	**0.31**
1%	**0.4**	**0.13%**	**0.25%**	**0.91**	**0.5**	**1.320**	**1.883**	**0.00**	**1.852**	**0.24**	**0.4**	**0.00**	**0.22**	**0.22**
1.5%	**0.4**	**0.25%**	**0.50%**	**1.83**	**0.4**	**1.140**	**1.343**	**0.00**	**1.340**	**0.17**	**0.7**	**0.00**	**0.32**	**0.32**
2%	**0.3**	**0.25%**	**0.50%**	**1.83**	**0.3**	**0.969**	**0.927**	**0.00**	**0.934**	**0.12**	**0.6**	**0.00**	**0.22**	**0.22**
3%	**0.3**	**0.50%**	**1.00%**	**3.65**	**0.3**	**0.815**	**0.633**	**0.00**	**0.635**	**0.08**	**1.1**	**0.00**	**0.30**	**0.30**
4%	**0.2**	**0.50%**	**1.00%**	**3.65**	**0.2**	**0.693**	**0.449**	**0.00**	**0.442**	**0.06**	**0.9**	**0.00**	**0.21**	**0.21**
5%	**0.2**	**0.50%**	**1.00%**	**3.65**	**0.2**	**0.604**	**0.340**	**0.00**	**0.324**	**0.04**	**0.8**	**0.00**	**0.15**	**0.15**
10%	**0.1**	**2.50%**	**5.00%**	**18.25**	**0.2**	**0.463**	**0.210**	**0.00**	**0.176**	**0.02**	**3.0**	**0.00**	**0.42**	**0.42**
20%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.274**	**0.105**	**0.00**	**0.048**	**0.01**	**3.6**	**0.00**	**0.23**	**0.23**
30%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.1**	**0.159**	**0.075**	**0.00**	**0.007**	**0.00**	**2.1**	**0.00**	**0.03**	**0.03**
40%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.108**	**0.068**	**0.00**	**0.000**	**0.00**	**1.4**	**0.00**	**0.00**	**0.00**
50%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.079**	**0.066**	**0.00**	**0.000**	**0.00**	**1.0**	**0.00**	**0.00**	**0.00**
60%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.061**	**0.065**	**0.00**	**0.000**	**0.00**	**0.8**	**0.00**	**0.00**	**0.00**
70%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**0.6**	**0.00**	**0.00**	**0.00**
80%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**0.5**	**0.00**	**0.00**	**0.00**
90%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**0.4**	**0.00**	**0.00**	**0.00**
100%	**0.0**	**5.00%**	**10.00%**	**36.50**	**0.0**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**0.2**	**0.00**	**0.00**	**0.00**
									Annual Totals:		**20.1** (cfs) **39.9** (acre-ft)	**0.0** (tons/yr)	**3.5** (tons/yr)	**3.5** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, A4a+ Reference Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

Enter Required Information for Existing Condition

13.0	D_{50}	Riffle bed material D_{50} (mm) **NOTE: Used D_{84}**			
N/A	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.84	D_{max}	Largest particle from **BED MATERIAL** (ft)	**256**	**(mm)**	304.8 mm/ft
0.198	S	Existing bankfull water surface slope (ft/ft)			
0.21	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

2.595		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 **200**	CO **300**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **2**	CO **3.3**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **0.16**	CO **0.27**	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 **0.1526**	CO **0.2518**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, A4a+ Reference** Stream Type: **A4a+**

Location: **Pike National Forest, CO** Valley Type: **I**

Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, A4a+ Reference Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

	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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**2**
		1.0 [✓ (2)]	(4)	(6)	(8)	
2	**Depositional Patterns (Worksheet 5-10)**	B1, B2	B4, B8	B3	B5, B6, B7	**0**
		[✓ **None**] (1)	(2)	(3)	(4)	
3	**Meander Patterns (Worksheet 5-9)**	**M1**, M3, M4		M2, M5, M6, M7, M8		**1**
		M1 [✓ (1)]		(3)		
4	**Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, **L/L**, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
		L/L [✓ (2)]	(4)	(6)	(8)	
5	**Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
		1.0 [✓ (1)]	(2)	(3)	(4)	
					Total Points	**6**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Trail Creek, A4a+ Reference Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
	Ref. Reach [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	1.0 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	**Current stream type at potential** or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, B4	B3, B5	B6, B7, B8	**0**
	[✓ **None**] **(1)**	**(2)**	**(3)**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D2 [✓ **(1)**]	**(2)**	**(3)**	**(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 **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, A4a+ Reference Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Galagher**	Date:	**9/3/2010**

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 5-22)**	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**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	Ref. Reach [✓ (2)]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**8**
	(2)	**(4)**	**(6)**	**3.00 [✓ (8)]**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.00 [✓ (1)]	**(2)**	**(3)**	**(4)**	
				Total Points	**15**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☐	***Slightly Incised*** **12 – 18** ☑	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, A4a+ Reference Reach** Stream Type: **A4a+**
Location: **Pike National Forest, Colorado** Valley Type: **I**
Observers: **Chavez, Kasun & Gallagher** Date: **9/3/2010**

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 5-24)**	**Stream Type at Potential**, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **at potential** [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* [✓ **(2)**]	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*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*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, A4a+ Reference Reach**	Stream Type:	**A4a+**
Location:	**Pike National Forest, Colorado**	Valley Type:	**I**
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	[✓ 1]	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	1	2
	Slightly Incised	[✓ 2]	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	[✓ 1]	1
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	[✓ 1]	1
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	**6**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☑	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, A4a+ Reference Reach**	Location:	**Pike National Forest, Colorado**											
Observers:	**Chavez, Kasun & Gallagher**	Date:	**9/3/2010**	Stream Type:	**A4a+**	Valley Type:	**I**							
Channel Dimension (XS 0+15.62)	Mean Bankfull Depth (ft):	**0.21**	Bankfull Width (ft):	**2.3**	Cross-Sectional Area (ft^2):	**0.48**	Width of Flood-Prone Area (ft):	**3.65**	Entrenchment Ratio:	**1.59**				
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**N/A**	L_m/W_{bkf}:	**N/A**	R_c/W_{bkf}:	**N/A**	MWR:	**1.52**	Sinuosity:	**1.11**			
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed									
	Max Bankfull Depth (ft):	Riffle	Pool	Depth Ratio (max to mean):	Riffle	Pool	Pool-to-Pool Spacing:	Ratio	Slope					
		0.38			**1.52**				Valley:	**0.220**	Water Surface:	**0.198**		
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density:	Potential Composition/Density:	Remarks: Condition, Vigor & Usage of Existing Reach:										
		Aspen, Forbs, Grasses	**Same w/o Invasives**	**Some rilling from south aspects**										
	Flow Regime:	**E1, E2, E8**	Stream Size & Order:	**S-2(1)**	Meander Patterns:	**M1**	Depositional Patterns:	**None**	Debris/Channel Blockages:	**D2 Infrequent**				
	Degree of Incision (Bank-Height Ratio):	**3.0**	Degree of Incision Stability Rating:	**Deeply Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**89 (Good)**								
	Width/depth Ratio (W/d):	**11**	Reference W/d Ratio (W/d_{ref}):	**11**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**1.0**	W/d Ratio State Stability Rating:	**Stable**						
	Meander Width Ratio (MWR):	**1.52**	Reference MWR_{ref}:	**1.52**	Degree of confinement (MWR / MWR_{ref}):	**1.0**	MWR / MWR_{ref} Stability Rating:	**No Departure**						
Bank Erosion Summary	Length of Reach Studied (ft):	**70**	Annual Streambank Erosion Rate:	**0.12** (tons/yr)	**0.0017** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:						
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks:										
Entrainment/ Competence	Largest Particle from **Bed Material** (mm):	**256**	$\tau =$	**2.6**	$\tau^* =$	**N/A**	Existing Depth:	**0.21**	Required Depth:	**0.16-0.27**	Existing Slope:	**0.198**	Required Slope:	**0.15-0.25**
Successional Stage Shift	**A4a+** →	**A4a+** →	→	→	→	Existing Stream State (Type):	**A4a+**	Potential Stream (Type):	**A4a+**					
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:									
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:									
Vertical Stability (Degradation)	☐ *Not Incised*	☑ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Because of BHR of 3.0**								
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:									
Sediment Supply (Channel Source)	☐ *Low*	☑ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:	**Because of BHR of 3.0**								

Appendix C17

A4/2 Stream Type

Reference Reach

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Appendix C17: A4/2 Reference Reach

A4/2 Reference Reach Location & Overview

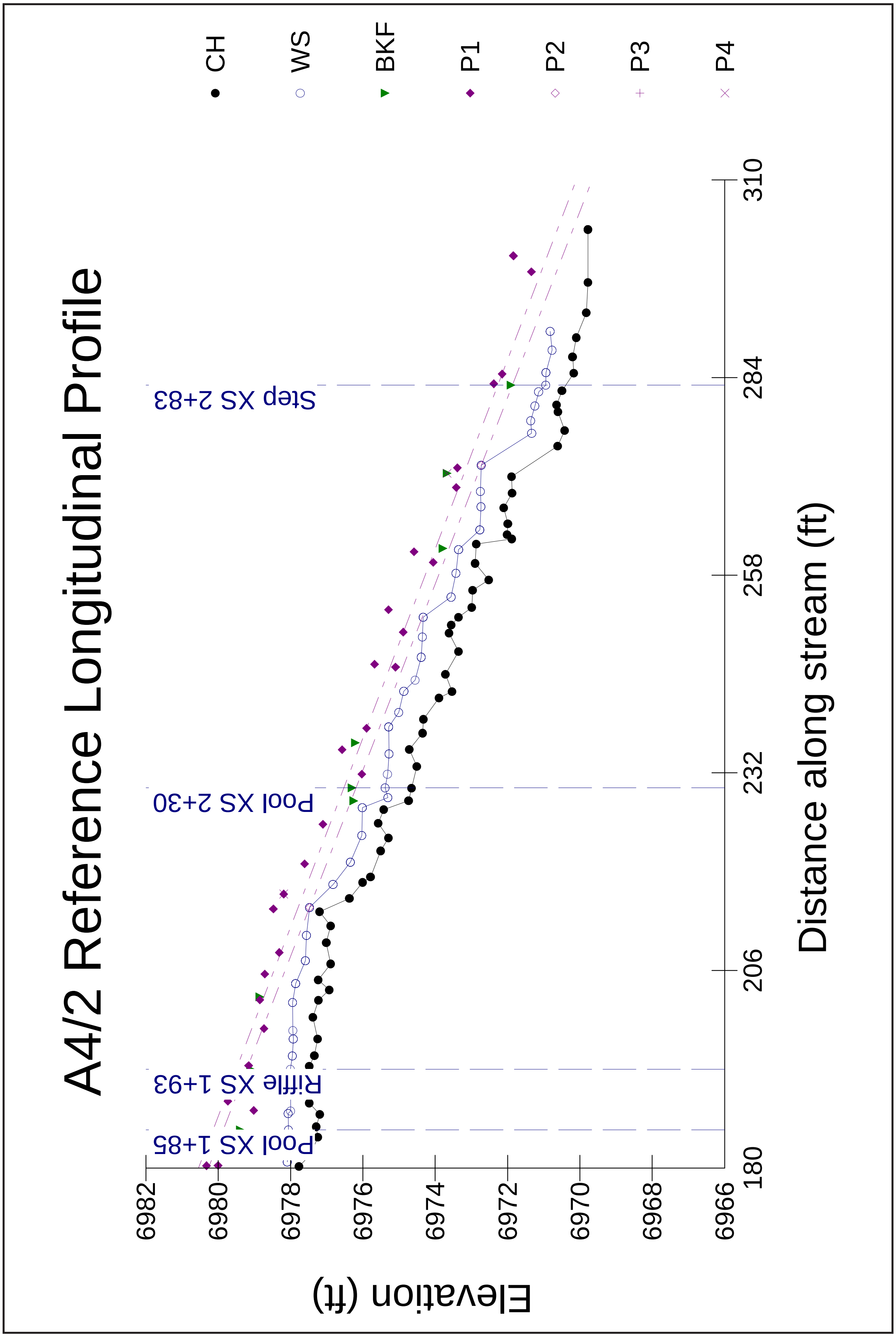
The A4/2 reference reach is in a Valley Type VIIIb located on the mainstem of West Monument Creek (see location map in **Figure C-1**). This reach is dominated by gravel and influenced by boulders. The channel bed and banks show little sediment yield and good stability from abundant vegetation and boulders. Bed features are generally dominated by step/pools. The channel is perennial and streamflow is seasonal by snowmelt and stormflow runoff. Flow is regulated by an upstream dam and is altered due to the Waldo Canyon Fire. The reach is a 4th order channel.

Typical of A stream types, the channel is entrenched and has a low width/depth ratio with a relatively straight pattern having a sinuosity of 1.05. Little channel source sediment is generated from this stream during high runoff events due to good riparian vegetation. The predicted streambank erosion rate of *0.0076 tons/yr/ft* represents an acceptable geologic rate (**Worksheet 5-18**).

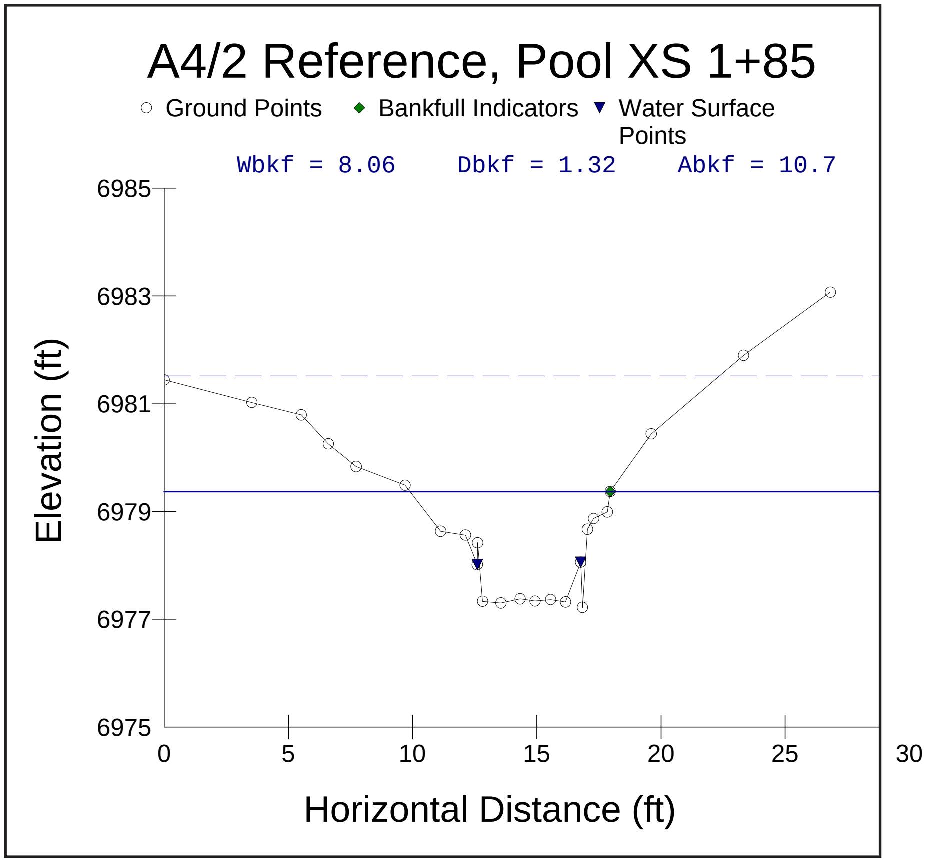
The photograph depicts the stable characteristics of this stream type. Such stream types are mapped where they occur by sub-watershed as shown in **Appendix D**.

The details of the dimension, pattern, profile, and materials are summarized. The following summary worksheets provide details of the morphology, hydraulics, stability, and streambank erosion rates for this reference reach. In the situation where impaired A4/2 stream types are located, an alternative for mitigation and sediment reduction is to use the data from the stable form to extrapolate for potential implementation of natural channel design.

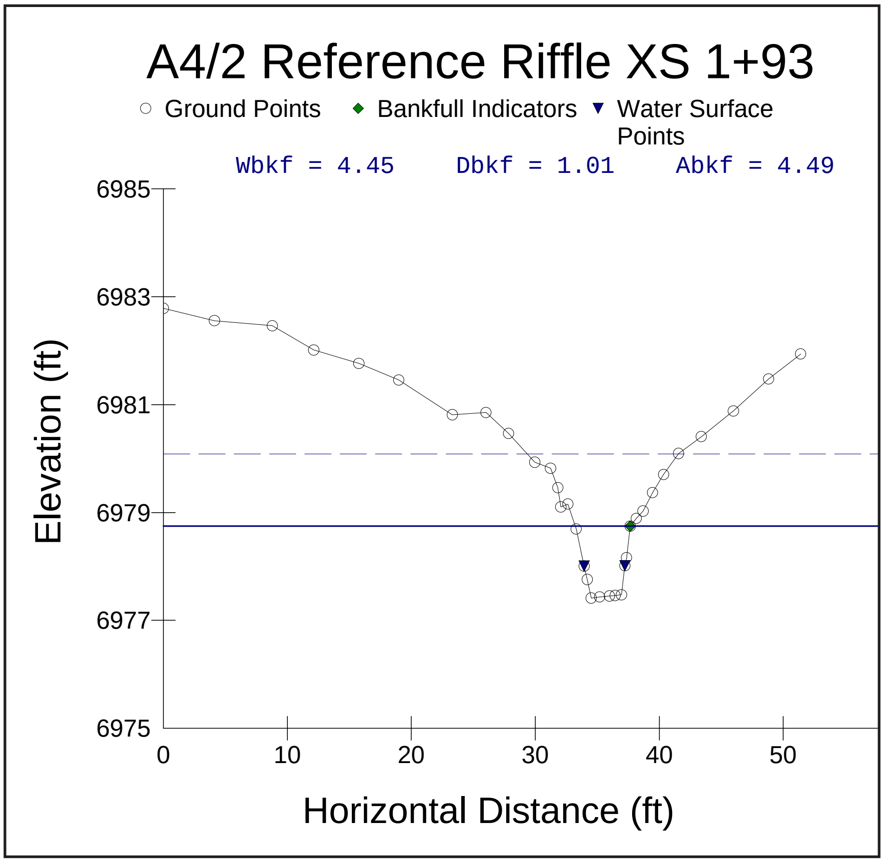
Survey Summary



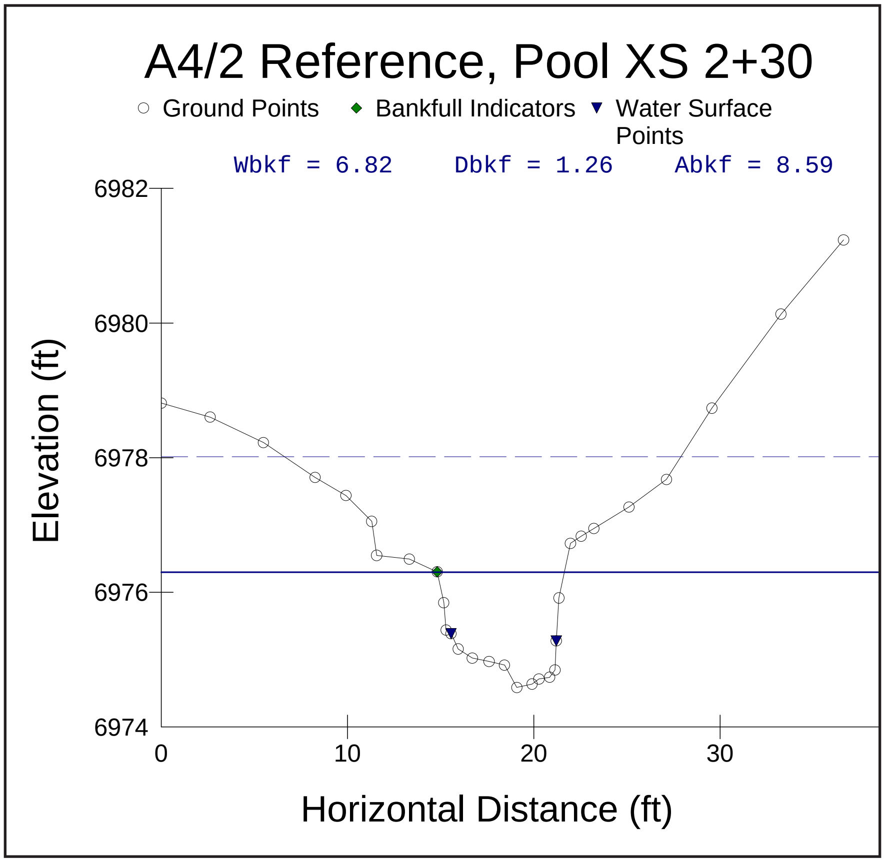
Longitudinal Profile (graph generated from RIVERMorph™)



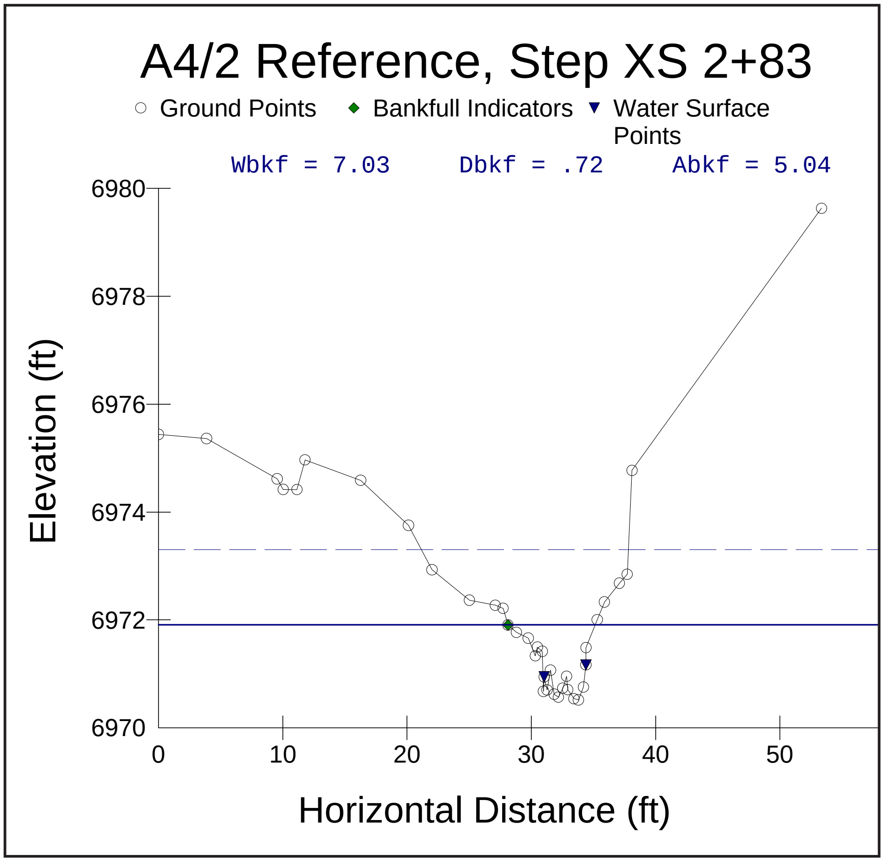
Cross-section 1+85 (graph generated from RIVERMorph^{TM})



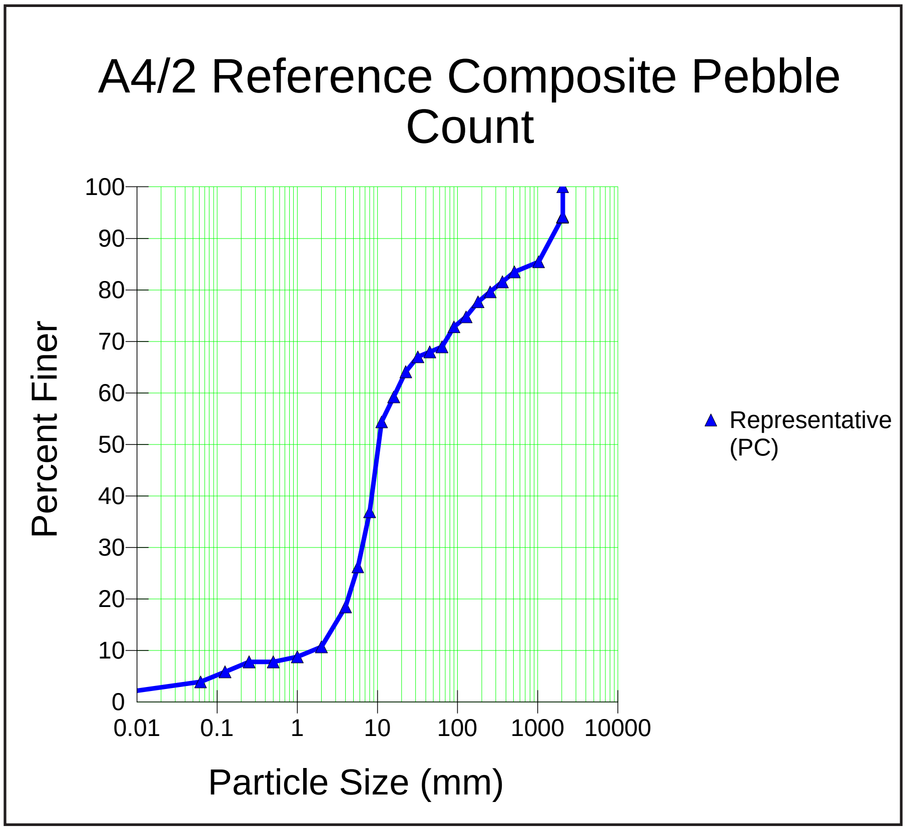
Cross-section 1+93 (graph generated from RIVERMorph^{TM})



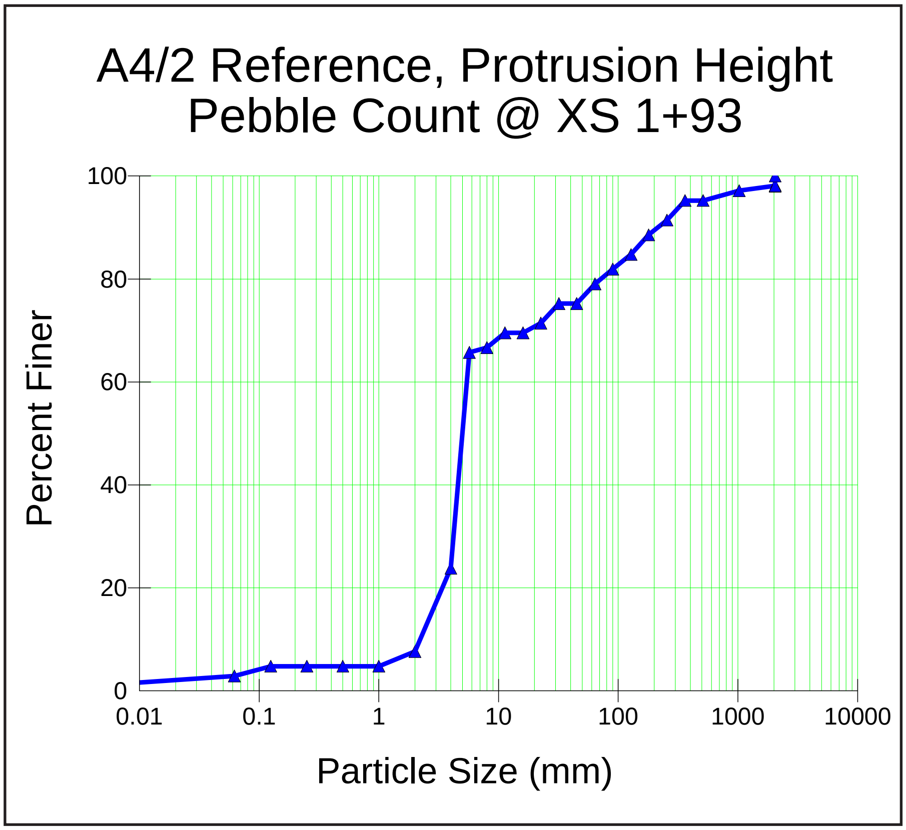
Cross-section 2+30 (graph generated from RIVERMorph^{TM})



Representative Cross-section 2+83 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Protrusion Height Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**West Monument A4/2 Reference**			Location:	**XS 2+83, Pike N.F., Colorado**
Date:	**11/6/2012**	Stream Type:	**A4/2**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**			HUC:	__ __ | __ __ | __ __ | __ __ | __ __ | __ __ | __ __ | __ __ | __ __ | __ __ | __ __

INPUT VARIABLES			**OUTPUT VARIABLES**		
Bankfull Riffle Cross-Sectional AREA	**5.04**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.72**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**7.0**	**W_{bkf}** (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**8.47**	**W_p** (ft)
D_{84} at Riffle	**224.9**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.74**	**D_{84}** (ft)
Bankfull SLOPE	**0.08**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.60**	**R** (ft)
Gravitational Acceleration	**32.2**	**g** (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**0.81**	**R / D_{84}**
Drainage Area	**10.95**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**1.247**	**u*** (ft/sec)

ESTIMATION METHODS	**Bankfull VELOCITY**		**Bankfull DISCHARGE**	
1. Friction Factor / Relative Roughness $u = [\,2.83 + 5.66 * Log\,\{\,R / D_{84}\,\}\,]\,u^*$	**2.31**	ft / sec	**11.64**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.09**	**3.05**	ft / sec	**15.37**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.15**	**1.83**	ft / sec	**9.22**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.167** **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	**1.65**	ft / sec	**8.32**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**3.80**	ft / sec	**19.2**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves **u = Q / A** **Return Period for Bankfull Discharge** **Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data **u = Q / A**		ft / sec		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 5-3. Level II stream classification.

Stream: **West Monument A4/2 Reference**

Basin: Drainage Area: **7011** acres **10.95** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 2+83** Date: **11/06/2012**

Observers: **Lee, Sumner, Jara, Leah** Valley Type: **VIIIb**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**7.03**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.72**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**5.04**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.76**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.39**	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.	**16.64**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.37**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**10.48**	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.	**0.08113**	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 (S_{val} / S).	**1.05**	

Stream Type → **A4/2** ← **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument A4/2 Reference** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/06/12** Valley Type: **VIIIb** Stream Type: **A4/2**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	**5.7**	**4.5**	**7.0**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**4.8**	**4.5**	**5.0**
Mean Riffle Depth (d_{bkf})	**0.87**	**0.72**	**1.01**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**7.1**	**4.4**	**9.8**
Maximum Riffle Depth (d_{max})	**1.37**	**1.34**	**1.39**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.629**	**1.327**	**1.931**
Width of Flood-Prone Area (W_{fpa})	**14.4**	**12.2**	**16.6**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	**2.6**	**2.4**	**2.7**
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	**7.4**	**6.8**	**8.1**	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	**1.296**	**1.188**	**1.404**
Mean Pool Depth (d_{bkfp})	**1.29**	**1.26**	**1.32**	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	**1.483**	**1.448**	**1.517**
Pool Cross-Sectional Area (A_{bkfp})	**9.6**	**8.6**	**10.7**	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	**2.019**	**1.801**	**2.243**
Maximum Pool Depth (d_{maxp})	**1.94**	**1.72**	**2.15**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.230**	**1.977**	**2.471**
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument A4/2 Reference** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/6/2012** Valley Type: **VIIIb** Stream Type: **A4/2**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**2.31**	ft/sec	Estimation Method	**Friction Factor**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**11.64**	cfs	Drainage Area	**10.95**	mi^2

Channel Pattern

Geometry	**Mean**	**Min**	**Max**		**Dimensionless Geometry Ratios**	**Mean**	**Min**	**Max**
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**14.4**	**12.5**	**18.1**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**2.51**	**2.18**	**3.15**
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)	**6.6**	**4.5**	**8.7**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**1.15**	**0.78**	**1.52**
Individual Pool Length (L_p)	**6.7**	**3.6**	**9.2**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.16**	**0.62**	**1.60**
Pool to Pool Spacing (P_s)	**16.0**	**8.7**	**26.5**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**2.79**	**1.51**	**4.62**

Channel Profile

Valley Slope (S_{val})	**0.0852**	ft/ft	Average Water Surface Slope (S)	**0.0811**	ft/ft	Sinuosity (S_{val} / S)	**1.05**
Stream Length (SL)	**172.0**	ft	Valley Length (VL)	**141.0**	ft	Sinuosity (SL / VL)	**1.23**

Low Bank Height (LBH)	start	**1.58**	ft	Max Bankfull Depth (d_{max})	start	**1.35**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	**1.2**
	end	**2.77**	ft		end	**1.97**	ft		end	**1.4**

Facet Slopes	**Mean**	**Min**	**Max**		**Dimensionless Facet Slope Ratios**	**Mean**	**Min**	**Max**
Riffle Slope (S_{rif})	**0.1180**	**0.0870**	**0.1490**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.4545**	**1.0724**	**1.8366**
Run Slope (S_{run})				ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	**0.0080**	**0.0000**	**0.0200**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.0986**	**0.0000**	**0.2465**
Glide Slope (S_g)				ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)			
Step Slope (S_s)	**0.3380**	**0.2300**	**0.5110**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**4.1662**	**2.8350**	**6.2985**

Max Depths[a]	**Mean**	**Min**	**Max**		**Dimensionless Depth Ratios**	**Mean**	**Min**	**Max**
Max Riffle Depth (d_{max})	**2.20**	**2.16**	**2.23**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**2.529**	**2.483**	**2.563**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})	**2.34**	**2.01**	**2.75**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.690**	**2.310**	**3.161**
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})	**2.12**	**1.97**	**2.33**	ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})	**2.437**	**2.264**	**2.678**

Channel Materials

	Reach[b]	**Riffle**[c]	**Bar**		**Reach**[b]	**Riffle**[c]	**Bar**	**Protrusion Height**[d]	
% Silt/Clay	**3.88**	**0.00**		D_{16}	**3.37**	**7.26**			mm
% Sand	**6.80**	**1.02**		D_{35}	**7.59**	**32.56**			mm
% Gravel	**58.25**	**51.02**		D_{50}	**10.48**	**60.20**			mm
% Cobble	**10.68**	**35.72**		D_{84}	**6.44**	**224.91**			mm
% Boulder	**14.56**	**12.24**		D_{95}	**Bedrock**	**870.07**			mm
% Bedrock	**5.83**	**0.00**		D_{100}	**Bedrock**	**2047.97**			mm

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **West Monument A4/2 Reference**

Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah**

Reference reach ☒ Disturbed (impacted reach) ☐

Date: **11/06/2012**

Existing species composition: **Aspen, Spruce, Ponderosa, Willow, Choke Cheery, Dogwood, rose, grass, forb**

Potential species composition: **Species at Potential**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**45%**	**45%**	**Aspen**	**45%**
				spruce	**50%**
				ponderosa	**5%**
					0%
					0%
					0%
					100%
2. Understory	Shrub layer	▨	**30%**	**willow**	**80%**
				choke cherry	**10%**
				dogwood	**2%**
				rose	**8%**
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	**10%**	**Grass**	**50%**
				forbes	**50%**
					0%
					0%
					0%
					0%
					100%
	Leaf or needle litter	▨	**5%**		
	Bare ground	▨	**10%**		
			Column Total = 100%		

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

Remarks:
Condition, vigor and/or usage of existing reach:
vigorous riparian vegetation density

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **West Monument A4/2 Reference** Location: **Pike National Forest, Colorado**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/6/2012**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P7**	**P8**				

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **West Monument A4/2 Reference**
Location: **Pike National Forest, Colorado**
Observers: **Lee, Sumner, Jara, Leah**
Date: **11/6/2012**

Stream Size Category and Order ☞ **S-3(4)**

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 5-9. Meander patterns.

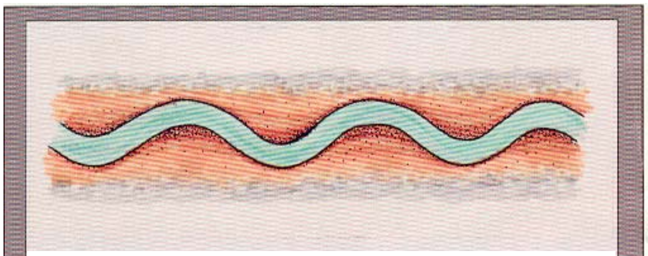
Meander Patterns

Stream: **West Monument A4/2 Reference** Location: **Pike National Forest, CO**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/6/2012**

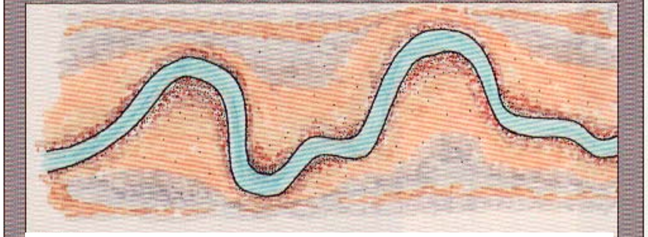
List ALL CATEGORIES that APPLY ☞	**N/A**				

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

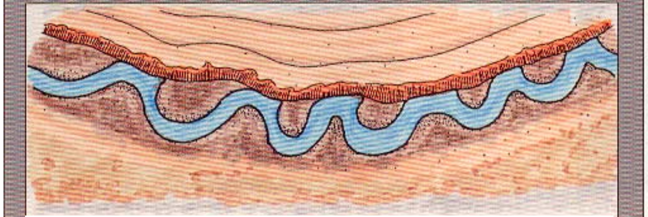


M1 REGULAR MEANDERS

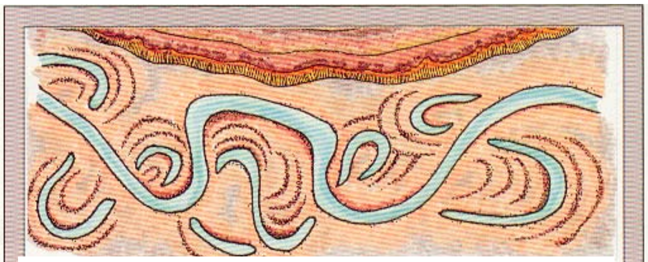
M2 TORTUOUS MEANDERS



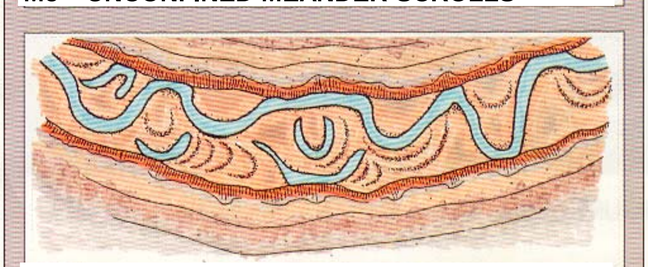
M3 IRREGULAR MEANDERS



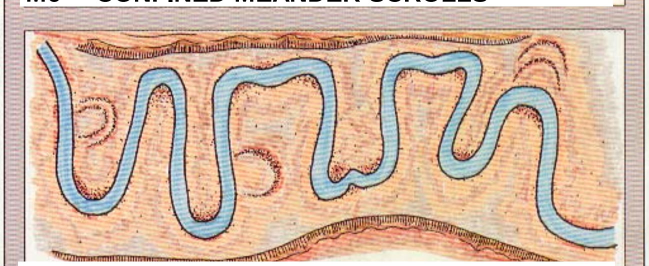
M4 TRUNCATED MEANDERS



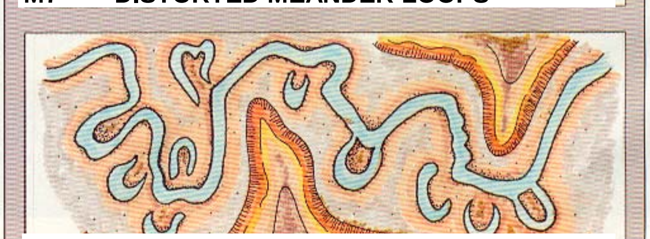
M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS



M8 IRREGULAR MEANDERS with oxbows and oxbow cutoffs

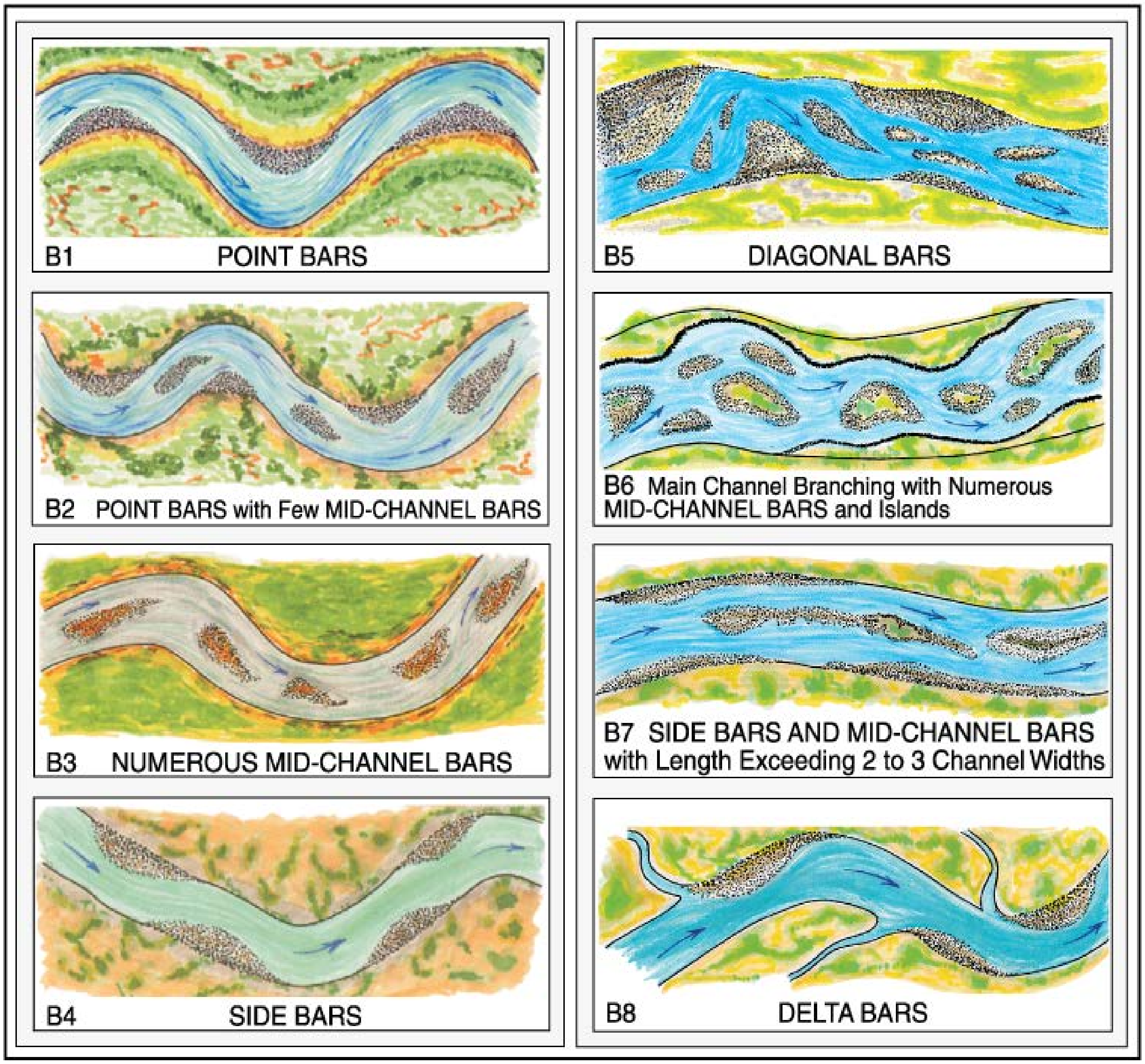
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**West Monument A4/2 Reference**	Location:	**Pike National Forest, CO**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/6/2012**

List ALL CATEGORIES that APPLY ☞	**NA**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages		
Stream: **West Monument A4/2 Reference**	Location: **Pike National Forest, Colorado**	
Observers: **Lee, Sumner, Jara, Leah**	Date: **11/6/2012**	
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.	☐

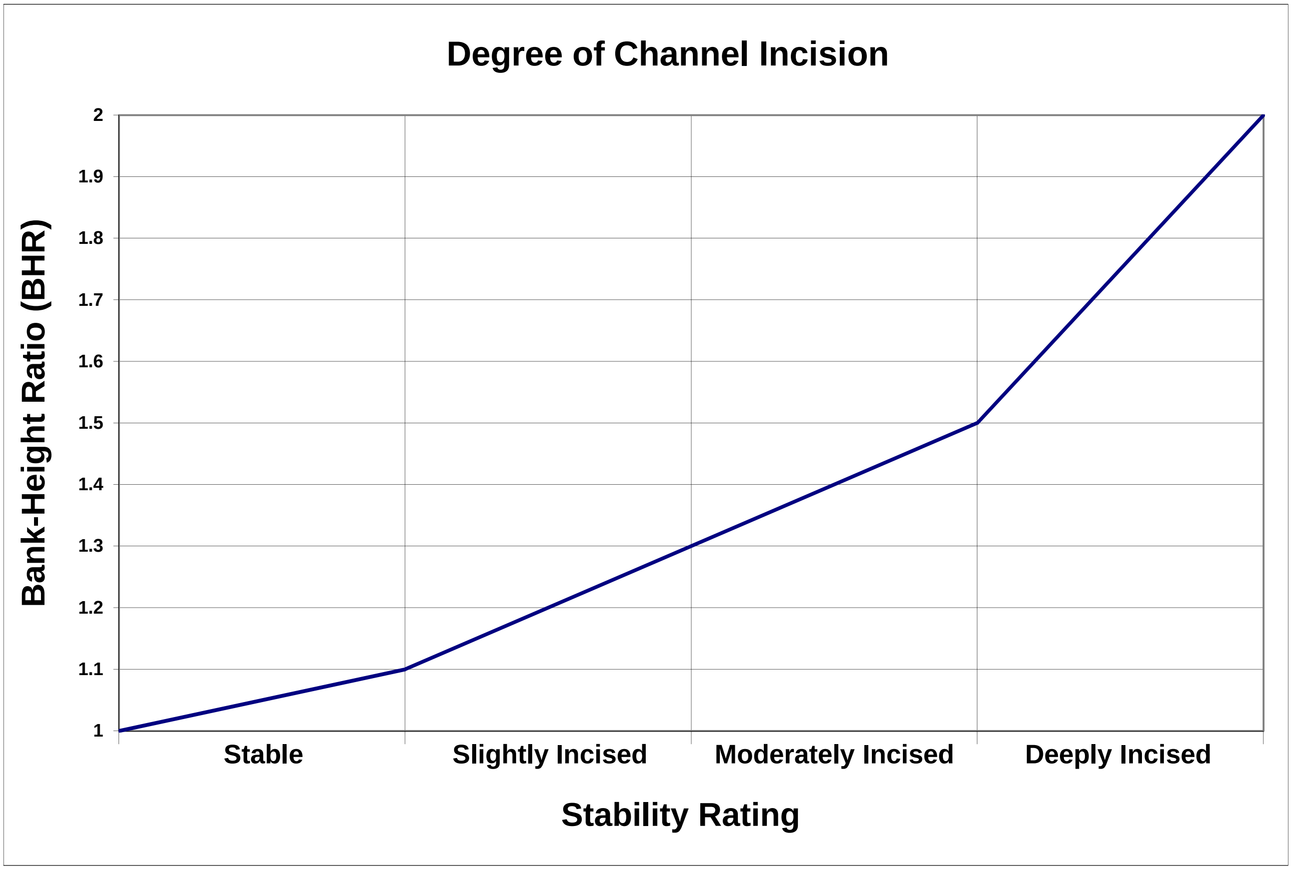
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**1.58**
Max Bankfull Depth:	**1.35**

Bank-Height Ratio:	**1.2**

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



Worksheet 5-13. Width/depth ratio state.

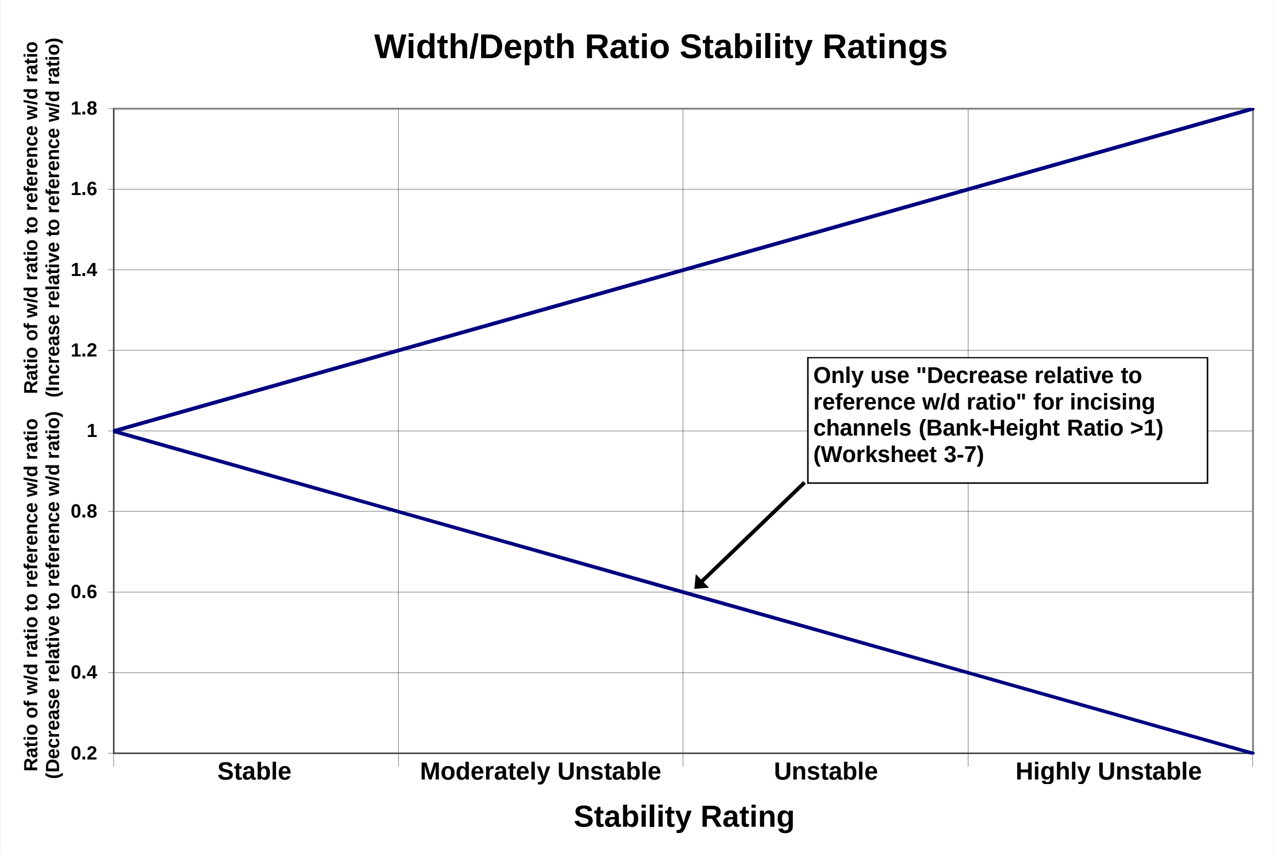
Width/Depth Ratio State

Existing Width/Depth Ratio: **4.41**

Reference Width/Depth Ratio: **4.41**

Ratio of existing W/d to reference W/d: **1.00**

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



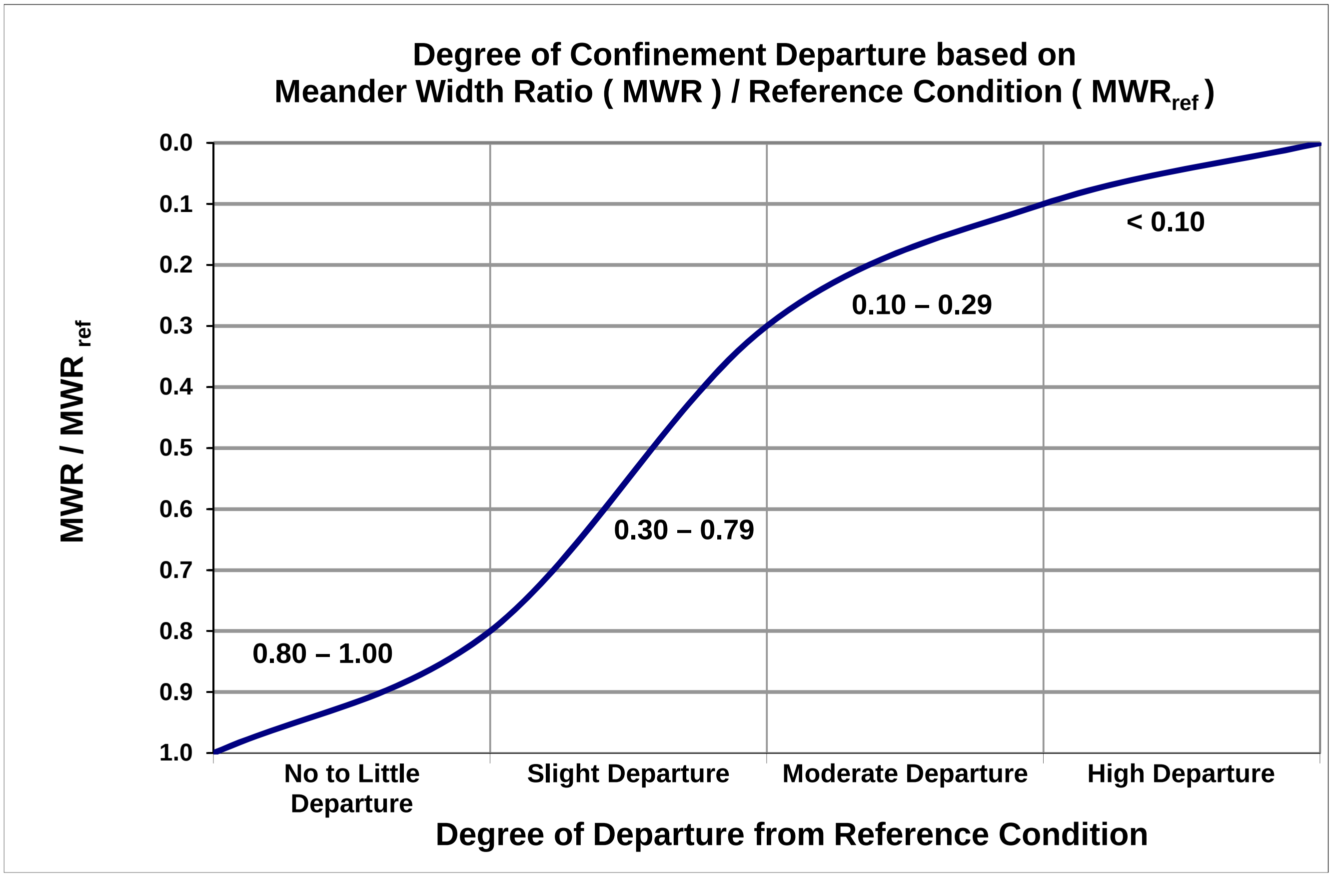
Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**2.51**	Ratio of MWR to MWR_{ref}:	**1.00**
Reference Meander Width Ratio (MWR_{ref}):	**2.51**		

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: West Monument A4/2 **Location:** Pike National Forest, CO **Valley Type:** VIIIb **Observers:** Lee, Sumner, Jara, Leah **Date:** 11/8/2012

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	[✓ 6]	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	[✓ 3]	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 4]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	[✓ 3]	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	[✓ 2]	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 4]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	[✓ 4]	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	[✓ 8]	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	[✓ 3]	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	[✓ 3]	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	[✓ 5]	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	[✓ 10]	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	[✓ 16]	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	[✓ 2]	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	13	Good total =	44	Fair total =	17	Poor total =	0

Stream type	A1	A2	A3	[✓ A4]	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	74
Existing stream type =	A2/4
*Potential stream type =	A2/4
Modified channel stability rating =	Good

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

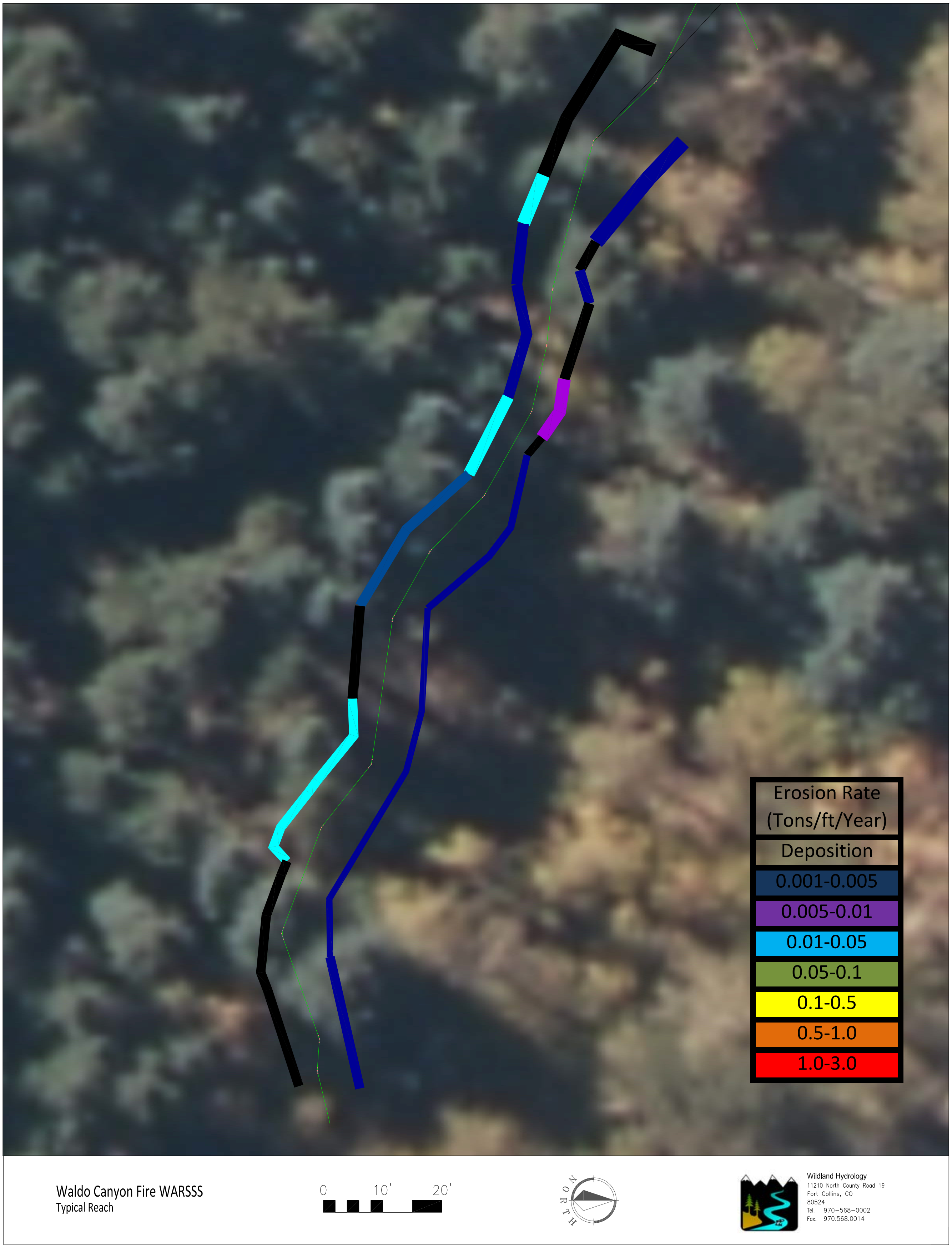
Stream: **West Monument Creek A4/2 Reference** Location: **A4/2 Reference**

Graph Used: **Colorado** Total Stream Length (ft): **174** Date: **11/6/2012**

Observers: **Lee, Sumner, Jara, Leah** Valley Type: **VIIIb** Stream Type: **A4/2**

(1) Station (ft)	(2) BEHI rating (Worksheet 3-11) (adjective)	(3) NBS rating (Worksheet 3-12) (adjective)	(4) Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. **R115-123**	**Very Low**	**High**	**0.021**	**8.0**	**1.5**	**0.26**	**0.00150**
2. **R128-154**	**Very Low**	**High**	**0.021**	**26.0**	**1.7**	**0.94**	**0.00170**
3. **R171-178**	**Low**	**Very High**	**0.323**	**7.0**	**1.7**	**3.84**	**0.02640**
4. **R178-183**	**Low**	**Low**	**0.036**	**5.0**	**1.4**	**0.24**	**0.00230**
5. **R183-201**	**Low**	**Low**	**0.036**	**18.0**	**1.4**	**0.87**	**0.00230**
6. **R201-212**	**Low**	**High**	**0.151**	**20.0**	**1.5**	**4.53**	**0.01090**
7. **R212-232**	**Very Low**	**Very High**	**0.050**	**12.0**	**1.3**	**0.78**	**0.00310**
8. **R244-266**	**Low**	**Very High**	**0.323**	**22.0**	**1.2**	**8.53**	**0.01870**
9. **L289-277**	**Low**	**Moderate**	**0.073**	**12.0**	**1.2**	**1.04**	**0.00420**
10. **L229-251**	**Very Low**	**Low**	**0.004**	**22.0**	**0.8**	**0.07**	**0.00015**
11. **L207-216**	**Very Low**	**High**	**0.021**	**9.0**	**0.9**	**0.17**	**0.00090**
12. **L196-203**	**Low**	**Moderate**	**0.072**	**7.0**	**1.6**	**0.81**	**0.00560**
13. **L182-186**	**Low**	**Low**	**0.036**	**4.0**	**1.3**	**0.19**	**0.00220**
14. **L161-177**	**Low**	**Low**	**0.036**	**16.0**	**2.0**	**1.12**	**0.00340**
15. **L144-154**	**Low**	**Very High**	**0.323**	**10.0**	**1.3**	**4.20**	**0.02020**
16 **L134-144**	**Very Low**	**Low**	**0.004**	**10.0**	**0.9**	**0.03**	**0.00020**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**27.63**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**1.02**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**1.33**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.0076**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

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	9.19	0.0163	23.015
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	0.1													
90.000	0.3	95.00	10.00	36.50	0.2	0.02	1.7	0.0	0.0002	0.00	1.80	0.00	0.00	0.00
80.000	0.4	85.00	10.00	36.50	0.4	0.04	2.4	0.0	0.0017	0.00	3.60	0.00	0.00	0.00
70.000	0.5	75.00	10.00	36.50	0.5	0.05	3.1	0.0	0.0031	0.00	4.60	0.00	0.00	0.00
60.000	0.6	65.00	10.00	36.50	0.6	0.06	4.0	0.0	0.0047	0.00	5.50	0.00	0.00	0.00
50.000	0.8	55.00	10.00	36.50	0.7	0.08	5.9	0.0	0.0083	0.00	7.00	0.00	0.00	0.00
40.000	1.0	45.00	10.00	36.50	0.9	0.10	9.8	0.0	0.0151	0.00	9.10	0.00	0.00	0.00
30.000	1.5	35.00	10.00	36.50	1.3	0.14	19.4	0.0	0.0305	0.00	12.50	0.36	0.00	0.36
20.000	2.2	25.00	10.00	36.50	1.8	0.20	34.8	0.0	0.0540	0.00	18.20	0.36	0.00	0.36
10.000	4.0	15.00	10.00	36.50	3.1	0.34	34.8	0.0	0.0540	0.09	31.00	0.73	3.28	4.01
5.000	6.4	7.50	5.00	18.25	5.2	0.57	34.8	0.1	0.0540	0.26	26.05	1.09	4.75	5.84
4.000	7.2	4.50	1.00	3.65	6.8	0.74	34.8	0.1	0.0540	0.48	6.79	0.51	1.75	2.26
3.000	8.4	3.50	1.00	3.65	7.8	0.85	34.8	0.2	0.0540	0.65	7.79	0.73	2.37	3.10
2.000	10.0	2.50	1.00	3.65	9.2	1.00	34.8	0.3	0.0540	0.91	9.19	1.24	3.32	4.56
1.500	11.4	1.75	0.50	1.83	10.7	1.17	34.8	0.6	0.0540	1.30	5.36	1.00	2.37	3.37
1.000	13.9	1.25	0.50	1.83	12.7	1.38	34.8	1.0	0.0540	1.90	6.34	1.75	3.47	5.22
0.900	14.9	0.95	0.10	0.37	14.4	1.57	34.8	1.5	0.0540	2.51	1.44	0.53	0.92	1.45
0.800	15.7	0.85	0.10	0.37	15.3	1.66	34.8	1.8	0.0540	2.85	1.53	0.65	1.04	1.69
0.700	16.6	0.75	0.10	0.37	16.1	1.76	34.8	2.1	0.0540	3.24	1.61	0.78	1.18	1.96
0.600	17.7	0.65	0.10	0.37	17.1	1.86	34.8	2.6	0.0540	3.67	1.71	0.95	1.34	2.29
0.500	18.9	0.55	0.10	0.37	18.3	1.99	34.8	3.2	0.0540	4.23	1.83	1.18	1.54	2.72
0.250	21.9	0.38	0.25	0.91	20.4	2.22	34.8	4.7	0.0540	5.40	5.09	4.24	4.93	9.17
0.100	25.3	0.18	0.15	0.55	23.6	2.56	34.8	7.6	0.0540	7.43	3.53	4.17	4.07	8.24
0.050	27.0	0.08	0.05	0.18	26.1	2.84	34.8	10.8	0.0540	9.33	1.31	1.97	1.70	3.67
0.010	29.4	0.03	0.04	0.15	28.2	3.07	34.8	14.0	0.0540	11.06	1.13	2.05	1.61	3.66
0.005	29.4	0.01	0.01	0.02	29.4	3.20	34.8	16.1	0.0540	12.10	0.15	0.29	0.22	0.51
0.001	29.4	0.00	0.00	0.01	29.4	3.20	34.8	16.1	0.0540	12.10	0.12	0.24	0.18	0.42
										Annual totals:		24.8 (tons/yr)	40.0 (tons/yr)	64.8 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

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	9.19	0.0163	23.02
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) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment **[(5)×(9)]**	(14) Bedload sediment **[(5)×(11)]**	(15) 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	**0.1**													
90.000	**0.3**	**95.00**	**10.00**	**36.50**	**0.2**	**0.02**	**1.7**	**0.0**	**0.0002**	**0.00**	**1.80**	**0.00**	**0.00**	**0.00**
80.000	**0.4**	**85.00**	**10.00**	**36.50**	**0.4**	**0.04**	**2.4**	**0.0**	**0.0017**	**0.00**	**3.60**	**0.00**	**0.00**	**0.00**
70.000	**0.5**	**75.00**	**10.00**	**36.50**	**0.5**	**0.05**	**3.1**	**0.0**	**0.0031**	**0.00**	**4.60**	**0.00**	**0.00**	**0.00**
60.000	**0.6**	**65.00**	**10.00**	**36.50**	**0.6**	**0.06**	**4.0**	**0.0**	**0.0047**	**0.00**	**5.50**	**0.00**	**0.00**	**0.00**
50.000	**0.8**	**55.00**	**10.00**	**36.50**	**0.7**	**0.08**	**5.9**	**0.0**	**0.0083**	**0.00**	**7.00**	**0.00**	**0.00**	**0.00**
40.000	**1.0**	**45.00**	**10.00**	**36.50**	**0.9**	**0.10**	**10.0**	**0.0**	**0.0154**	**0.00**	**9.20**	**0.00**	**0.00**	**0.00**
30.000	**1.6**	**35.00**	**10.00**	**36.50**	**1.3**	**0.14**	**22.2**	**0.0**	**0.0350**	**0.00**	**13.30**	**0.36**	**0.00**	**0.36**
20.000	**3.2**	**25.00**	**10.00**	**36.50**	**2.4**	**0.26**	**34.8**	**0.0**	**0.0540**	**0.04**	**24.20**	**0.36**	**1.46**	**1.82**
10.000	**6.6**	**15.00**	**10.00**	**36.50**	**4.9**	**0.53**	**34.8**	**0.1**	**0.0540**	**0.22**	**49.10**	**2.19**	**8.03**	**10.22**
5.000	**9.8**	**7.50**	**5.00**	**18.25**	**8.2**	**0.89**	**34.8**	**0.2**	**0.0540**	**0.73**	**41.05**	**4.38**	**13.32**	**17.70**
4.000	**10.7**	**4.50**	**1.00**	**3.65**	**10.3**	**1.12**	**34.8**	**0.5**	**0.0540**	**1.21**	**10.29**	**1.79**	**4.42**	**6.21**
3.000	**12.2**	**3.50**	**1.00**	**3.65**	**11.5**	**1.25**	**34.8**	**0.7**	**0.0540**	**1.51**	**11.46**	**2.52**	**5.51**	**8.03**
2.000	**13.8**	**2.50**	**1.00**	**3.65**	**13.0**	**1.41**	**34.8**	**1.0**	**0.0540**	**1.99**	**12.98**	**3.80**	**7.26**	**11.06**
1.500	**15.3**	**1.75**	**0.50**	**1.83**	**14.6**	**1.58**	**34.8**	**1.5**	**0.0540**	**2.59**	**7.28**	**2.77**	**4.73**	**7.50**
1.000	**17.8**	**1.25**	**0.50**	**1.83**	**16.6**	**1.80**	**34.8**	**2.3**	**0.0540**	**3.41**	**8.29**	**4.25**	**6.22**	**10.47**
0.900	**18.7**	**0.95**	**0.10**	**0.37**	**18.3**	**1.99**	**34.8**	**3.2**	**0.0540**	**4.23**	**1.83**	**1.18**	**1.54**	**2.72**
0.800	**19.6**	**0.85**	**0.10**	**0.37**	**19.2**	**2.08**	**34.8**	**3.8**	**0.0540**	**4.71**	**1.92**	**1.38**	**1.72**	**3.10**
0.700	**20.4**	**0.75**	**0.10**	**0.37**	**20.0**	**2.18**	**34.8**	**4.4**	**0.0540**	**5.18**	**2.00**	**1.61**	**1.89**	**3.50**
0.600	**21.5**	**0.65**	**0.10**	**0.37**	**21.0**	**2.28**	**34.8**	**5.2**	**0.0540**	**5.75**	**2.10**	**1.88**	**2.10**	**3.98**
0.500	**22.8**	**0.55**	**0.10**	**0.37**	**22.1**	**2.41**	**34.8**	**6.2**	**0.0540**	**6.48**	**2.21**	**2.25**	**2.37**	**4.62**
0.250	**25.7**	**0.38**	**0.25**	**0.91**	**24.2**	**2.64**	**34.8**	**8.4**	**0.0540**	**7.91**	**6.06**	**7.66**	**7.22**	**14.88**
0.100	**29.1**	**0.18**	**0.15**	**0.55**	**27.4**	**2.99**	**34.8**	**12.8**	**0.0540**	**10.41**	**4.12**	**6.99**	**5.70**	**12.69**
0.050	**30.9**	**0.08**	**0.05**	**0.18**	**30.0**	**3.27**	**34.8**	**17.3**	**0.0540**	**12.66**	**1.50**	**3.16**	**2.31**	**5.47**
0.010	**33.3**	**0.03**	**0.04**	**0.15**	**32.1**	**3.49**	**34.8**	**21.7**	**0.0540**	**14.69**	**1.28**	**3.17**	**2.14**	**5.31**
0.005	**33.3**	**0.01**	**0.01**	**0.02**	**33.3**	**3.62**	**34.8**	**24.6**	**0.0540**	**15.90**	**0.17**	**0.45**	**0.29**	**0.74**
0.001	**33.3**	**0.00**	**0.00**	**0.01**	**33.3**	**3.62**	**34.8**	**24.6**	**0.0540**	**15.90**	**0.13**	**0.36**	**0.23**	**0.59**
										Annual totals:		**52.5** (tons/yr)	**78.5** (tons/yr)	**131.0** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**West Mounment A4/2 Reference**	Stream Type:	**A4/2**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/06/2012**

Enter Required Information for Existing Condition

10.5	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
2.113	$D_{\max}$	Largest particle from **Bed Material** (ft)	**644**	**(mm)**	304.8 mm/ft
0.08113	S	Existing bankfull water surface slope (ft/ft)			
0.72	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	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:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
61.45	$D_{\max}/D_{50}$	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{\max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**2**

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

N/A	**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

N/A	**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

3.645		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 **300.1**	CO **393.6**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **7.586**	CO **7.12**	Predicted shear stress required to initiate movement of measured $D_{\max}$ (mm) **(Figure 5-49)**	
Shields **1.50**	CO **1.41**	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 **0.1689**	CO **0.1585**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **West Monument A4/2 Reference** Stream Type: **A4/2**

Location: **Pike National Forest, CO** Valley Type: **VIIIb**

Observers: **Lee, Sumner, Jara, Leah** Date: **11/06/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **West Monument A4/2 Reference** Stream Type: **A4/2**
Location: **Pike National Forest, Colorado** Valley Type: **VIIIb**
Observers: **Lee, Sumner, Jara, Leah** Date: **11/06/2012**

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 5-13)**	< 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**N/A**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**N/A**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL [✓ **(2)**]	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**2**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**5**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**West Monument A4/2 Reference**	Stream Type:	**A4/2**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/06/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 (7)	**2**
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2 (2)	1.2 – 1.4 [✓ (4)]	1.4 – 1.6 (6)	>1.6 (8)	**2**
4 **Stream Succession States (Worksheet 5-24)**	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) (6)	(C→D), (F→D) (8)	**2**
5 **Depositional Patterns (Worksheet 5-10)**	B1 [✓ (1)]	B2, B4 (2)	B3, **B5** (3)	**B6, B7**, B8 (4)	**1**
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3 [✓ (1)]	D4, D7 (2)	D5, D8 (3)	D6, D9, D10 (4)	**1**
				Total Points	**10**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**West Monument A4/2 Reference**	Stream Type:	**A4/2**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/06/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 5-12)**	1.00 – 1.10 [✓ **(2)**]	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00 [✓ **(1)**]	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**1**
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**West Monument A4/2 Reference**	Stream Type:	**A4/2**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/06/2012**

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 5-24)**	Stream Type at Potential, (C→E), $(F_b \rightarrow B)$, (G→B), $(F \rightarrow B_c)$, (F→C), (D→C) [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* [✓ **(2)**]	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**8**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**West Monument A4/2 Reference**	Stream Type:	**A4/2**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Lee, Sumner, Jara, Leah**	Date:	**11/06/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	[✓ 1]	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	[✓ 1]	1
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	[✓ 1]	1
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	**5**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** 5 ☑	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☐	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**West Monument Creek A4/2 Reference**				Location: **A4/2 Reference**					
Observers:	**Lee, Sumner, Jara, Leah**		Date: **11/6/2012**		Stream Type: **A4/2**		Valley Type: **VIIIb**			
Channel Dimension	Mean Bankfull Depth (ft):	**1.01**	Bankfull Width (ft):	**4.45**	Cross-Sectional Area (ft^2):	**4.49**	Width/Depth Ratio:	**4.41**	Entrenchment Ratio:	**2.74**
Channel Pattern	Mean: Range:	λ/W_{bkf}: **0** **0.00 - 0.00**	L_m/W_{bkf}:	**0** **0.00 - 0.00**	R_c/W_{bkf}:	**0** **0.00 - 0.00**	MWR:	**3.23** **2.81 - 4.07**	Sinuosity:	**1.05**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☑ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
	Max Bankfull Depth (ft):	Riffle **1.34**	Pool **1.94**	Depth Ratio (max to mean):	Riffle **1.33**	Pool **1.5**	Pool-to-Pool Spacing:	Ratio **15.97**	Slope Valley: **0.0852**	Water Surface: **0.08113**
Level III Stream Stability Indices ☑	Riparian Vegetation	Current Composition/Density: **Aspen, Spruce, Ponderosa, Wi**		Potential Composition/Density: **Willow/Alder/Grass/Aspen**		Remarks: Condition, Vigor & Usage of Existing Reach: **Species at Potential**				
	Flow Regime:	**P1, P2** **P7, P8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**N/A**	Depositional Patterns:	**N/A**	Debris/Channel Blockages:	**D3**
	Degree of Incision (Bank-Height Ratio):	**1.2**	Degree of Incision Stability Rating:	**Slightly Incised**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**74 (Good)**				
	Width/depth Ratio (W/d):	**4.41**	Reference W/d Ratio (W/d$_{ref}$):	**4.41**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**1**	W/d Ratio State Stability Rating:	**Stable**		
	Meander Width Ratio (MWR):	**2.51**	Reference MWR$_{ref}$:	**2.51**	Degree of confinement (MWR / MWR$_{ref}$):	**1**	MWR / MWR$_{ref}$ Stability Rating:	**Stable**		
Bank Erosion Summary ☑	Length of Reach Studied (ft):	**174**	Annual Streambank Erosion Rate: **1.33** (tons/yr)	**0.0076** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:	**Used Yellowstone curve for very low BEHI**			
Sediment Capacity (POWERSED) ☑	Sufficient Capacity	Insufficient Capacity	Excess Capacity	Remarks:						
Entrainment/ Competence ☑	Largest Particle from Bar Sample (mm):	**644**	τ = **7.586**	τ* = **N/A**	Existing Depth:	**0.92**	Required Depth: **1.5**	Existing Slope: **0.081**	Required Slope:	**0.13**
Successional Stage Shift ☑	→	→	→	→	→	Existing Stream State (Type):	**A4/2**	Potential Stream State (Type):	**A2/4**	
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:					
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:					
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:					
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:					
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:	**Stable condition, also had bedrock control associated with the Windy Gap Granite**				

B4 Stream Type

Reference Reach

Table of Contents

Appendix C18: B4 Reference Reach

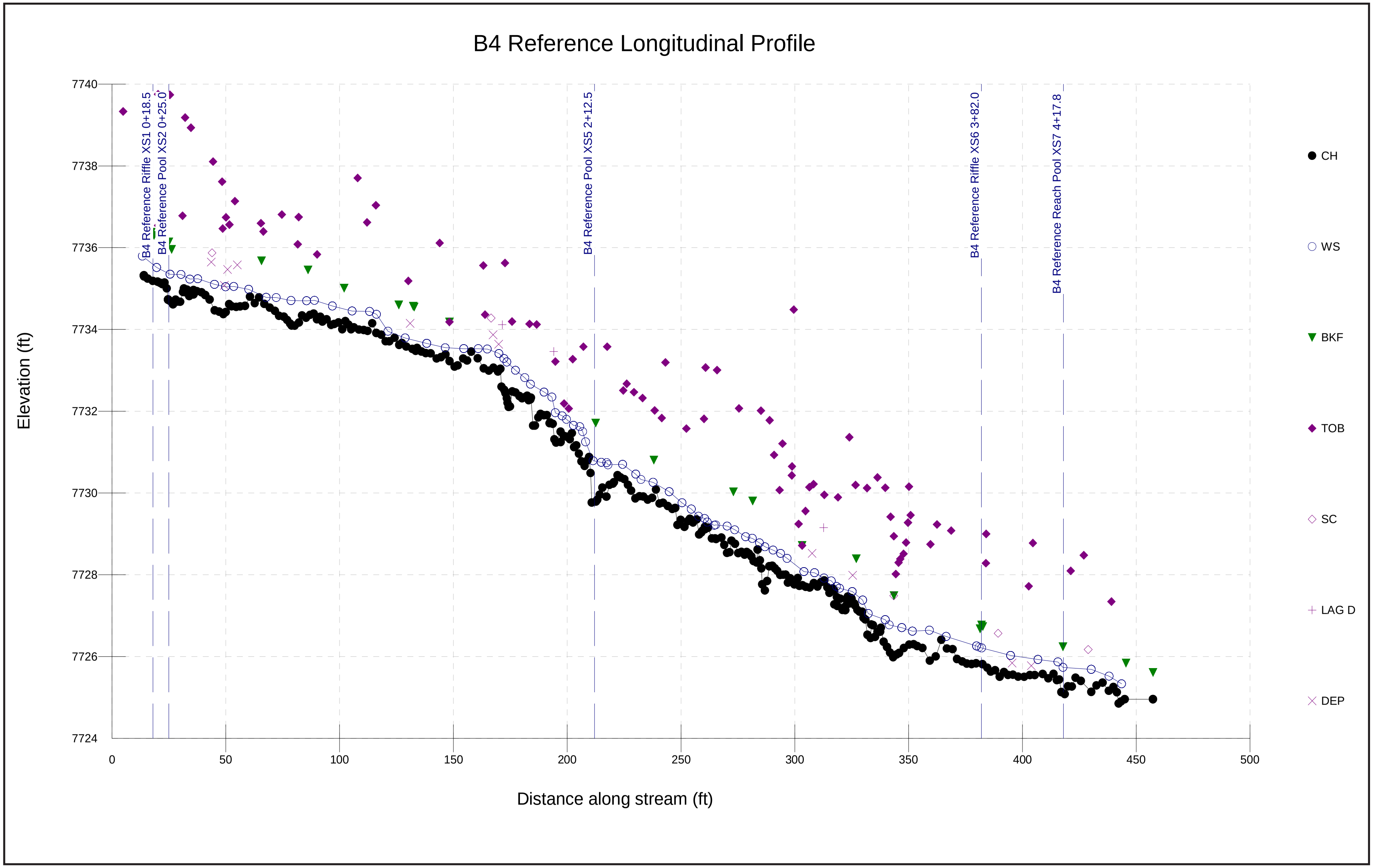
B4 Reference Reach Location & Overview

The B4 reference reach exists in a Valley Type VIII and is typical of a gravel-cobble and sand composite channel material. The channel bed and banks are potentially erodible, but due to the vegetation condition, this reference reach shows little sediment yield from this 3rd order, perennial channel. Bed features are generally dominated by rapids and pools and some step/pool features. The stream is confined (lateral contained) and as such has evolved from a post-disturbance F4b stream type. This evolution has occurred due to the presence of riparian vegetation that over time reduced the streambank erosion to a condition where the stream changed to a B4 stream type. The stable form for G4 and F4b stream types is the B4 stream type. The morphological data from this reach will be used to develop dimension, pattern and profile data for impaired streams that potentially should be B4 stream types. This reach has little sediment storage and very low streambank erosion rates (*0.0048 tons/yr/ft*, see **Worksheet 5-18**).

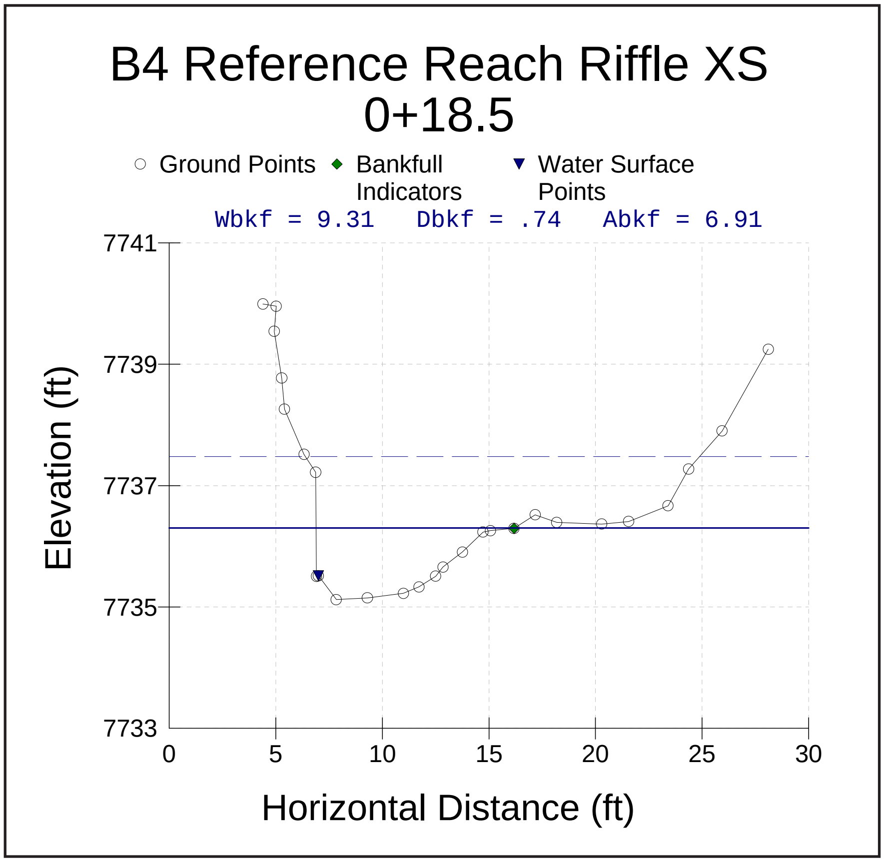
The location of this reach is shown in **Figure C-2**, and the photograph depicts the stable characteristics of the B4 stream type. The willow community and the dominating Carex/Juncus understory that has occupied the riparian areas are key components responsible for such stable conditions. There is little to no evidence of active channel-source sediment from this stream type. Such stream types are mapped where they occur by sub-watershed as shown in **Appendix D**.

The details of the dimension, pattern, profile, and materials are summarized. The POWERSED model was not run on this reference reach as the bed is obviously stable. The following summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability for this stable reach. In the situation where impaired B4, G4 and F4b stream types are located, an alternative for mitigation and sediment reduction from increased flow is to use the data from the stable form to extrapolate for potential implementation of natural channel design.

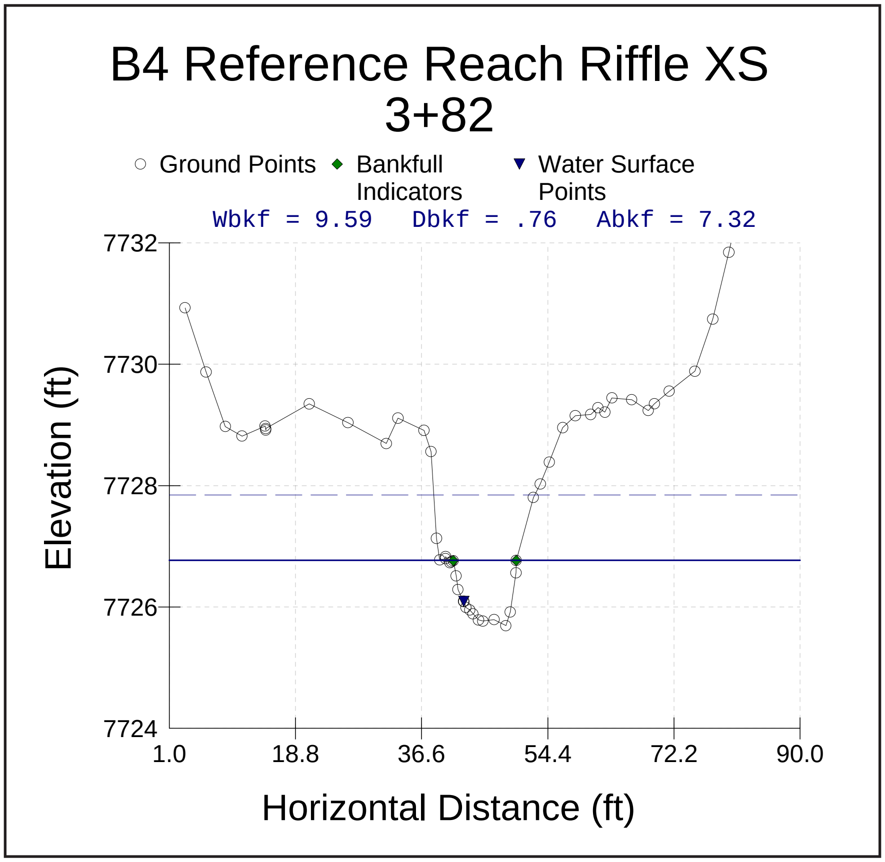
Survey Summary



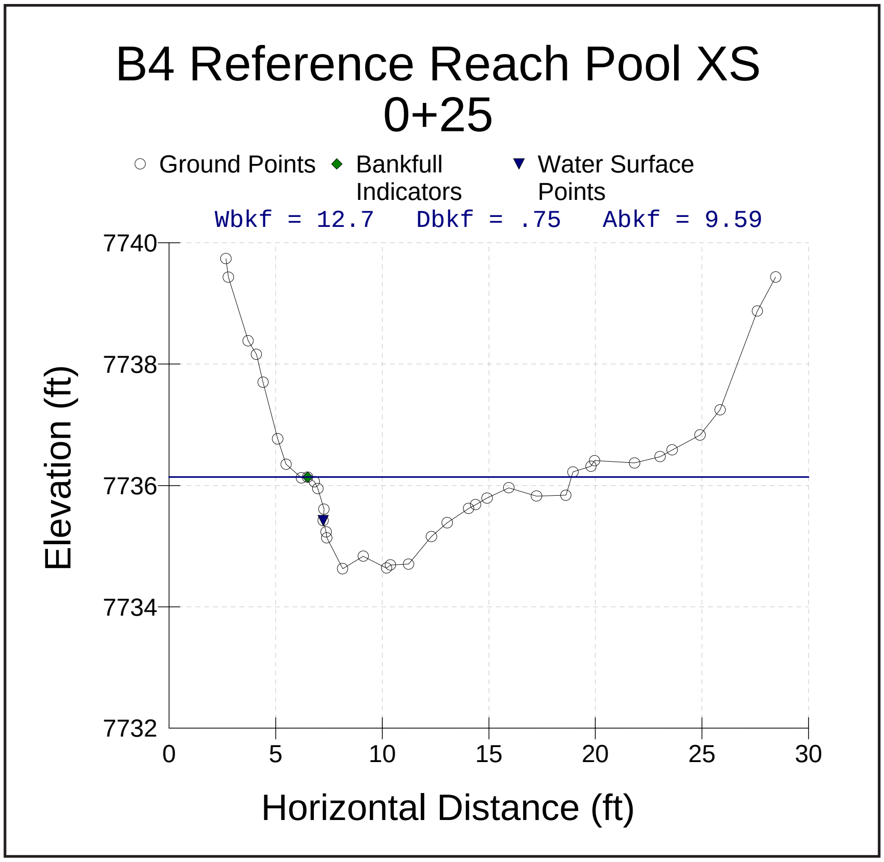
Longitudinal Profile (graph generated from RIVERMorph^{TM})



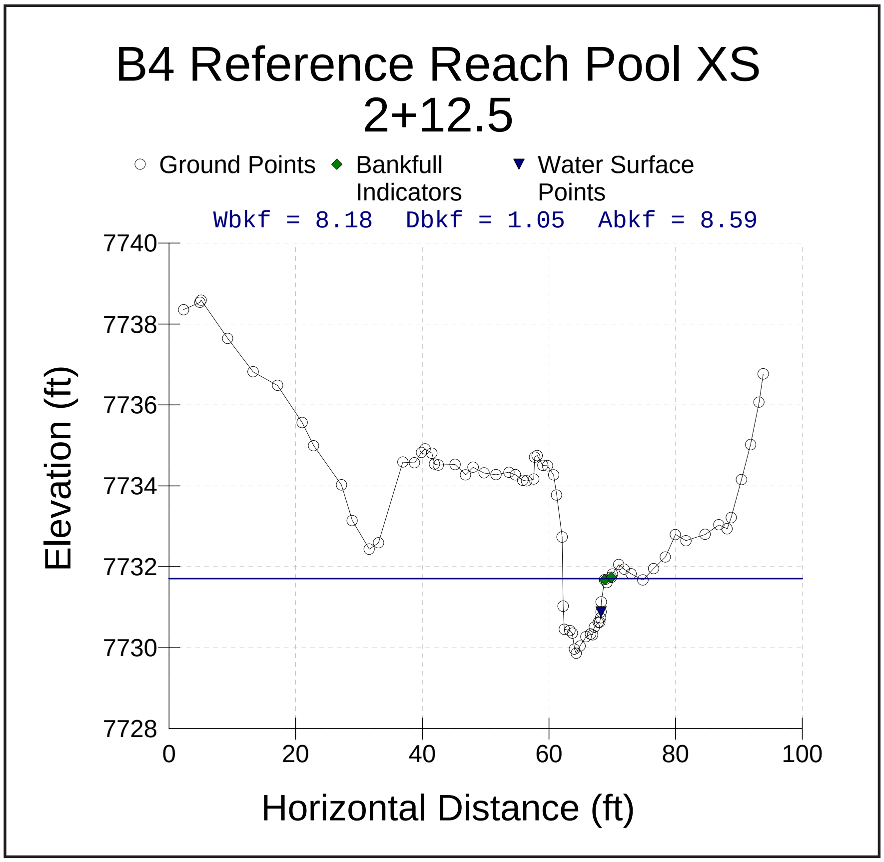
Representative Riffle Cross-section 0+18.5 (graph generated from RIVERMorph^{TM})



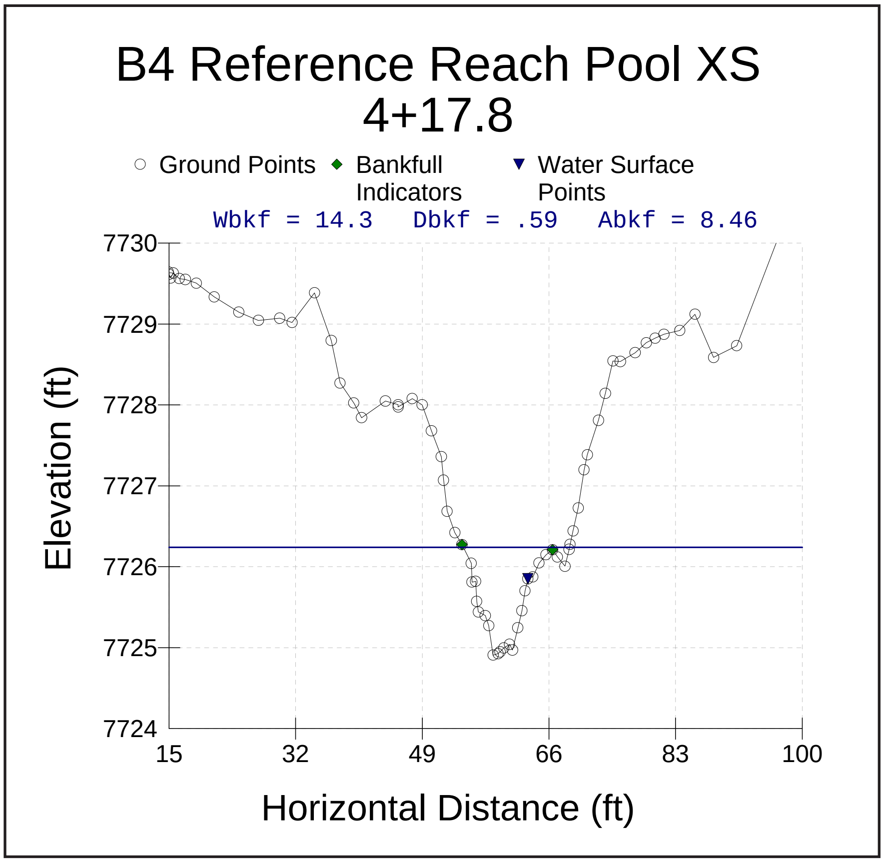
Riffle Cross-section 3+82 (graph generated from RIVERMorph^{TM})



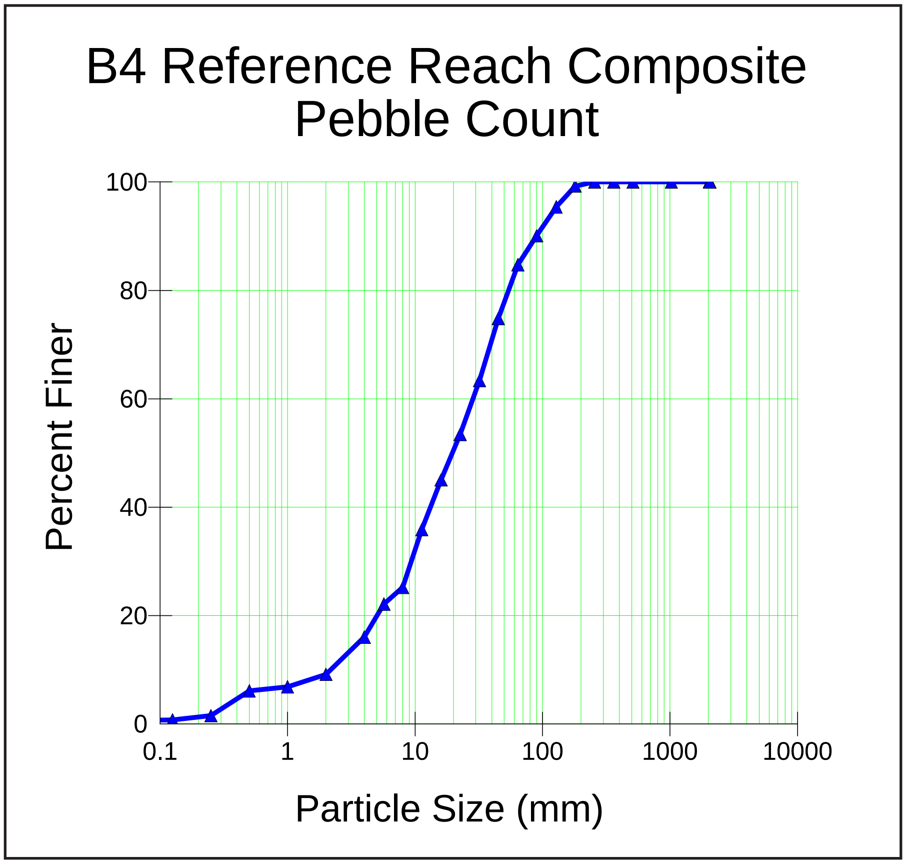
Pool Cross-section 0+25 (graph generated from RIVERMorph^{TM})



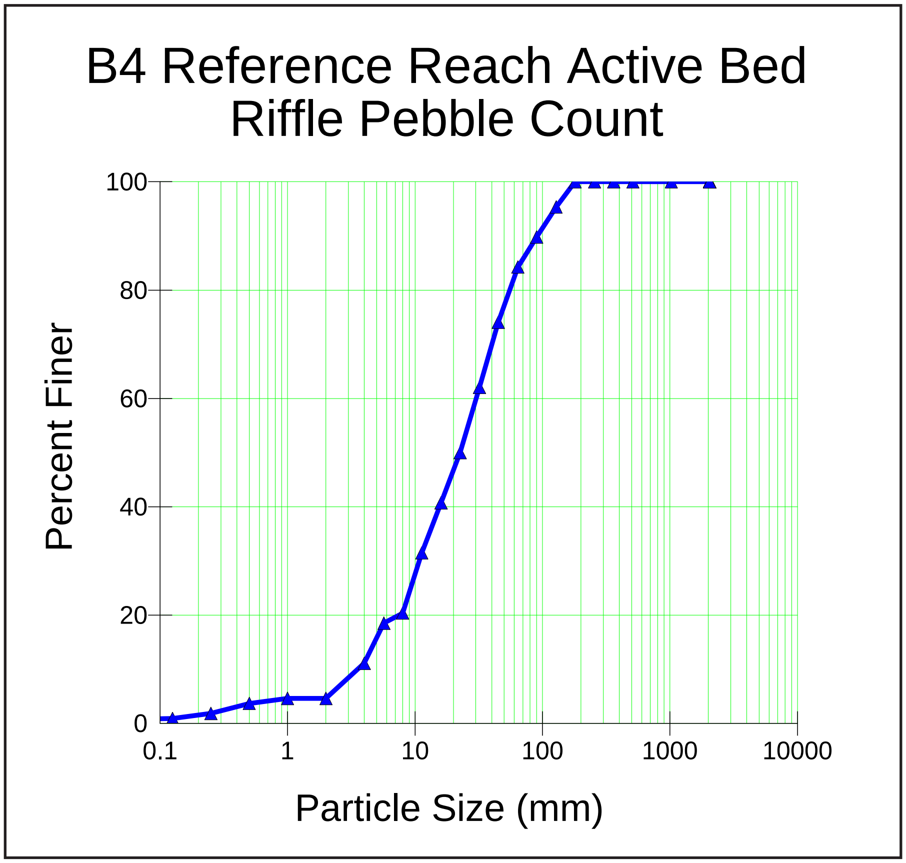
Pool Cross-section 2+12.5 (graph generated from RIVERMorph^{TM})



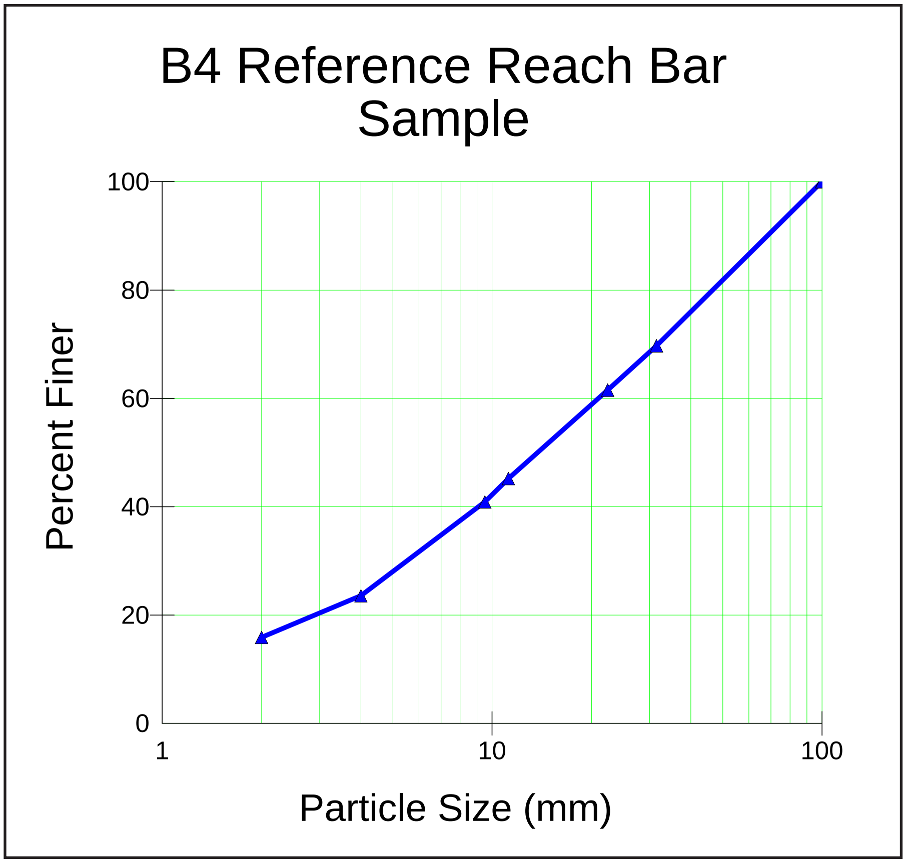
Pool Cross-section 4+17.8 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, B4 Reference Reach**	Location:	**Riffle 1 XS 0+18.5, Pike N.F., CO**
Date:	**8/14/2010**	Valley Type:	**VIII**
Stream Type:	**B4**	HUC:	_ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _
Observers:	**Rosgen & Kasun**		

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**6.91**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.74**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**9.31**	W_{bkf} (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**10.32**	W_p (ft)
D_{84} at Riffle	**63.52**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.21**	D_{84} (ft)
Bankfull SLOPE	**0.0242**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.67**	**R** (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.21**	R / D_{84}
Drainage Area	**14.3**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.722**	**u*** (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [2.83 + 5.66 * Log\{R / D_{84}\}] u^*$	**4.12**	ft / sec	**28.45**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.0374**	**4.74**	ft / sec	**32.78**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.037**	**4.79**	ft / sec	**33.13**	cfs
2. Roughness Coefficient: c) Manning's *n* from Jarrett (USGS): $u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.101** **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	**1.75**	ft / sec	**12.12**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach**	**4.15**	ft / sec	**28.7**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Hey**	**4.10**	ft / sec	**28.3**	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ______ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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 5-3. Level II stream classification.

Stream: **Trail Creek, B4 Reference Reach, Riffle 1 XS 0+18.5**

Basin: Drainage Area: **9152** acres **14.3** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **39.12433 Lat / 105.23528 Long** Date: **8/14/2010**

Observers: **Rosgen & Kasun** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**9.31**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.74**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**6.91**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**12.57**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.18**	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.	**18.48**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**1.99**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**19.9**	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.	**0.0242**	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 (S_{val} / S).	**1.13**	

Stream Type **B4** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen & Kasun** Date: **8/14/2010** Valley Type: **VIII** Stream Type: **B4**

River Reach Dimension Summary Data…..1

	Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Dimensions*, **, ***	Riffle Width (W_{bkf})	11.78	9.31	14.24	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	7.12	6.91	7.32
	Mean Riffle Depth (d_{bkf})	0.75	0.74	0.76	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	12.60	12.58	12.62
	Maximum Riffle Depth (d_{max})	1.13	1.08	1.18	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	1.508	1.421	1.595
	Width of Flood-Prone Area (W_{fpa})	16.4	14.2	18.5	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	1.74	1.48	1.99
	Riffle Inner Berm Width (W_{ib})	7.3	5.6	8.8	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.616	0.476	0.750
	Riffle Inner Berm Depth (d_{ib})	0.32	0.20	0.43	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.427	0.267	0.573
	Riffle Inner Berm Area (A_{ib})	2.42	1.28	3.79	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.340	0.180	0.533
	Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	23.6	20.5	32.1					

	Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Dimensions*, **, ***	Pool Width (W_{bkfp})	14.0	8.2	21.1	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.190	0.695	1.792
	Mean Pool Depth (d_{bkfp})	0.80	0.59	1.05	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.067	0.787	1.400
	Pool Cross-Sectional Area (A_{bkfp})	8.9	8.5	9.6	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.248	1.189	1.348
	Maximum Pool Depth (d_{maxp})	1.56	1.33	1.85	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.080	1.773	2.467
	Pool Inner Berm Width (W_{ibp})	4.8	4.5	5.1	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.343	0.320	0.361
	Pool Inner Berm Depth (d_{ibp})	0.31	0.22	0.40	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.388	0.275	0.500
	Pool Inner Berm Area (A_{ibp})	1.5	1.0	2.0	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.172	0.114	0.226
	Point Bar Slope (S_{pb})	0.290	0.220	0.360	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	0.88	0.82	0.93

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

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

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/20/2010** Valley Type: **III** Stream Type: **B4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.74**	ft/sec	Estimation Method	**Manning's n - RR/FF**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**32.78**	cfs	Drainage Area	**14.3**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**104.0**	**87.0**	**129.0**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**8.8**	**7.4**	**11.0**
Stream Meander Length (L_m)	**112.0**	**94.5**	**135.0**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**9.5**	**8.0**	**11.5**
Radius of Curvature (R_c)	**64.0**	**39.5**	**82.0**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**5.4**	**3.4**	**7.0**
Belt Width (W_{blt})	**27.2**	**14.6**	**60.0**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**2.3**	**1.2**	**5.1**
Arc Length (L_a)	**39.6**	**10.0**	**70.9**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**3.4**	**0.8**	**6.0**
Riffle Length (L_r)	**14.7**	**2.7**	**28.2**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**1.2**	**0.2**	**2.4**
Individual Pool Length (L_p)	**60.1**	**23.0**	**101.0**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**5.10**	**1.95**	**8.58**
Pool to Pool Spacing (P_s)	**28.1**	**12.2**	**47.3**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**2.4**	**1.0**	**4.0**

Channel Profile

Valley Slope (S_{val})	**0.0264**	ft/ft	Average Water Surface Slope (S)	**0.0242**	ft/ft	Sinuosity (S_{val} / S)	**1.09**
Stream Length (SL)	**514.1**	ft	Valley Length (VL)	**581.0**	ft	Sinuosity (SL / VL)	**1.13**

Low Bank Height (LBH)	start	**1.18**	ft	Max Bankfull Depth (d_{max})	start	**1.18**	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start **1.0**
	end	**1.08**	ft		end	**1.08**	ft		end **1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0340**	**0.0159**	**0.0585**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**1.4037**	**0.6587**	**2.4182**
Run Slope (S_{run})				ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	**0.0027**	**0.0001**	**0.0099**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.1124**	**0.0041**	**0.4107**
Glide Slope (S_g)				ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)			
Step Slope (S_s)	**1.0600**	**0.9300**	**1.1800**	ft/ft	Step Slope to Average Water Surface Slope (S_s / S)	**43.80**	**38.43**	**48.76**

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.06**	**0.93**	**1.18**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.413**	**1.240**	**1.573**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})	**1.52**	**1.33**	**1.85**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.027**	**1.773**	**2.467**
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**0.00**	**0.00**	**0.00**	D_{16}	**3.99**	**5.12**	**2.03**		mm
% Sand	**9.16**	**4.63**	**15.87**	D_{35}	**11.03**	**13.09**	**7.64**		mm
% Gravel	**75.57**	**79.63**	**72.43**	D_{50}	**19.90**	**22.60**	**14.49**		mm
% Cobble	**15.27**	**15.74**	**11.70**	D_{84}	**62.60**	**63.52**	**63.81**		mm
% Boulder	**0.00**	**0.00**	**0.00**	D_{95}	**125.01**	**125.47**	**88.69**		mm
% Bedrock	**0.00**	**0.00**	**0.00**	D_{100}	**255.99**	**180.00**	**100.00**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, B4 Reference Reach**

Location: **Pike National Forest, Colorado**

Observers: **Rosgen & Kasun**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **8/13/2010**

Existing species composition: **Aspen, Willow, Grasses,Carex Juncus, Mullen, Thistle**

Potential species composition: **Same but without Thistle and Mullen**

Riparian cover categories		**Percent aerial cover***	**Percent of site coverage****	**Species composition**	**Percent of total species composition**
1. Overstory	Canopy layer	**30%**	**< 10%**	**Willow**	**95%**
				Aspen	**5%**
					100%
2. Understory	Shrub layer	▨	**70%**	**Willow**	**90%**
				Raspberry	**10%**
					100%
3. Ground level	Herbaceous	▨	**95%**	**Grasses**	**10%**
				Red Top	**8%**
				Poa	**5%**
				Carex Juncus	**75%**
				Mullen	**1%**
				Thistle	**1%**
					100%
	Leaf or needle litter	▨			
	Bare ground	▨	**5%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Current Riparian Vegetation Condition Good; Recovering Riparian inside of past G/Fb

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, B4 Reference** Location: **Pike National Forest, Colorado**

Observers: **Rosgen & Kasun** Date: **8/14/2010**

List ALL COMBINATIONS that APPLY...............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trail Creek, B4 Reference Reach**
Location: **Pike National Forest, Colorado**
Observers: **Rosgen & Kasun**
Date: **8/12/2010**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

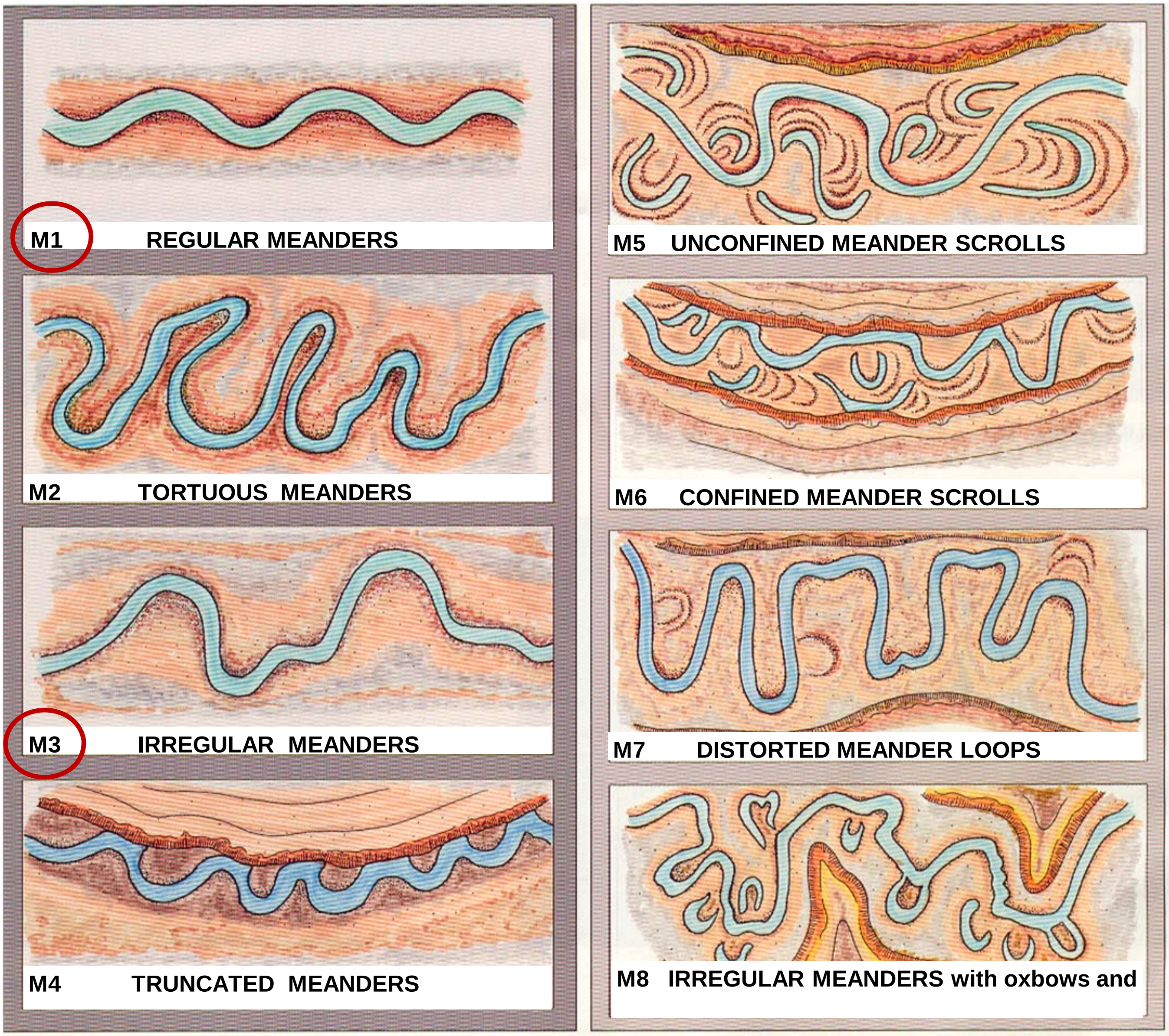
Meander Patterns

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, CO**

Observers: **Rosgen & Kasun** Date: **8/14/2010**

List ALL CATEGORIES that APPLY ☞	**M1**	**M3**			

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



Worksheet 5-10. Depositional patterns.

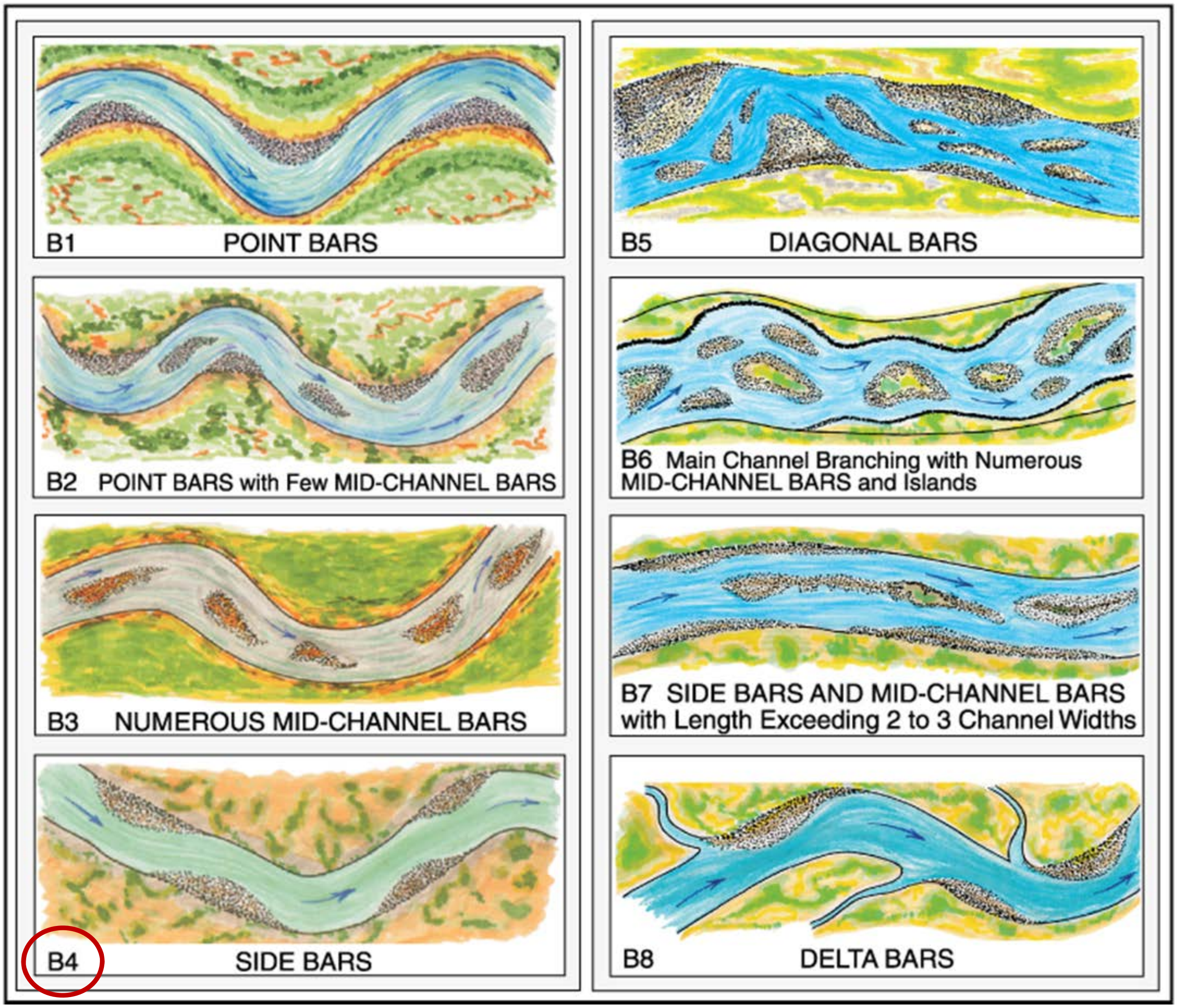
Depositional Patterns

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen & Kasun** Date: **8/14/2010**

List ALL CATEGORIES that APPLY ☞	**B4**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **Rosgen & Kasun** Date: **8/14/2010**

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.	☐

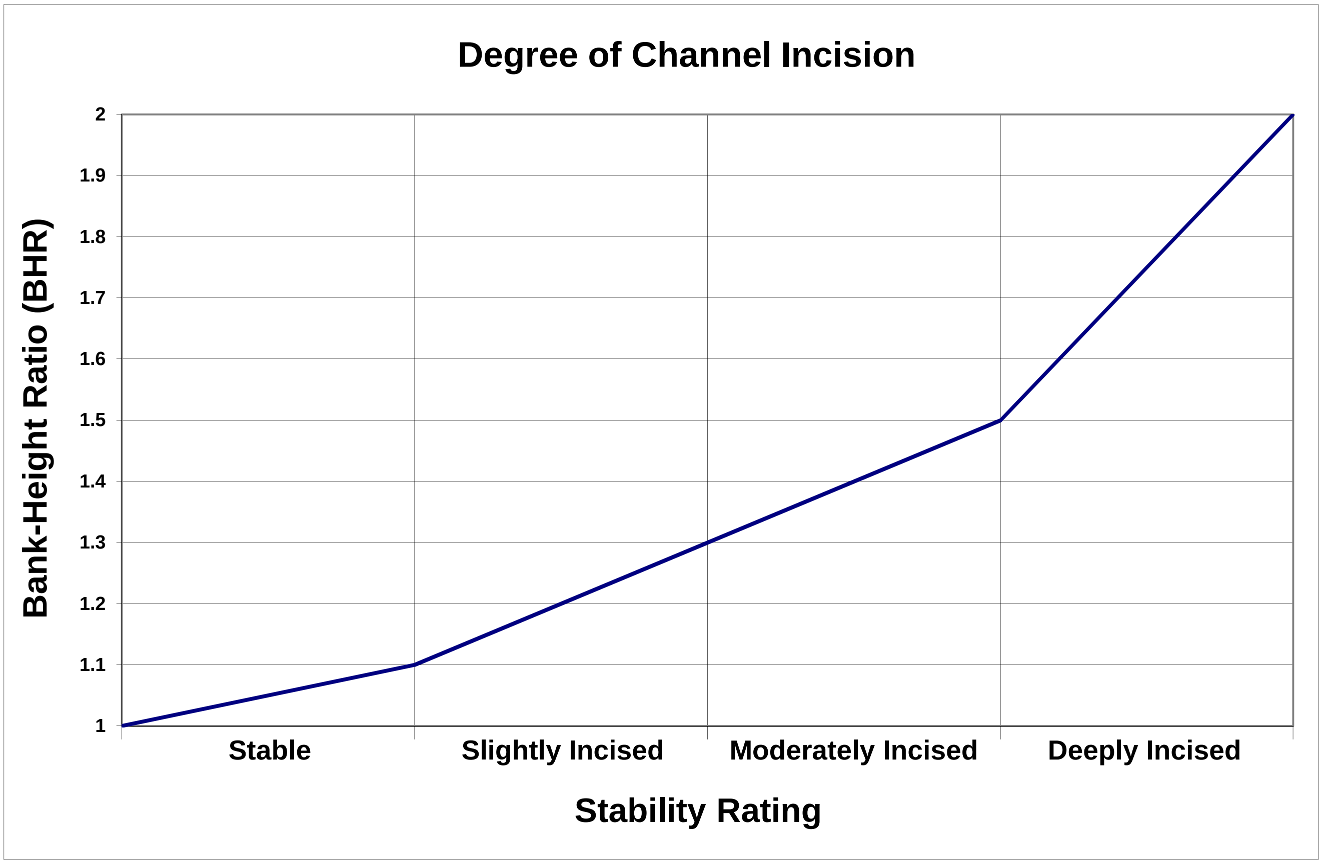
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	1.18
Max Bankfull Depth:	1.18

Bank-Height Ratio:	1.0

Degree of Channel Incision Stability Rating ☞	**Stable**

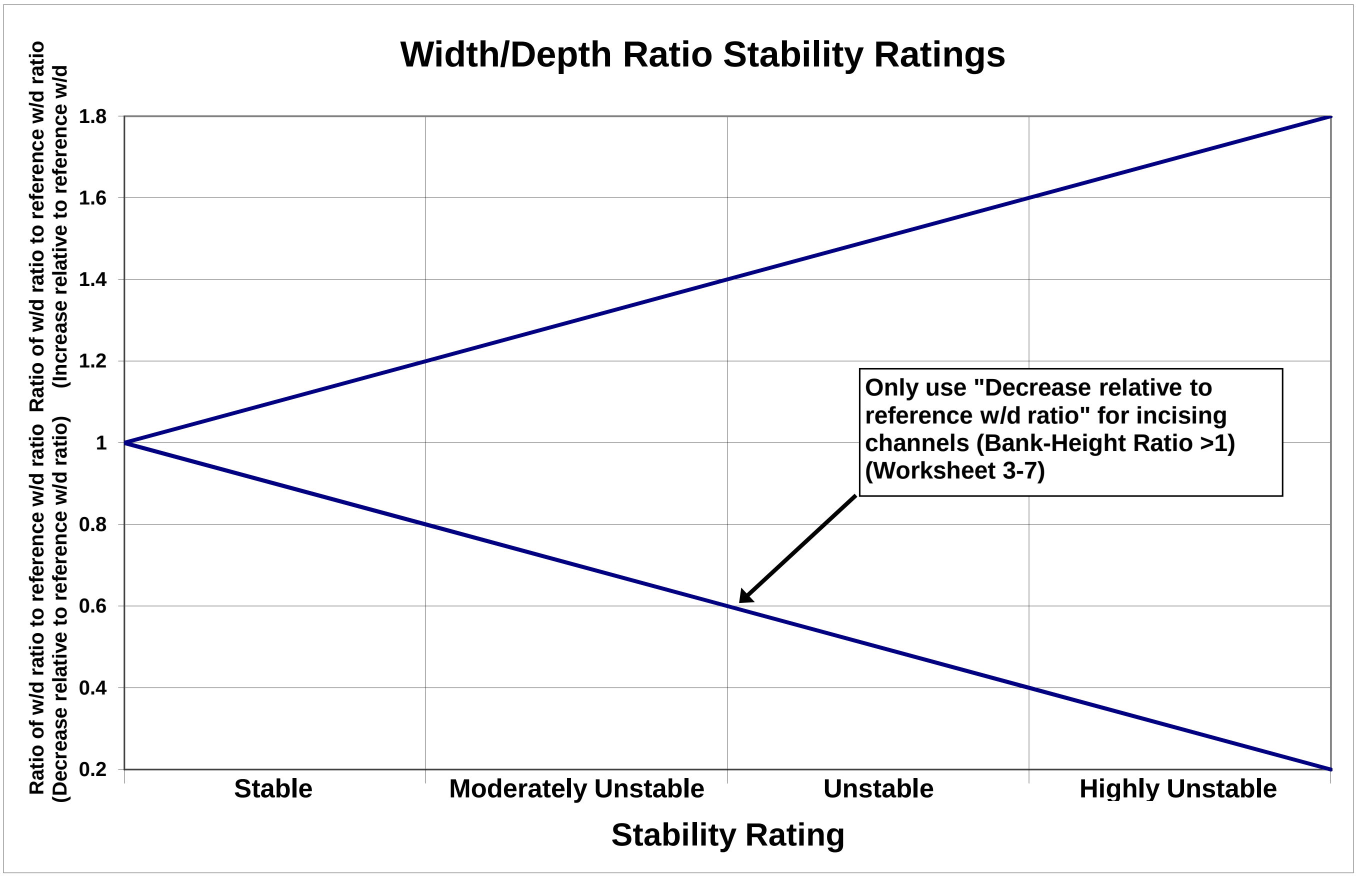


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**12.57**	Ratio of existing W/d to reference W/d:	**1.00**
Reference Width/Depth Ratio:	**12.57**		

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



Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

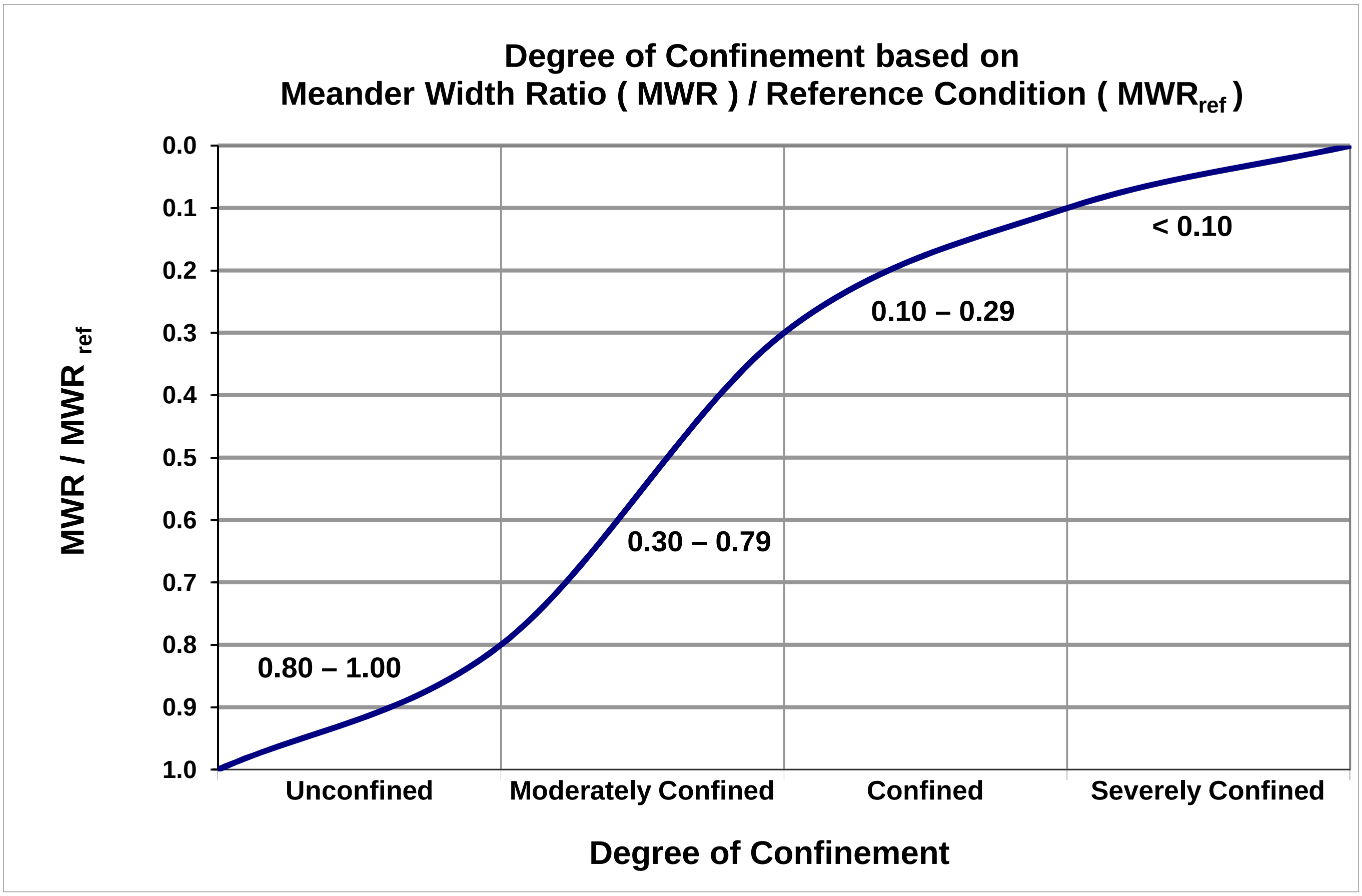
Degree of Confinement

Existing Meander Width Ratio (MWR): **2.7**

Reference Meander Width Ratio (MWR_{ref}): **2.7**

Ratio of MWR to MWR_{ref}: **1.00**

Degree of Confinement Stability Rating ☞ **Unconfined**



Degree of Confinement based on Meander Width Ratio (MWR) / Reference Condition (MWR_{ref})

Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, B4 Reference Reach Location: Pike National Forest, CO Valley Type: VIII Observers: Rosgen & Kasun Date: 8/14/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	[✓ 4]	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	[✓ 4]	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	[✓ 3]	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	[✓ 2]	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 3]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	[✓ 4]	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	[✓ 6]	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	[✓ 3]	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	[✓ 2]	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	[✓ 6]	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	[✓ 12]	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	[✓ 4]
			Excellent total =	18	Good total =	31	Fair total =	3	Poor total =	8

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	[✓ B4]	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	60
Existing stream type =	B4
*Potential stream type =	B4
Modified channel stability rating =	Good

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-16a. The Bank Erosion Hazard Index (BEHI) rating.

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Station: **0+00 L** Observers: **Rosgen & Kasun**

Date: **8/14/2010** Stream Type: **B4** Valley Type: **VIII**

BEHI Score (Fig. 5-15)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	**5.00** **(A)**	**Bankfull Height** (ft) =	**1.00** **(B)**	(A) / (B) =	**5.00** **(C)**	**10.0**

Root Depth / Study Bank Height (E)

Root Depth (ft) =	**4.50** **(D)**	**Study Bank Height** (ft) =	**5.00** **(A)**	(D) / (A) =	**0.90** **(E)**	**1.0**

Weighted Root Density (G)

Root Density as **%** =	**75** **(F)**	(F) × (E) =	**67.5** **(G)**	**3.0**

Bank Angle (H)

Bank Angle as *Degrees* =	**30** **(H)**	**3.0**

Surface Protection (I)

Surface Protection as **%** =	**95%** **(I)**	**1.0**

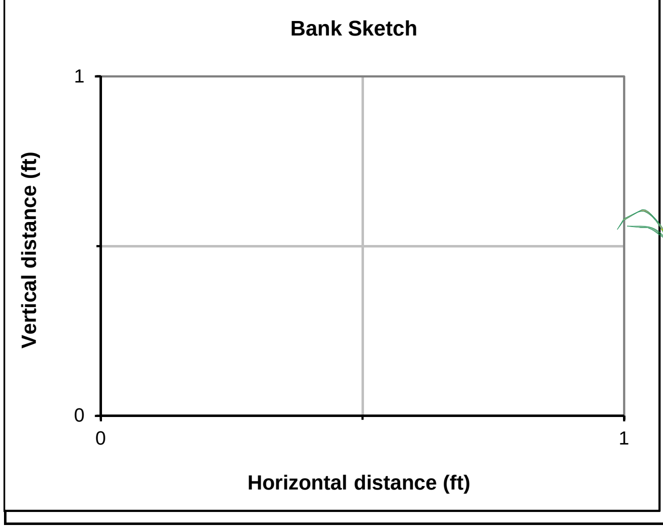
Bank Material Adjustment:

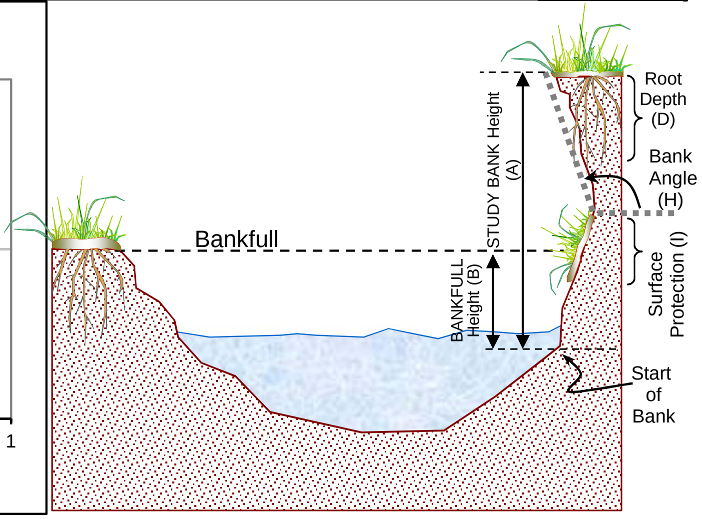
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

Bank Material Adjustment **0**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0**

Very Low	**Low**	**Moderate**	**High**	**Very High**	**Extreme**	**Adjective Rating**	**Low**
5 – 9.5	**10 – 19.5**	**20 – 29.5**	**30 – 39.5**	**40 – 45**	**46 – 50**	and **Total Score**	**18.0**


Bank Sketch



Worksheet 5-16b. The Bank Erosion Hazard Index (BEHI) rating.

Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Station: **2+26** Observers: **Rosgen & Kasun**

Date: **8/14/2010** Stream Type: **B4** Valley Type: **VIII**

BEHI Score (Fig. 5-15)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	**1.00** **(A)**	**Bankfull Height** (ft) =	**1.00** **(B)**	(A) / (B) =	**1.00** **(C)**	**1.0**

Root Depth / Study Bank Height (E)

Root Depth (ft) =	**1.00** **(D)**	**Study Bank Height** (ft) =	**1.00** **(A)**	(D) / (A) =	**1.00** **(E)**	**1.0**

Weighted Root Density (G)

Root Density as **%** =	**85** **(F)**	(F) × (E) =	**85** **(G)**	**1.0**

Bank Angle (H)

Bank Angle as *Degrees* =	**40** **(H)**	**3.0**

Surface Protection (I)

Surface Protection as **%** =	**85%** **(I)**	**1.0**

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

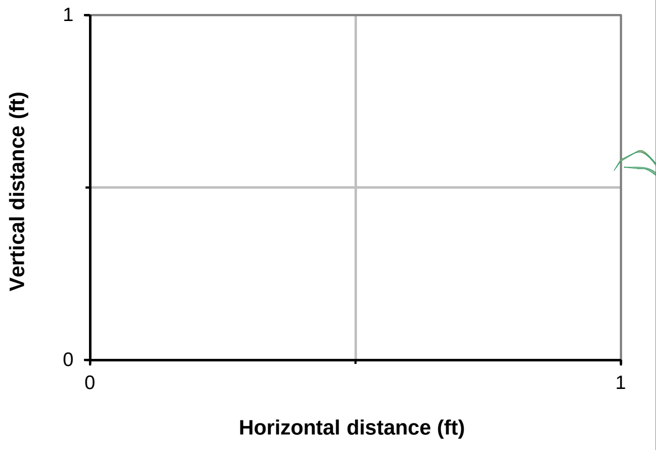
Bank Material Adjustment **-10**

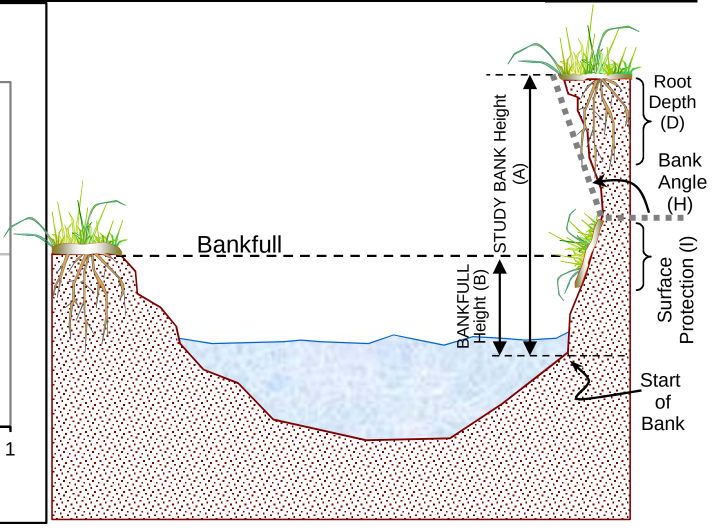
Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0**

Very Low	Low	Moderate	High	Very High	Extreme
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50

Adjective Rating and **Total Score**: **Very Low** **-3.0**

Bank Sketch





Worksheet 5-18. Annual streambank erosion estimates.

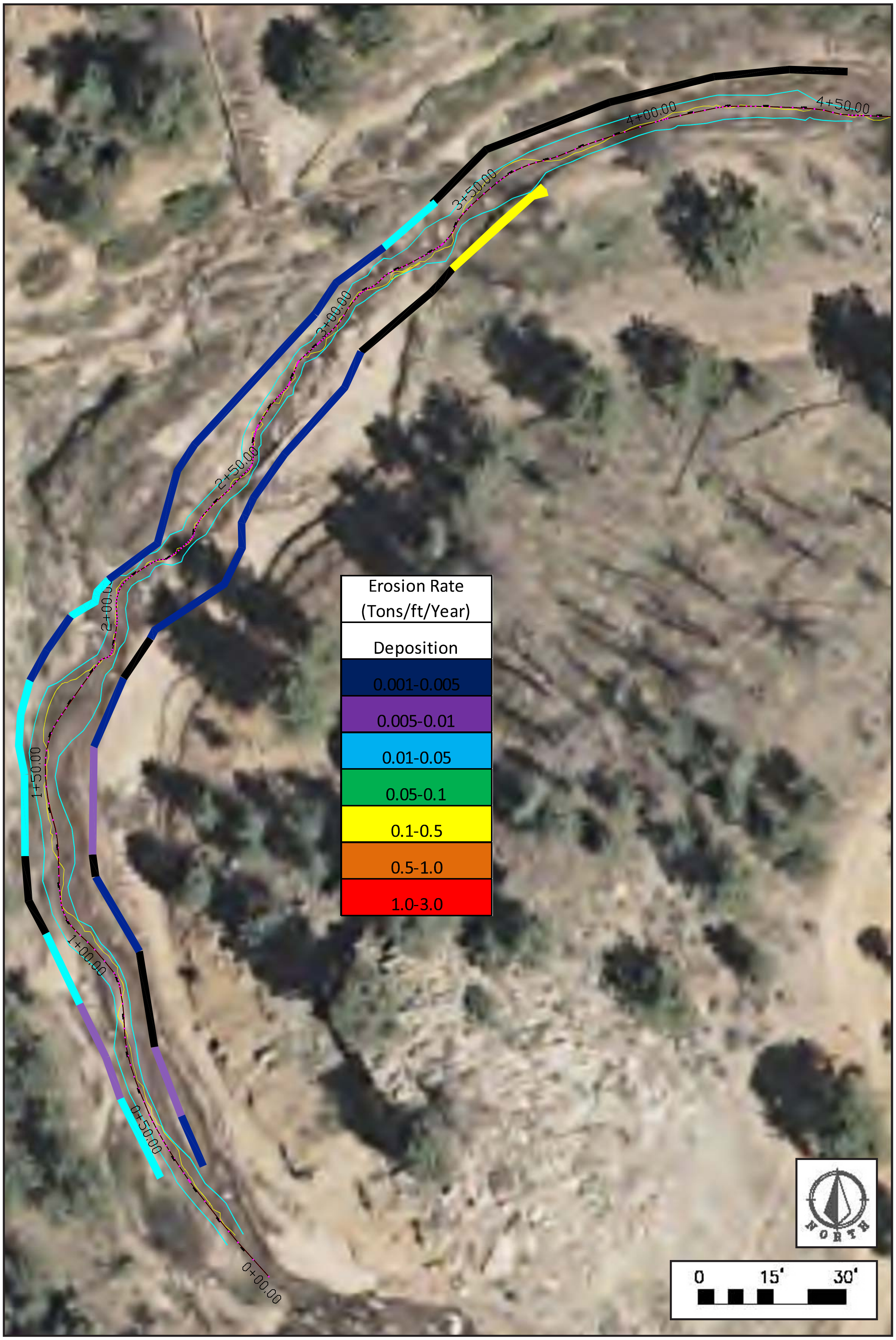
Stream: **Trail Creek, B4 Reference Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **406** Date: **8/14/2010**

Observers: **Rosgen & Kasun** Valley Type: **VIII** Stream Type: **B4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+26L**	**Low**	**High**	**0.15505**	**26.0**	**5.0**	**20.16**	**0.03733**
2. **0+20R**	**Very Low**	**Low**	**0.00386**	**20.0**	**1.0**	**0.08**	**0.00019**
3. **0+57R**	**Very Low**	**High**	**0.02130**	**37.0**	**1.0**	**0.79**	**0.00103**
4. **0+27L**	**Moderate**	**Low**	**0.15287**	**11.0**	**1.0**	**1.68**	**0.00736**
5. **0+54L**	**Very Low**	**High**	**0.02130**	**19.0**	**1.0**	**0.40**	**0.00103**
6. **0+63R**	**Low**	**Moderate**	**0.07435**	**20.0**	**1.0**	**1.49**	**0.00358**
7. **0+92L**	**Very Low**	**Low**	**0.00386**	**53.0**	**1.0**	**0.20**	**0.00019**
8 **1+35**	**Very Low**	**High**	**0.02130**	**17.0**	**1.0**	**0.36**	**0.00103**
9 **1+38L**	**Very Low**	**Very High**	**0.05002**	**17.0**	**1.0**	**0.85**	**0.00241**
10 **1+58R**	**Very Low**	**Moderate**	**0.00907**	**17.0**	**1.0**	**0.15**	**0.00044**
11 **1+69L**	**Very Low**	**Low**	**0.00386**	**6.0**	**1.0**	**0.02**	**0.00019**
12 **1+75L**	**Moderate**	**Low**	**0.15287**	**18.0**	**4.5**	**12.38**	**0.03312**
13 **2+26L**	**Very Low**	**Very Low**	**0.00164**	**47.0**	**1.0**	**0.08**	**0.00008**
14 **2+26R**	**Very Low**	**Very Low**	**0.00164**	**47.0**	**1.0**	**0.08**	**0.00008**
15 **2+71L**	**Low**	**Low**	**0.03566**	**29.0**	**2.0**	**2.07**	**0.00343**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**40.79**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**1.51**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**1.96**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0048**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**32.78**	**0.017684404**	**28.94115478**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**83.4**													
0.10%	**71.5**	**0.05%**	**0.09%**	**0.34**	**77.5**	**2.363**	**7.461**	**45.16**	**6.670**	**11.24**	**26.6**	**15.49**	**3.86**	**19.35**
0.25%	**61.9**	**0.08%**	**0.15%**	**0.55**	**66.7**	**2.036**	**5.232**	**27.28**	**4.809**	**8.10**	**36.5**	**14.94**	**4.44**	**19.37**
0.50%	**53.5**	**0.13%**	**0.25%**	**0.91**	**57.7**	**1.761**	**3.706**	**16.71**	**3.494**	**5.89**	**52.7**	**15.25**	**5.37**	**20.62**
0.75%	**45.7**	**0.13%**	**0.25%**	**0.91**	**49.6**	**1.513**	**2.592**	**10.04**	**2.502**	**4.22**	**45.3**	**9.16**	**3.85**	**13.01**
1%	**39.5**	**0.13%**	**0.25%**	**0.91**	**42.6**	**1.300**	**1.817**	**6.05**	**1.790**	**3.02**	**38.9**	**5.52**	**2.75**	**8.27**
1.5%	**33.9**	**0.25%**	**0.50%**	**1.83**	**36.7**	**1.120**	**1.289**	**3.70**	**1.289**	**2.17**	**67.0**	**6.75**	**3.96**	**10.71**
2%	**28.3**	**0.25%**	**0.50%**	**1.83**	**31.1**	**0.949**	**0.886**	**2.15**	**0.893**	**1.50**	**56.8**	**3.93**	**2.74**	**6.67**
3%	**23.8**	**0.50%**	**1.00%**	**3.65**	**26.1**	**0.795**	**0.600**	**1.22**	**0.602**	**1.01**	**95.1**	**4.46**	**3.70**	**8.16**
4%	**20.4**	**0.50%**	**1.00%**	**3.65**	**22.1**	**0.674**	**0.424**	**0.73**	**0.415**	**0.70**	**80.6**	**2.67**	**2.55**	**5.23**
5%	**18.1**	**0.50%**	**1.00%**	**3.65**	**19.2**	**0.587**	**0.322**	**0.48**	**0.304**	**0.51**	**70.2**	**1.77**	**1.87**	**3.64**
10%	**11.4**	**2.50%**	**5.00%**	**18.25**	**14.8**	**0.450**	**0.200**	**0.23**	**0.165**	**0.28**	**269.3**	**4.21**	**5.07**	**9.28**
20%	**6.2**	**5.00%**	**10.00%**	**36.50**	**8.8**	**0.269**	**0.103**	**0.07**	**0.045**	**0.08**	**321.3**	**2.58**	**2.79**	**5.38**
30%	**4.1**	**5.00%**	**10.00%**	**36.50**	**5.2**	**0.158**	**0.075**	**0.03**	**0.006**	**0.01**	**189.0**	**1.10**	**0.39**	**1.50**
40%	**2.9**	**5.00%**	**10.00%**	**36.50**	**3.5**	**0.108**	**0.068**	**0.02**	**0.000**	**0.00**	**129.1**	**0.69**	**0.00**	**0.69**
50%	**2.2**	**5.00%**	**10.00%**	**36.50**	**2.6**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**94.5**	**0.48**	**0.00**	**0.48**
60%	**1.7**	**5.00%**	**10.00%**	**36.50**	**2.0**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**72.4**	**0.37**	**0.00**	**0.37**
70%	**1.4**	**5.00%**	**10.00%**	**36.50**	**1.6**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**56.7**	**0.28**	**0.00**	**0.28**
80%	**1.2**	**5.00%**	**10.00%**	**36.50**	**1.3**	**0.039**	**0.064**	**0.01**	**0.000**	**0.00**	**47.2**	**0.24**	**0.00**	**0.24**
90%	**0.9**	**5.00%**	**10.00%**	**36.50**	**1.0**	**0.032**	**0.064**	**0.01**	**0.000**	**0.00**	**37.8**	**0.19**	**0.00**	**0.19**
100%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**18.9**	**0.09**	**0.00**	**0.09**
									Annual Totals:		**1,805.9** (cfs) **3,582.0** (acre-ft)	**90.2** (tons/yr)	**43.4** (tons/yr)	**133.5** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**32.78**	**0.017684404**	**28.94115478**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**113.6**													
0.10%	**101.8**	**0.05%**	**0.09%**	**0.34**	**107.7**	**3.285**	**16.420**	**138.16**	**13.749**	**23.16**	**36.9**	**47.40**	**7.95**	**55.35**
0.25%	**92.1**	**0.08%**	**0.15%**	**0.55**	**97.0**	**2.958**	**12.771**	**96.76**	**10.923**	**18.40**	**53.1**	**52.97**	**10.08**	**63.05**
0.50%	**83.7**	**0.13%**	**0.25%**	**0.91**	**87.9**	**2.683**	**10.107**	**69.45**	**8.815**	**14.85**	**80.2**	**63.37**	**13.55**	**76.92**
0.75%	**75.9**	**0.13%**	**0.25%**	**0.91**	**79.8**	**2.435**	**8.017**	**50.00**	**7.126**	**12.01**	**72.8**	**45.62**	**10.95**	**56.58**
1%	**69.7**	**0.13%**	**0.25%**	**0.91**	**72.8**	**2.222**	**6.441**	**36.66**	**5.826**	**9.82**	**66.5**	**33.45**	**8.96**	**42.41**
1.5%	**63.7**	**0.25%**	**0.50%**	**1.83**	**66.7**	**2.036**	**5.230**	**27.27**	**4.807**	**8.10**	**121.8**	**49.76**	**14.78**	**64.55**
2%	**57.7**	**0.25%**	**0.50%**	**1.83**	**60.7**	**1.851**	**4.175**	**19.80**	**3.903**	**6.58**	**110.8**	**36.13**	**12.00**	**48.13**
3%	**53.2**	**0.50%**	**1.00%**	**3.65**	**55.4**	**1.691**	**3.368**	**14.59**	**3.197**	**5.39**	**202.3**	**53.25**	**19.66**	**72.91**
4%	**47.3**	**0.50%**	**1.00%**	**3.65**	**50.3**	**1.533**	**2.675**	**10.51**	**2.578**	**4.34**	**183.5**	**38.35**	**15.85**	**54.20**
5%	**41.9**	**0.50%**	**1.00%**	**3.65**	**44.6**	**1.361**	**2.021**	**7.04**	**1.980**	**3.34**	**162.8**	**25.71**	**12.18**	**37.89**
10%	**26.1**	**2.50%**	**5.00%**	**18.25**	**34.0**	**1.036**	**1.079**	**2.86**	**1.085**	**1.83**	**619.9**	**52.29**	**33.35**	**85.64**
20%	**8.8**	**5.00%**	**10.00%**	**36.50**	**17.4**	**0.532**	**0.267**	**0.36**	**0.242**	**0.41**	**636.0**	**13.28**	**14.90**	**28.18**
30%	**4.3**	**5.00%**	**10.00%**	**36.50**	**6.5**	**0.200**	**0.083**	**0.04**	**0.018**	**0.03**	**238.8**	**1.55**	**1.13**	**2.67**
40%	**2.9**	**5.00%**	**10.00%**	**36.50**	**3.6**	**0.111**	**0.068**	**0.02**	**0.000**	**0.00**	**132.3**	**0.71**	**0.00**	**0.71**
50%	**2.2**	**5.00%**	**10.00%**	**36.50**	**2.6**	**0.079**	**0.066**	**0.01**	**0.000**	**0.00**	**94.5**	**0.48**	**0.00**	**0.48**
60%	**1.7**	**5.00%**	**10.00%**	**36.50**	**2.0**	**0.061**	**0.065**	**0.01**	**0.000**	**0.00**	**72.4**	**0.37**	**0.00**	**0.37**
70%	**1.4**	**5.00%**	**10.00%**	**36.50**	**1.6**	**0.047**	**0.064**	**0.01**	**0.000**	**0.00**	**56.7**	**0.28**	**0.00**	**0.28**
80%	**1.2**	**5.00%**	**10.00%**	**36.50**	**1.3**	**0.039**	**0.064**	**0.01**	**0.000**	**0.00**	**47.2**	**0.24**	**0.00**	**0.24**
90%	**0.9**	**5.00%**	**10.00%**	**36.50**	**1.0**	**0.032**	**0.064**	**0.01**	**0.000**	**0.00**	**37.8**	**0.19**	**0.00**	**0.19**
100%	**0.2**	**5.00%**	**10.00%**	**36.50**	**0.5**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**18.9**	**0.09**	**0.00**	**0.09**
									Annual Totals:		**3,045.2** (cfs) **6,040.1** (acre-ft)	**515.5** (tons/yr)	**175.3** (tons/yr)	**690.8** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, B4 Reference Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen & Kasun**	Date:	**8/14/2010**

Enter Required Information for Existing Condition

22.6	D_{50}	Riffle bed material D_{50} (mm)			
14.5	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.33	D_{max}	Largest particle from bar sample (ft)	**100**	**(mm)**	304.8 mm/ft
0.0242	S	Existing bankfull water surface slope (ft/ft)			
0.74	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.56	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
4.42	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

1.117		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 **84**	CO **180**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.4**	CO **0.58**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.93**	CO **0.38**	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope	$d = \dfrac{\tau}{\gamma S}$
Shields **0.0303**	CO **0.0126**	Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, d = existing depth	$S = \dfrac{\tau}{\gamma d}$

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trail Creek, B4 Reference** Stream Type: **B4**

Location: **Pike National Forest, CO** Valley Type: **VIII**

Observers: **Rosgen & Kasun** Date: **8/14/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trail Creek, B4 Reference Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen & Kasun**	Date:	**8/14/2010**

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 5-13)**	< 1.2 **1.0** [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	**B4**, B8 **B4** [✓ **(2)**]	B3 **(3)**	B5, B6, B7 **(4)**	**2**
3 **Meander Patterns (Worksheet 5-9)**	**M1, M3**, M4 **M1, M3** [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL [✓ **(2)**]	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**2**
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0 **1.0** [✓ **(1)**]	0.3 – 0.79 **(2)**	0.1 – 0.29 **(3)**	< 0.1 **(4)**	**1**
				Total Points	**8**
	Lateral Stability Category Point Range				
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐	

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trail Creek, B4 Reference Reach** Stream Type: **B4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **Rosgen & Kasun** Date: **8/14/2010**

	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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
		[✓ (2)]	**(4)**	**(6)**	**(8)**	
2	**Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
		Ref. Reach [✓ (2)]	**(4)**	**(6)**	**(8)**	
3	**W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
		1.0 [✓ (2)]	**(4)**	**(6)**	**(8)**	
4	**Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
		at potential [✓ (2)]	**(4)**	**(6)**	**(8)**	
5	**Depositional Patterns (Worksheet 5-10)**	B1	B2, **B4**	B3, B5	B6, B7, B8	**2**
		(1)	**B4 [✓ (2)]**	**(3)**	**(4)**	
6	**Debris / Blockages (Worksheet 5-11)**	D1, **D2**, D3	D4, D7	D5, D8	D6, D9, D10	**1**
		D2 [✓ (1)]	**(2)**	**(3)**	**(4)**	
					Total Points	**11**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, B4 Reference Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen & Kasun**	Date:	**8/14/2010**

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 5-22)**	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) (Worksheet 5-20)**	Does not indicate excess capacity **Ref. Reach** [✓ **(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 5-12)**	1.00 – 1.10 **1.00** [✓ **(2)**]	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00 **1.00** [✓ **(1)**]	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**1**
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Trail Creek, B4 Reference Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen & Kasun**	Date:	**8/14/2010**

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 5-24)**	**Stream Type at Potential**, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C)	(C→High W/d C), (E→C)	(G→F), (F→D)	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F)	2
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Lateral Stability (Worksheet 5-25)**	*Stable*	*Moderately Unstable*	*Unstable*	*Highly Unstable*	2
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition*	*Moderate Deposition*	*Excess Deposition*	*Aggradation*	2
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised*	*Slightly Incised*	*Moderately Incised*	*Degradation*	2
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
				Total Points	**8**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, B4 Reference Reach**	Stream Type:	**B4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**Rosgen & Kasun**	Date:	**8/14/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 Lateral Stability (Worksheet 5-25)	***Stable***	[✓ **1**]	**1**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)	***No Deposition***	[✓ **1**]	**1**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 Vertical Stability Channel Incision or Degradation (Worksheet 5-27)	***Not Incised***	[✓ **1**]	**1**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 Channel Enlargement Prediction (Worksheet 5-28)	***No Increase***	[✓ **1**]	**1**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 Pfankuch Channel Stability (Worksheet 5-15)	***Good: Stable***	[✓ **1**]	**1**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**5**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☑	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, B4 Reference Reach**					Location:	**Pike National Forest, Colorado**				
Observers:	**Rosgen & Kasun**			Date:	**8/14/2010**	Stream Type:	**B4**	Valley Type:	**VIII**		
Channel Dimension (Riffle XS 0+18.5)	Mean Bankfull Depth (ft):	**0.74**	Bankfull Width (ft):	**9.31**	Cross-Sectional Area (ft^2):	**6.91**	Width of Flood-Prone Area (ft):	**18.48**	Entrenchment Ratio:	**1.99**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**10.4** **8.7-12.9**	L_m/W_{bkf}:	**11.2** **9.4-13.5**	R_c/W_{bkf}:	**3.9** **1.0-7.6**	MWR:	**2.7** **1.5-6.0**	Sinuosity:	**1.13**
River Profile & Bed Features	Check: ☐ Riffle/Pool	☑ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed						
	Max Bankfull Depth (ft):	Riffle **1.06**	Pool **1.52**	Depth Ratio (max to mean):	Riffle **1.53**	Pool **2.19**	Pool-to-Pool Spacing:	Ratio **2.8**	Slope Valley: **0.02735**	Water Surface: **0.0242**	
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Aspen, Willow - High**		Potential Composition/Density: **Aspen, Willow - High**		Remarks: Condition, Vigor & Usage of Existing Reach: **Recovering Riparian inside of past G/F_b**					
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-3(3)**	Meander Patterns:	**M1, M3**	Depositional Patterns:	**B4**	Debris/Channel Blockages:	**D2 (Infrequent)**	
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**60 (Good)**					
	Width/depth Ratio (W/d):	**12.6**	Reference W/d Ratio (W/d_{ref}):	**12.6**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$:	**1.0**	W/d Ratio State Stability Rating:	**Stable**			
	Meander Width Ratio (MWR):	**2.7**	Reference MWR_{ref}:	**2.7**	Degree of confinement (MWR / MWR_{ref}):	**1.0**	MWR / MWR_{ref} Stability Rating:	**Unconfined**			
Bank Erosion Summary	Length of Reach Studied (ft):	**406**	Annual Streambank Erosion Rate: **1.96** (tons/yr)	**0.0048** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:					
Sediment Capacity (POWERSED)	☑ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks:							
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**100**	$\tau =$	**1.117**	$\tau^* =$	**N/A**	Existing Depth:	**0.70**	Required Depth: **.38-.93**	Existing Slope: **0.024**	Required Slope: **.0126-0.0303**
Successional Stage Shift	C ⟶ G ⟶ F ⟶ [✓ B] ⟶ ⟶						Existing Stream State (Type):	**B4**	Potential Stream State (Type):	**B4**	
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Reference Reach**					
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:	**Reference Reach**					
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Reference Reach**					
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**Reference Reach**					
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:	**Reference Reach**					

Appendix C19

B4/2c Stream Type

Reference Reach

Table of Contents

Appendix C19: B4/2c Reference Reach

B4/2c Reference Reach Location & Overview

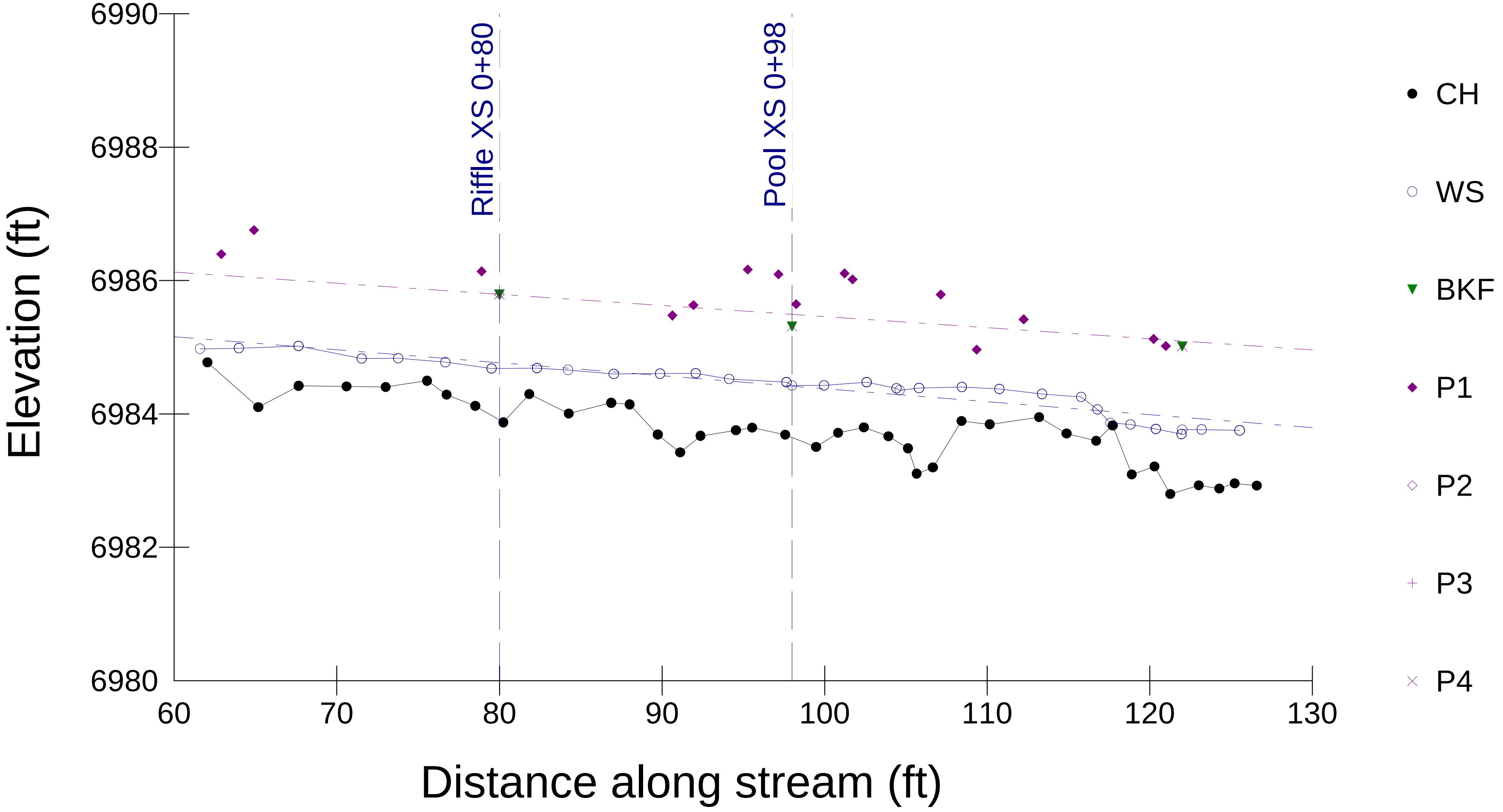
The B4/2c reference reach is in a Valley Type VIIIb located on the mainstem on West Monument Creek (see location map **Figure C-1**). This reach is dominated by gravel and influenced by boulders. The channel bed and banks show little sediment yield and good stability from abundant vegetation and boulders. Bed features are generally dominated by rapids and pool. The channel is perennial and streamflow is seasonal by snowmelt and stormflow runoff. Flow is regulated by an upstream dam and is altered due to Waldo Canyon Fire. The reach is a 4th order channel. This reach has very low streambank erosion rates (*0.0050 tons/yr/ft*, see **Worksheet 5-18**).

The photograph depicts the stable characteristics of this stream type. There is little to no evidence of active channel-source sediment from this stream type. Such stream types are mapped where they occur by sub-watershed as shown in **Appendix D**.

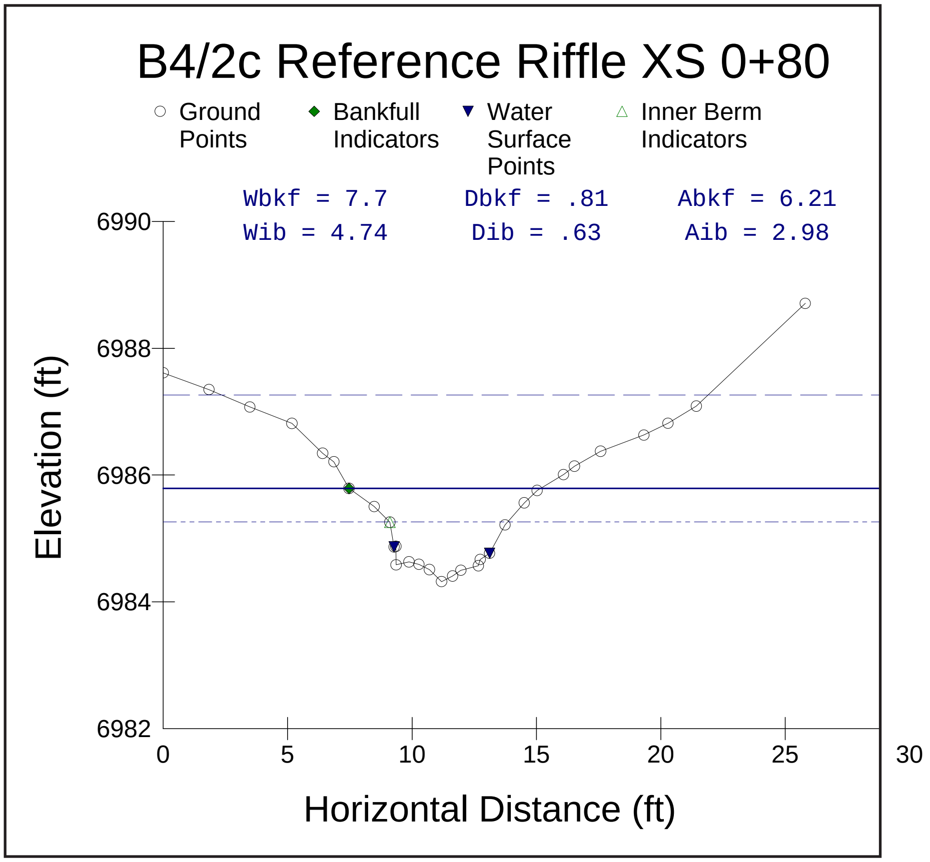
The details of the dimension, pattern, profile, and materials are summarized. The following summary worksheets provide details of the morphology, hydraulics, stability, and streambank erosion rates for this reference reach. In the situation where impaired B4/2, G4/2, and F4/2 stream types are located, an alternative for mitigation and sediment reduction is to use the data from the stable form to extrapolate for potential implementation of natural channel design.

Survey Summary

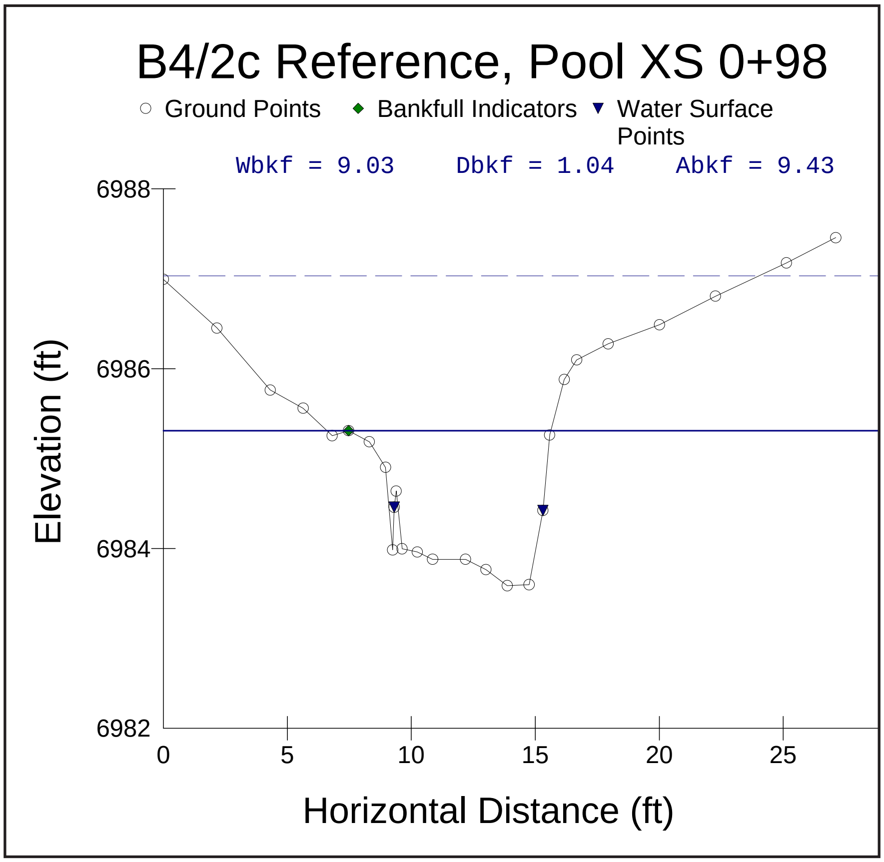
B4/2c Reference Longitudinal Profile



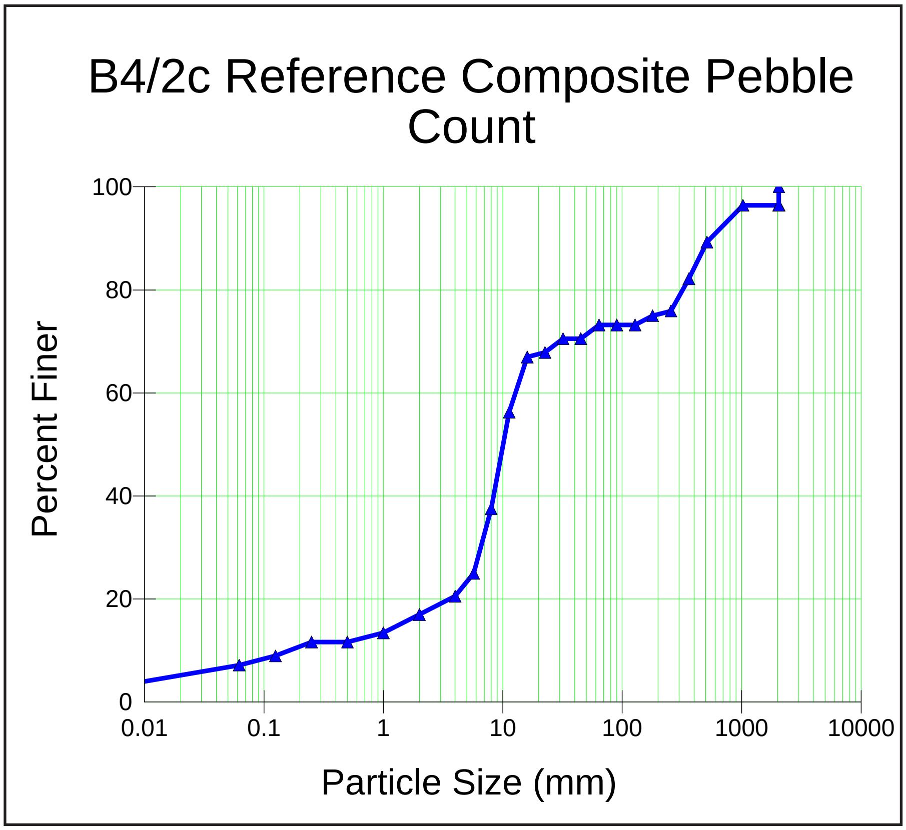
Longitudinal Profile (graph generated from RIVERMorph^{TM})



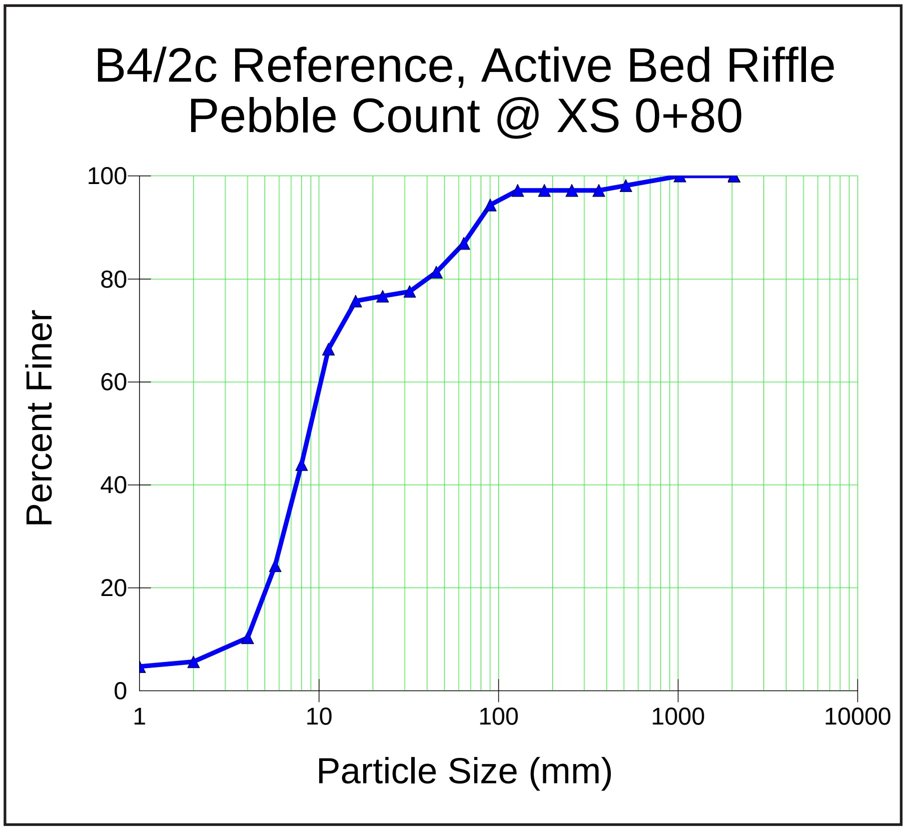
Representative Cross-section 0+80 (graph generated from RIVERMorph^{TM})



Cross-section 0+98 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS **Worksheets**

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**West Monument B4/2c Reference**		Location:	**XS 0+80, Pike N.F., Colorado**	
Date:	**11/6/2012**	Stream Type: **B4/2c**	Valley Type:	**VIIIb**	
Observers:	**Bones, Kyle, David, Luke, Kim**		HUC:	__ __ __ __ __ __ __ __ __ __ __	

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**6.21**	**A_{bkf}** (ft^2)	Bankfull Riffle Mean DEPTH	**0.81**	**d_{bkf}** (ft)
Bankfull Riffle WIDTH	**7.7**	**W_{bkf}** (ft)	Wetted PERMIMETER ~ $(2 * d_{bkf}) + W_{bkf}$	**8.72**	**W_p** (ft)
D_{84} at Riffle	**54.1**	**Dia.** (mm)	D_{84} (mm) / 304.8	**0.18**	**D_{84}** (ft)
Bankfull SLOPE	**0.01**	**S_{bkf}** (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.71**	**R** (ft)
Gravitational Acceleration	**32.2**	**g** (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**4.01**	**R / D_{84}**
Drainage Area	**10.95**	**DA** (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.546**	**u*** (ft/sec)

ESTIMATION METHODS		Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness	$u = [\,2.83 + 5.66 * \text{Log}\{R / D_{84}\}\,]\,u^*$	**3.41**	ft / sec	**21.18**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8)	$u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.046**	**2.94**	ft / sec	**18.26**	cfs
2. Roughness Coefficient: b) Manning's *n* from Stream Type (Fig. 5-9)	$u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.08**	**1.69**	ft / sec	**10.49**	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	$u = 1.49*R^{2/3}*S^{1/2} / n$ $n = 0.39*S^{0.38}*R^{-0.16}$ $n =$ **0.079**	**1.71**	ft / sec	**10.64**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**		**3.85**	ft / sec	**23.9**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)			ft / sec		cfs
4. Continuity Equations: a) Regional Curves **u = Q / A** **Return Period for Bankfull Discharge** **Q =** ______ **year**			ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data **u = Q / A**			ft / sec		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. Level II stream classification.

Stream: **West Mounment Creek, B2/4c Reference**

Basin: Drainage Area: **7010** acres **10.95** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: **;** Sec.&Qtr.: **;**

Cross-Section Monuments (Lat./Long.): **XS 0+80** Date: **11/06/12**

Observers: **Bones, Kyle, David, Luke, Kim** Valley Type: VIIIb

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**7.7**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.81**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**6.21**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**9.51**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.47**	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.	**19.54**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.54**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**10.2**	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.	**0.013**	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 (S_{val} / S).	**1.06**	

Stream Type **B2/4c** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument B4/2c Reference** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/06/12** Valley Type: **VIIIb** Stream Type: **B4/2c**

River Reach Dimension Summary Data.....1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	8.04	7.70	8.37	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	5.23	4.25	6.21
Mean Riffle Depth (d_{bkf})	0.66	0.51	0.81	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	12.96	9.51	16.41
Maximum Riffle Depth (d_{max})	1.12	0.77	1.47	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.66	1.51	1.82
Width of Flood-Prone Area (W_{fpa})	16.46	13.37	19.54	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	2.07	1.60	2.54
Riffle Inner Berm Width (W_{ib})	5.19	4.74	5.64	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.65	0.62	0.67
Riffle Inner Berm Depth (d_{ib})	0.48	0.33	0.63	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.71	0.64	0.78
Riffle Inner Berm Area (A_{ib})	2.41	1.85	2.98	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.46	0.43	0.48
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	12.39	7.56	17.23					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	7.010	4.990	9.030	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	0.872	0.621	1.123
Mean Pool Depth (d_{bkfp})	1.320	1.040	1.600	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	2.000	1.576	2.424
Pool Cross-Sectional Area (A_{bkfp})	8.690	7.990	9.380	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.662	1.528	1.793
Maximum Pool Depth (d_{maxp})	1.990	1.720	2.260	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	3.015	2.606	3.424
Pool Inner Berm Width (W_{ibp})	3.2	2.8	3.7	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.523	0.305	0.740
Pool Inner Berm Depth (d_{ibp})	0.26	0.18	0.34	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.194	0.176	0.212
Pool Inner Berm Area (A_{ibp})	0.9	0.5	1.3	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.106	0.054	0.157
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **West Monument B4/2c Reference**		Location: **Pike National Forest, Colorado**	
Observers: **Bones, Kyle, David, Luke, Kim**	Date: **11/6/2012**	Valley Type: **VIIIb**	Stream Type: **B4/2c**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	1.69	ft/sec	Estimation Method	n By Stream Type	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	10.49	cfs	Drainage Area	10.95	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	51.0	43.0	59.0	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	6.34	5.35	7.34
Stream Meander Length (L_m)	55.0	50.0	60.0	ft	Stream Meander Length Ratio (L_m / W_{bkf})	6.84	6.22	7.46
Radius of Curvature (R_c)	22.3	15.0	34.0	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	2.89	1.95	4.42
Belt Width (W_{blt})	18.0	15.4	20.4	ft	Meander Width Ratio (W_{blt} / W_{bkf})	10.45	5.94	18.51
Arc Length (L_a)	12.0	9.4	15.7	ft	Arc Length to Riffle Width (L_a / W_{bkf})	1.49	1.17	1.95
Riffle Length (L_r)	13.3	13.3	13.3	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	1.65	1.65	1.65
Individual Pool Length (L_p)	5.4	5.0	6.1	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.67	0.62	0.76
Pool to Pool Spacing (P_s)	20.3	14.5	26.0	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	2.52	1.80	3.23

Channel Profile

Valley Slope (S_{val})	0.0146	ft/ft	Average Water Surface Slope (S)	0.0130	ft/ft	Sinuosity (S_{val} / S)	1.06
Stream Length (SL)	154.2	ft	Valley Length (VL)	145.4	ft	Sinuosity (SL / VL)	1.06

Low Bank Height (LBH)	start	1.50	ft	Max Bankfull Depth (d_{max})	start	1.50	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start	1.0
	end	1.50	ft		end	1.50	ft		end	1.0

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.0180	0.0180	0.0180	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	1.3846	1.3846	1.3846
Run Slope (S_{run})				ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)			
Pool Slope (S_p)	0.0020	0.0000	0.0060	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.1538	0.0000	0.4615
Glide Slope (S_g)	0.0130	0.0130	0.0130	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	1.0000	1.0000	1.0000
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	1.55	1.55	1.55	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	2.348	2.348	2.348
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})	2.13	1.94	2.25	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	3.227	2.939	3.409
Max Glide Depth (d_{maxg})	1.41	1.41	1.41	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	2.136	2.136	2.136
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	7.14	0.00		D_{16}	1.73	4.69			mm
% Sand	9.82	5.61		D_{35}	7.54	6.95			mm
% Gravel	56.25	81.31		D_{50}	10.20	8.89			mm
% Cobble	2.68	10.28		D_{84}	401.02	54.11			mm
% Boulder	20.54	2.80		D_{95}	921.46	98.25			mm
% Bedrock	3.57	0.00		D_{100}	Bedrock	1023.97			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **West Monument B4/2c Reference**

Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **11/6/2012**

Existing species composition: **Spruce, Aspen, Willows, Choke Cherry, Grass and Moss**

Potential species composition: **Spruce, Aspen, Willows, Choke Cherry, Grass and Moss**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	85%	15%	blue spruce	50%
				aspen	40%
				douglas fir	10%
					0%
					0%
					0%
					100%
2. Understory	Shrub layer	▨	10%	willow	60%
				redtwig dogwood	5%
				rose	5%
				chokecherry	30%
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	5%	grasses	70%
				moss	30%
					0%
					0%
					0%
					0%
					100%
	Leaf or needle litter	▨	65%		
	Bare ground	▨	5%		
			Column Total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Riparian zone is vigorus and healthy

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **West Monument B4/2c Referenc** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/6/2012**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P7**	**P8**				

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **West Monument B4/2c Reference**
Location: **Pike National Forest, Colorado**
Observers: **Bones, Kyle, David, Luke, Kim**
Date: **11/6/2012**

Stream Size Category and Order ☞ **S-3(4)**

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 5-9. Meander patterns.

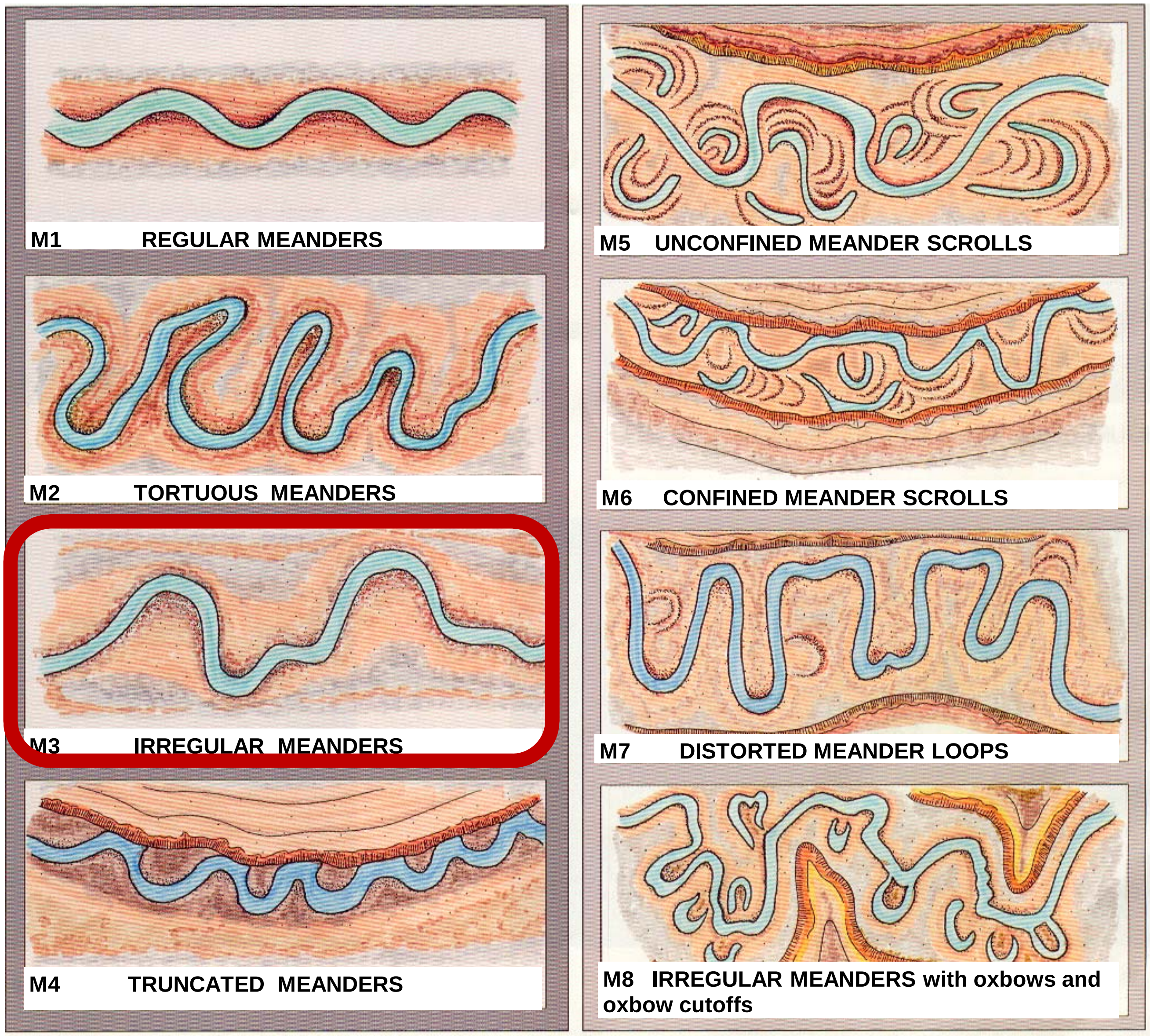
Meander Patterns

Stream: **West Monument B4/2c Reference** Location: **Pike National Forest, CO**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/6/2012**

List ALL CATEGORIES that APPLY ☞	**M3**				

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



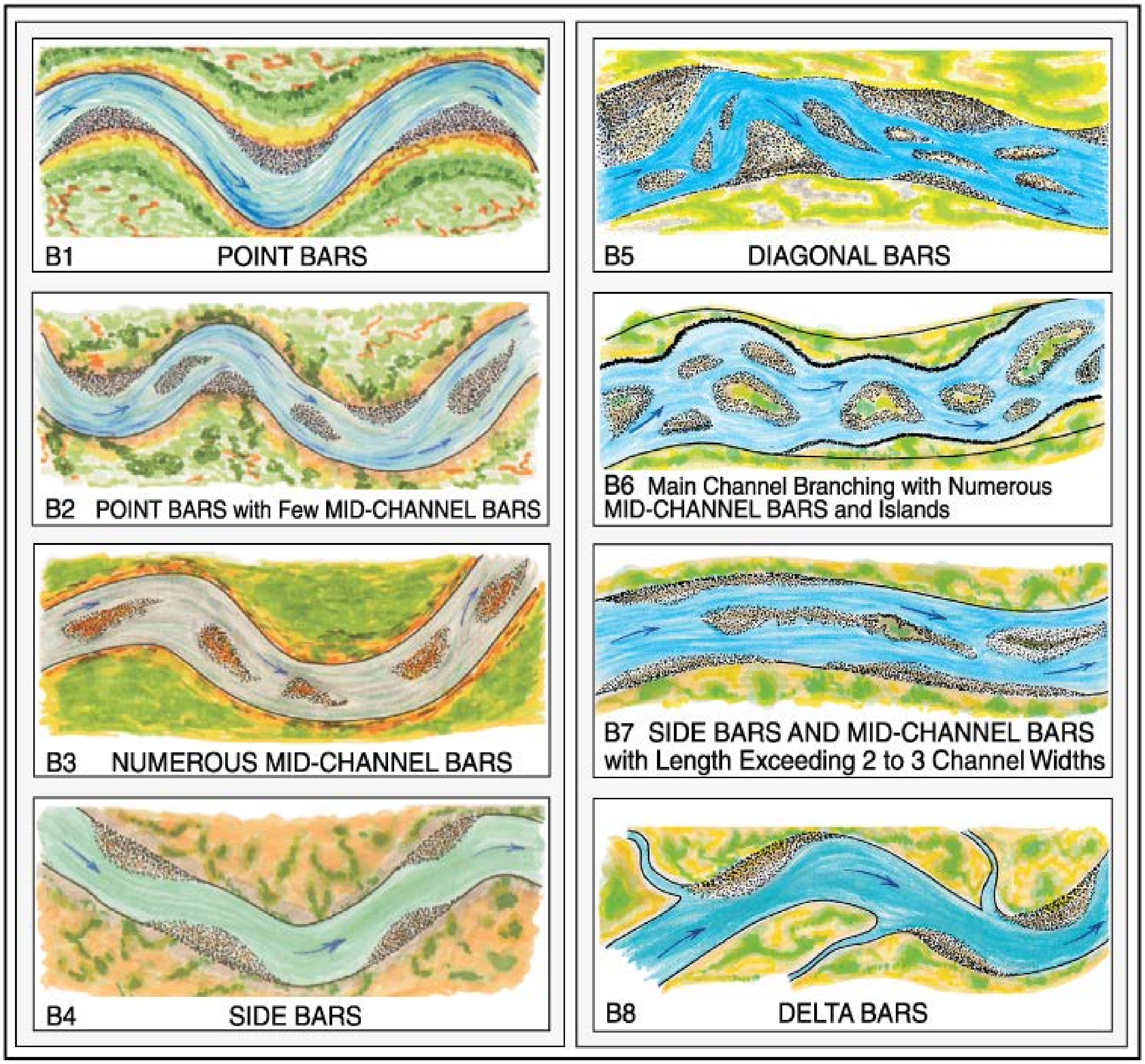
Worksheet 5-10. Depositional patterns.

Depositional Patterns

Stream:	**West Monument B4/2c Reference**	Location:	**Pike National Forest, Colorado**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/6/2012**

List ALL CATEGORIES that APPLY ☞	**NA**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **West Monument B4/2c Reference** Location: **Pike National Forest, Colorado**
Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/6/2012**

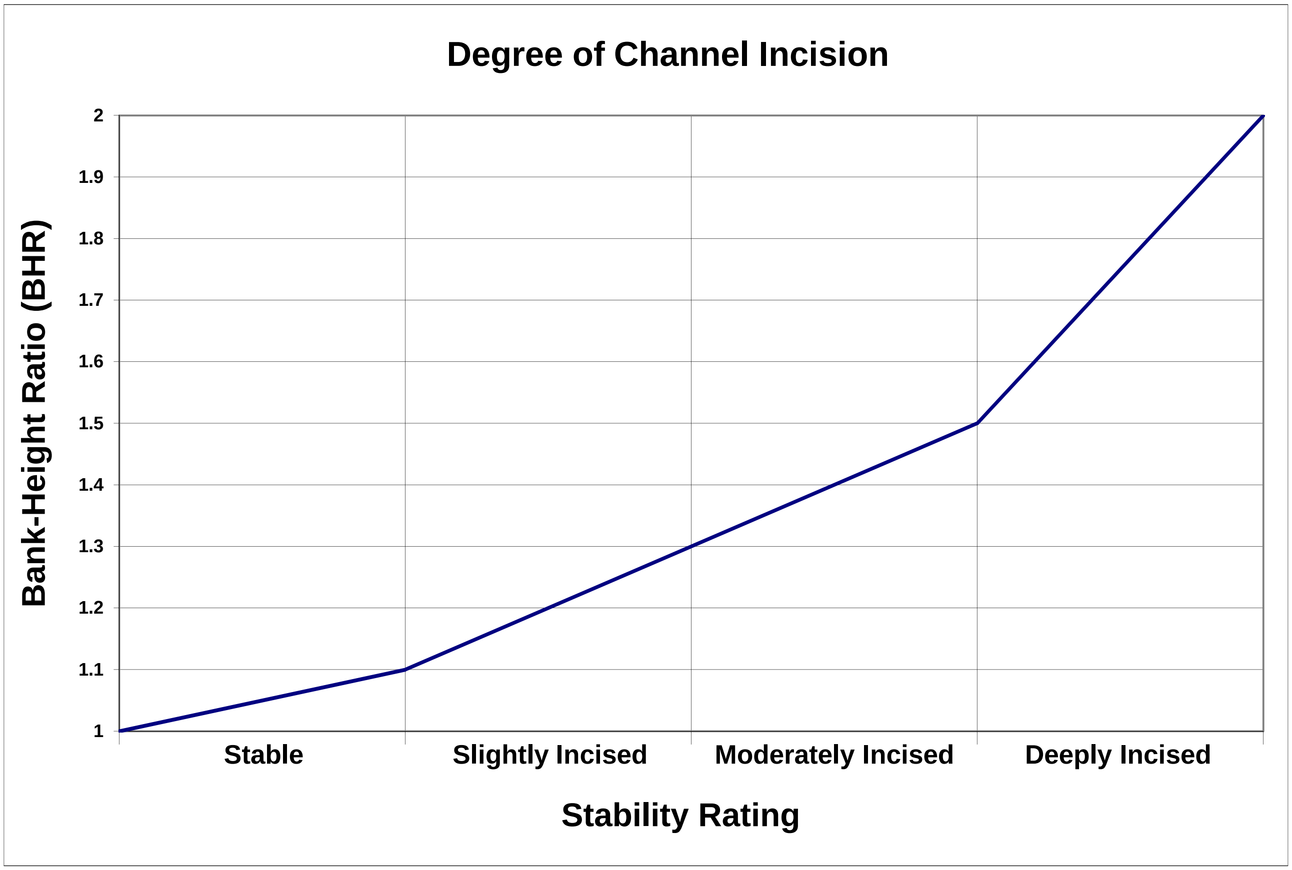
Description/extent		**Materials that upon placement into the active channel or flood-prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.**	**Check (✓) all that apply**
D1	None	Minor amounts of small, floatable material.	☐
D2	Infrequent	Debris 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 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**1.5**	Bank-Height Ratio:	**1.0**
Max Bankfull Depth:	**1.5**		

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

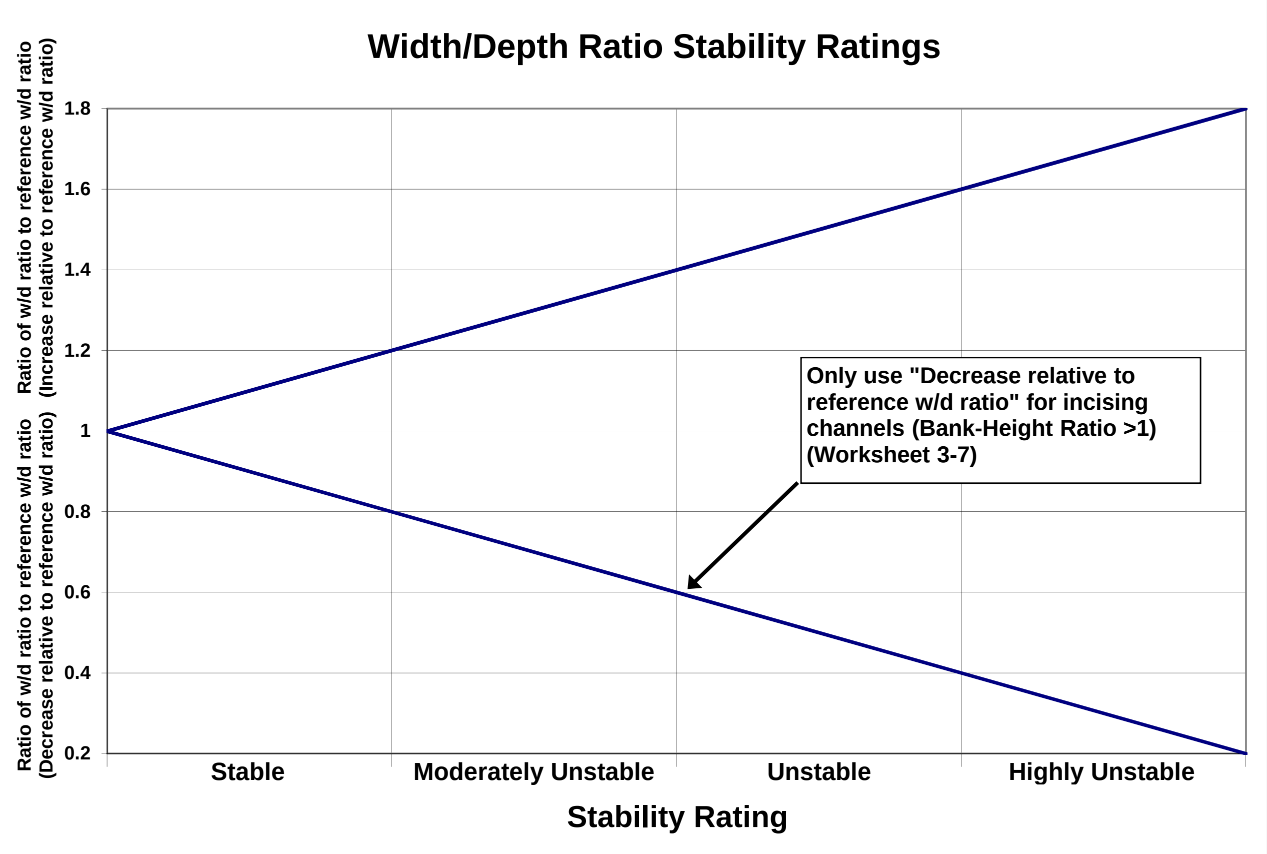
Width/Depth Ratio State

Existing Width/Depth Ratio: **9.51**

Reference Width/Depth Ratio: **9.51**

Ratio of existing W/d to reference W/d: **1.00**

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

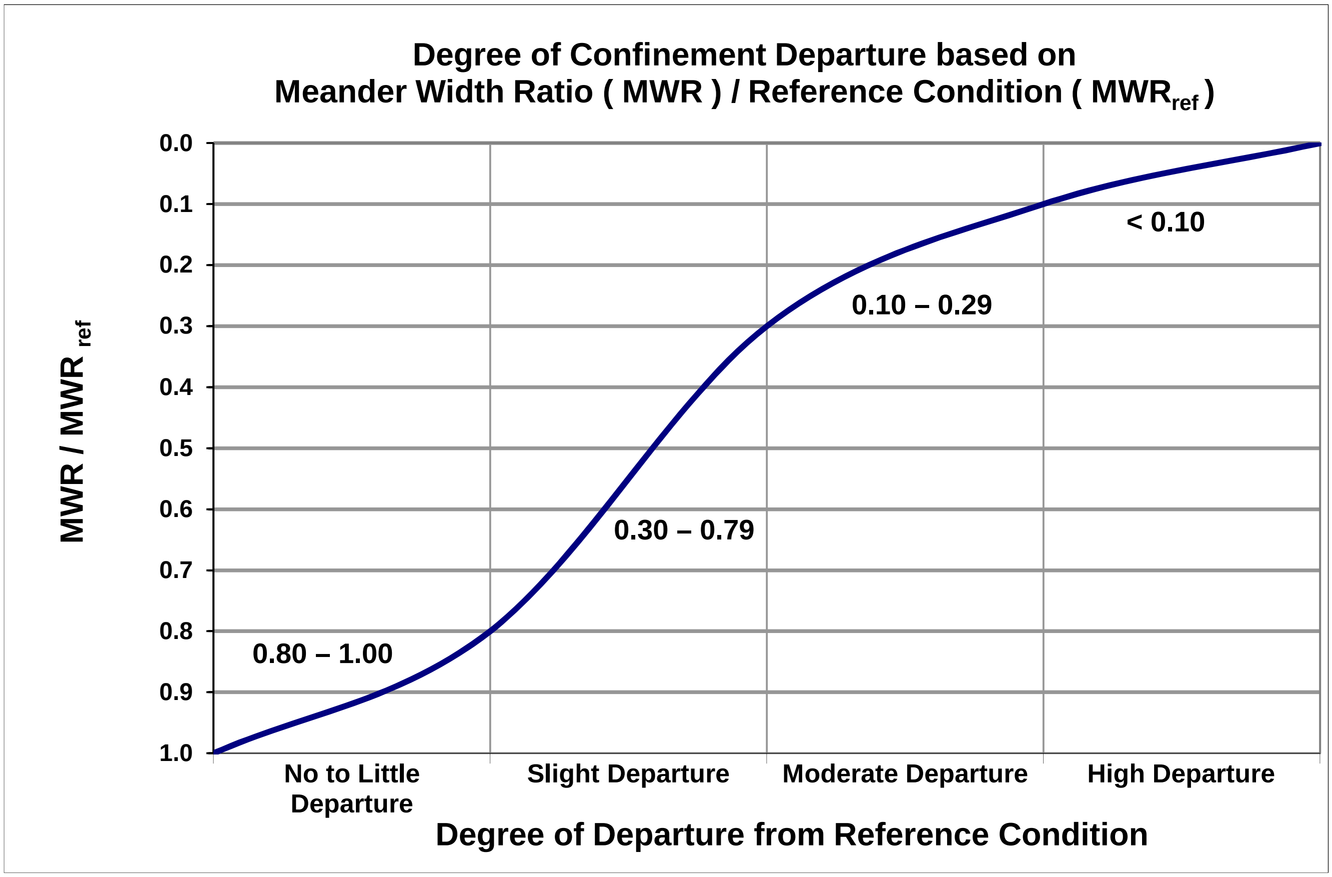


Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**2.34**	Ratio of MWR to MWR_{ref}:	**1.00**
Reference Meander Width Ratio (MWR_{ref}):	**2.34**		

Degree of Confinement Stability Rating ☞	**Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: West Monument B4/2c Reference **Location:** Pike National Forest, CO **Valley Type:** VIIIb **Observers:** Bones, Kyle, David, Luke, Kim **Date:** 11/6/2012

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	[✓ 2]	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	[✓ 3]	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	[✓ 5]	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	[✓ 3]	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	[✓ 2]	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	[✓ 4]	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	[✓ 4]	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	[✓ 4]	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	13	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	[✓ 3]	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	[✓ 4]	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	[✓ 8]	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	[✓ 6]	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	[✓ 3]	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	25	Good total =	29	Fair total =	6	Poor total =	0

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	[✓ B4]	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	54
Existing stream type =	B2/4c
*Potential stream type =	B2/4c
Modified channel stability rating =	Good

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

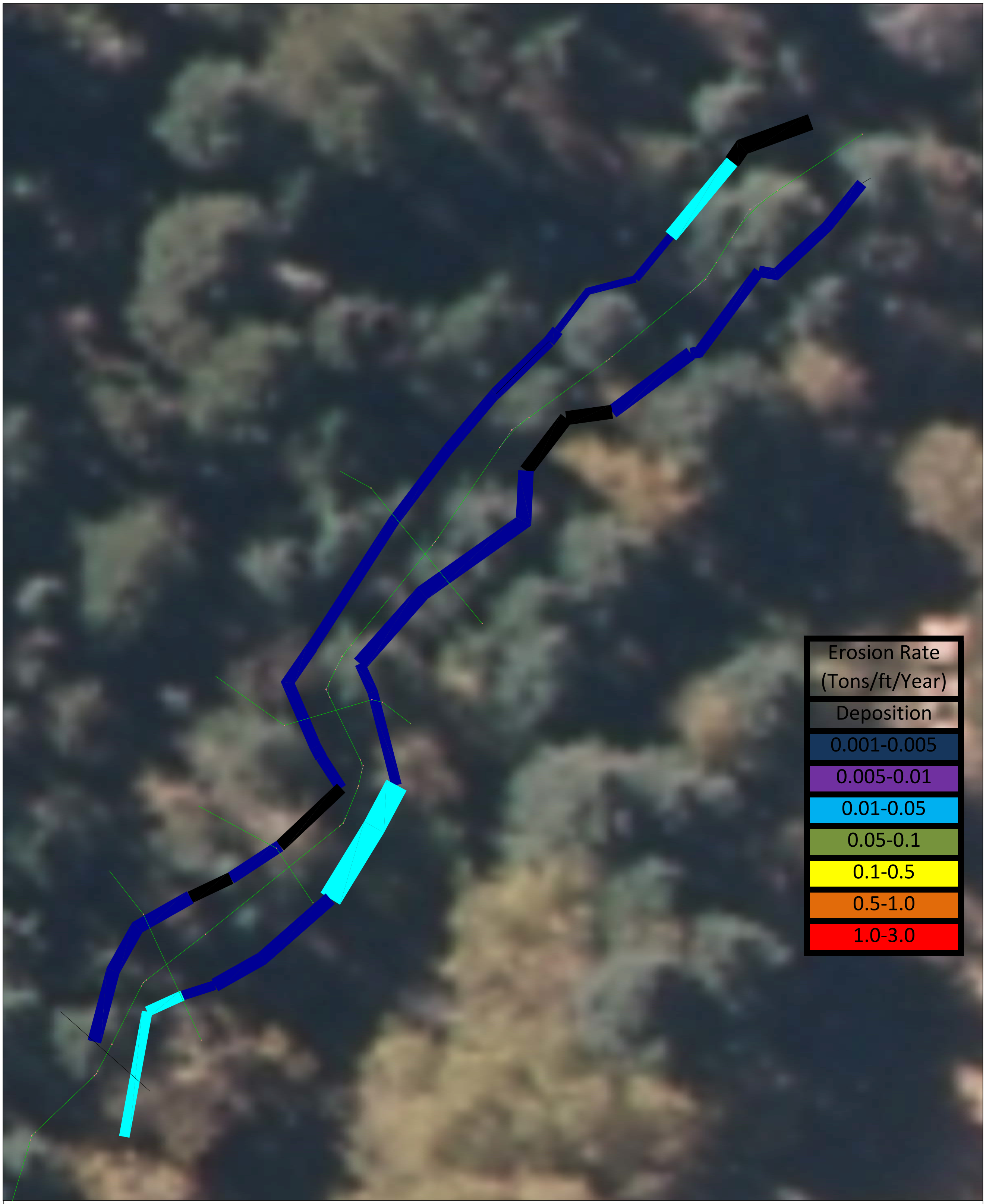
Stream: **West Monument B4/2c Reference** Location: **B4/2c Reference**

Graph Used: **Colorado** Total Stream Length (ft): **115** Date: **11/6/2012**

Observers: **David Luke Bones Kyle Kim** Valley Type: **VIIIb** Stream Type: **B4/2c**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 3-11) (adjective)**	**NBS rating (Worksheet 3-12) (adjective)**	**Bank erosion rate (Figure 3-9 or 3-10) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **RB 10 to 22**	**Moderate**	**Low**	**0.153**	**12.0**	**1.7**	**3.12**	**0.01250**
2. **LB 0 to 17**	**Very Low**	**Low**	**0.004**	**17.0**	**1.5**	**0.10**	**0.00030**
3. **LB 17 to 32**	**Low**	**Very Low**	**0.018**	**15.0**	**1.4**	**0.37**	**0.00120**
4. **RB 22 to 32**	**Very Low**	**Low**	**0.004**	**10.0**	**1.0**	**0.04**	**0.00020**
5. **LB 32 to 42**	**Low**	**Low**	**0.042**	**10.0**	**1.7**	**0.71**	**0.00340**
6. **RB 32 to 42**	**Low**	**Low**	**0.042**	**10.0**	**0.9**	**0.38**	**0.00180**
7. **RB 42 to 51**	**Low**	**Low**	**0.042**	**9.0**	**1.5**	**0.56**	**0.00300**
8. **RB 51 to 58**	**Low**	**Low**	**0.042**	**7.0**	**1.4**	**0.41**	**0.00280**
9. **LB 56 to 89**	**Very Low**	**Low**	**0.004**	**33.0**	**1.9**	**0.24**	**0.00040**
10. **RB 58 to 89**	**Low**	**Moderate**	**0.073**	**31.0**	**1.4**	**3.15**	**0.00490**
11. **LB 89 to97**	**Very Low**	**Low**	**0.004**	**12.0**	**1.3**	**0.06**	**0.00020**
12. **RB 89 to 99**	**Low**	**Low**	**0.042**	**14.0**	**1.5**	**0.88**	**0.00300**
13. **LB 97 to 101**	**Moderate**	**Low**	**0.153**	**4.0**	**2.8**	**1.71**	**0.02060**
14. **RB 99 to 104**	**Low**	**Very Low**	**0.018**	**5.0**	**1.4**	**0.12**	**0.00110**
15. **LB 101 to 115**	**Very Low**	**Moderate**	**0.009**	**14.0**	**1.7**	**0.22**	**0.00070**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**12.06**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**0.45**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**0.58**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Unit Erosion Rate (tons/yr/ft)**	**0.0050**	

Streambank Erosion Map



Waldo Canyon Fire WARSSS
Typical Reach

Wildland Hydrology
11210 North County Road 19
Fort Collins, CO
80524
Tel. 970-568-0002
Fax. 970.568.0014

FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation type	Intercept	Coefficient	Exponent	Form (e.g., linear, non-linear, etc.)	Equation name
1. Bedload (dimensionless)	-0.0113	1.0139	2.1929	Non-Linear	Pagosa Springs Reference Curve
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve
3. User-defined relations (bedload)					
4. User-defined relations (suspended sediment)					

Bankfull discharge (cfs)	Bankfull bedload (kg/s)	Bankfull suspended (mg/l)
8.30	0.0163	11.50

Notes:

Pre-Fire Flow Duration Curve, Good/Fair Sediment Curves, Good/Fair Regional Sediment Curves

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment [(5)×(9)]	(14) Bedload sediment [(5)×(11)]	(15) 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	0.1													
90.000	0.3	95.00	10.00	36.50	0.2	0.02	0.8	0.0	0.0000	0.00	1.70	0.00	0.00	0.00
80.000	0.4	85.00	10.00	36.50	0.3	0.04	0.8	0.0	0.0000	0.00	3.30	0.00	0.00	0.00
70.000	0.4	75.00	10.00	36.50	0.4	0.05	0.8	0.0	0.0000	0.00	4.10	0.00	0.00	0.00
60.000	0.6	65.00	10.00	36.50	0.5	0.06	0.8	0.0	0.0000	0.00	4.90	0.00	0.00	0.00
50.000	0.7	55.00	10.00	36.50	0.6	0.08	0.8	0.0	0.0000	0.00	6.30	0.00	0.00	0.00
40.000	0.9	45.00	10.00	36.50	0.8	0.10	0.8	0.0	0.0000	0.00	8.20	0.00	0.00	0.00
30.000	1.3	35.00	10.00	36.50	1.1	0.14	0.8	0.0	0.0001	0.00	11.30	0.00	0.00	0.00
20.000	2.0	25.00	10.00	36.50	1.7	0.20	0.9	0.0	0.0004	0.00	16.50	0.00	0.00	0.00
10.000	3.6	15.00	10.00	36.50	2.8	0.34	1.2	0.0	0.0017	0.09	27.90	0.36	3.28	3.64
5.000	5.8	7.50	5.00	18.25	4.7	0.57	2.3	0.0	0.0060	0.26	23.50	0.55	4.75	5.30
4.000	6.5	4.50	1.00	3.65	6.1	0.74	3.7	0.1	0.0109	0.48	6.13	0.22	1.75	1.97
3.000	7.6	3.50	1.00	3.65	7.0	0.85	4.8	0.1	0.0148	0.65	7.03	0.33	2.37	2.70
2.000	9.0	2.50	1.00	3.65	8.3	1.00	6.8	0.2	0.0214	0.91	8.29	0.55	3.32	3.87
1.500	10.3	1.75	0.50	1.83	9.7	1.17	9.6	0.3	0.0302	1.30	4.83	0.46	2.37	2.83
1.000	12.6	1.25	0.50	1.83	11.5	1.38	14.0	0.4	0.0439	1.90	5.73	0.78	3.47	4.25
0.900	13.4	0.95	0.10	0.37	13.0	1.57	17.4	0.7	0.0540	2.51	1.30	0.24	0.92	1.16
0.800	14.2	0.85	0.10	0.37	13.8	1.66	17.4	0.8	0.0540	2.85	1.38	0.29	1.04	1.33
0.700	14.9	0.75	0.10	0.37	14.6	1.76	17.4	1.0	0.0540	3.20	1.46	0.35	1.17	1.52
0.600	15.9	0.65	0.10	0.37	15.4	1.86	17.4	1.2	0.0540	3.63	1.54	0.42	1.32	1.74
0.500	17.0	0.55	0.10	0.37	16.5	1.99	17.4	1.5	0.0540	4.23	1.65	0.53	1.54	2.07
0.250	19.7	0.38	0.25	0.91	18.4	2.22	17.4	2.1	0.0540	5.36	4.59	1.91	4.89	6.80
0.100	22.8	0.18	0.15	0.55	21.3	2.56	17.4	3.4	0.0540	7.39	3.19	1.86	4.05	5.91
0.050	24.4	0.08	0.05	0.18	23.6	2.84	17.4	4.9	0.0540	9.29	1.18	0.89	1.70	2.59
0.010	26.5	0.03	0.04	0.15	25.5	3.07	17.4	6.3	0.0540	10.97	1.02	0.92	1.60	2.52
0.005	26.5	0.01	0.01	0.02	26.5	3.20	17.4	7.2	0.0540	12.01	0.13	0.13	0.22	0.35
0.001	26.5	0.00	0.00	0.01	26.5	3.20	17.4	7.2	0.0540	12.01	0.11	0.11	0.18	0.29
											Annual totals:	10.9 (tons/yr)	39.9 (tons/yr)	50.8 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

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	8.30	0.0163	11.50
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve			
3. User-defined relations (bedload)						Notes: **Post-Fire Flow Duration Curve, Good/Fair Sediment Curves, Good/Fair Regional Sediment Curves**		
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	0.1													
90.000	0.3	95.00	10.00	36.50	0.2	0.02	0.8	0.0	0.0000	0.00	1.60	0.00	0.00	0.00
80.000	0.4	85.00	10.00	36.50	0.3	0.04	0.8	0.0	0.0000	0.00	3.30	0.00	0.00	0.00
70.000	0.4	75.00	10.00	36.50	0.4	0.05	0.8	0.0	0.0000	0.00	4.10	0.00	0.00	0.00
60.000	0.6	65.00	10.00	36.50	0.5	0.06	0.8	0.0	0.0000	0.00	4.90	0.00	0.00	0.00
50.000	0.7	55.00	10.00	36.50	0.6	0.08	0.8	0.0	0.0000	0.00	6.30	0.00	0.00	0.00
40.000	0.9	45.00	10.00	36.50	0.8	0.10	0.8	0.0	0.0000	0.00	8.20	0.00	0.00	0.00
30.000	1.5	35.00	10.00	36.50	1.2	0.14	0.8	0.0	0.0001	0.00	11.90	0.00	0.00	0.00
20.000	2.9	25.00	10.00	36.50	2.2	0.26	1.0	0.0	0.0008	0.04	21.80	0.36	1.46	1.82
10.000	6.0	15.00	10.00	36.50	4.4	0.53	2.1	0.0	0.0052	0.22	44.30	0.73	8.03	8.76
5.000	8.9	7.50	5.00	18.25	7.4	0.89	5.4	0.1	0.0166	0.73	37.05	2.01	13.32	15.33
4.000	9.7	4.50	1.00	3.65	9.3	1.12	8.7	0.2	0.0275	1.17	9.28	0.80	4.27	5.07
3.000	11.0	3.50	1.00	3.65	10.3	1.25	11.1	0.3	0.0350	1.51	10.34	1.13	5.51	6.64
2.000	12.4	2.50	1.00	3.65	11.7	1.41	14.7	0.5	0.0460	1.99	11.71	1.68	7.26	8.94
1.500	13.8	1.75	0.50	1.83	13.1	1.58	17.4	0.7	0.0540	2.55	6.57	1.24	4.65	5.89
1.000	16.1	1.25	0.50	1.83	15.0	1.80	17.4	1.0	0.0540	3.41	7.47	1.90	6.22	8.12
0.900	16.9	0.95	0.10	0.37	16.5	1.99	17.4	1.5	0.0540	4.23	1.65	0.53	1.54	2.07
0.800	17.7	0.85	0.10	0.37	17.3	2.09	17.4	1.7	0.0540	4.71	1.73	0.62	1.72	2.34
0.700	18.5	0.75	0.10	0.37	18.1	2.18	17.4	2.0	0.0540	5.14	1.81	0.72	1.88	2.60
0.600	19.4	0.65	0.10	0.37	19.0	2.28	17.4	2.3	0.0540	5.75	1.90	0.84	2.10	2.94
0.500	20.5	0.55	0.10	0.37	20.0	2.41	17.4	2.8	0.0540	6.44	2.00	1.01	2.35	3.36
0.250	23.2	0.38	0.25	0.91	21.9	2.64	17.4	3.8	0.0540	7.86	5.47	3.43	7.17	10.60
0.100	26.3	0.18	0.15	0.55	24.8	2.99	17.4	5.7	0.0540	10.32	3.72	3.13	5.65	8.78
0.050	27.9	0.08	0.05	0.18	27.1	3.27	17.4	7.8	0.0540	12.57	1.35	1.41	2.29	3.70
0.010	30.0	0.03	0.04	0.15	29.0	3.49	17.4	9.7	0.0540	14.56	1.16	1.42	2.13	3.55
0.005	30.0	0.01	0.01	0.02	30.0	3.62	17.4	11.0	0.0540	15.81	0.15	0.20	0.29	0.49
0.001	30.0	0.00	0.00	0.01	30.0	3.62	17.4	11.0	0.0540	15.81	0.12	0.16	0.23	0.39
											Annual totals:	23.3 (tons/yr)	78.1 (tons/yr)	101.4 (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**West Monument B4/2c Reference**	Stream Type:	**B4/2c**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/6/2012**

Enter Required Information for Existing Condition

8.9	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.322	D_{max}	Largest particle from **Bed Material** (ft)	**98**	**(mm)**	304.8 mm/ft
0.13000	S	Existing bankfull water surface slope (ft/ft)			
0.81	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	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:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
12.37	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	**2**

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

N/A	**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

N/A	**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

0.657		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 **50.33**	CO **111.6**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **1.391**	CO **0.644**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **1.72**	CO **0.79**	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 **0.0275**	CO **0.0127**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **West Monument B4/2c Referenc** Stream Type: **B4/2c**

Location: **Pike National Forest, CO** Valley Type: **VIIIb**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/06/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **West Monument B4/2c Reference** Stream Type: **B4/2c**
Location: **Pike National Forest, Colorado** Valley Type: **VIIIb**
Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/06/2012**

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 5-13)**	< 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 [✓ **(1)**]	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 **(4)**	**1**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 [✓ **(1)**]		M2, M5, M6, M7, M8 **(3)**		**1**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL [✓ **(2)**]	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**2**
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(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* 7 – 9** ☑	***Moderately Unstable* 10 – 12** ☐	***Unstable* 13 – 21** ☐	***Highly Unstable* > 21** ☐

Worksheet 5-26. Vertical stability − aggradation.

Stream:	**West Monument B4/2c Reference**	Stream Type:	**B4/2c**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/06/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 **(7)**	**2**
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	>1.6 **(8)**	**2**
4 **Stream Succession States (Worksheet 5-24)**	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) **(6)**	(C→D), (F→D) **(8)**	**2**
5 **Depositional Patterns (Worksheet 5-10)**	B1 [✓ **(1)**]	B2, B4 **(2)**	B3, **B5** **(3)**	**B6, B7**, B8 **(4)**	**1**
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3 [✓ **(1)**]	D4, D7 **(2)**	D5, D8 **(3)**	D6, D9, D10 **(4)**	**1**
				Total Points	**10**

Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Excess Deposition / Aggradation**			
	No Deposition **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**West Monument B4/2c Reference**	Stream Type:	**B4/2c**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/06/2012**

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 5-22)**	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) (Worksheet 5-20)**	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 5-12)**	1.00 – 1.10 [✓ **(2)**]	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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) **(8)**	**2**
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00 [✓ **(1)**]	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**1**
				Total Points	**9**

Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	**Vertical Stability Category Point Range for Channel Incision / Degradation**			
	Not Incised **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	West Monument B4/2c Reference	Stream Type:	B4/2c
Location:	Pike National Forest, Colorado	Valley Type:	VIIIb
Observers:	Bones, Kyle, David, Luke, Kim	Date:	11/06/2012

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 5-24)**	Stream Type at Potential, (C→E), (F$_b$→B), (G→B), (F→B$_c$), (F→C), (D→C) [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* [✓ **(2)**]	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* [✓ **(2)**]	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**8**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**West Monument B4/2c Reference**	Stream Type:	**B4/2c**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIIIb**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/06/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)		**Stability Rating**	**Points**	**Selected Points**
1	**Lateral Stability (Worksheet 5-25)**	***Stable***	[✓ 1]	1
		Mod. Unstable	2	
		Unstable	3	
		Highly Unstable	4	
2	**Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	[✓ 1]	1
		Mod. Deposition	2	
		Excess Deposition	3	
		Aggradation	4	
3	**Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	[✓ 1]	1
		Slightly Incised	2	
		Mod. Incised	3	
		Degradation	4	
4	**Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	[✓ 1]	1
		Slight Increase	2	
		Mod. Increase	3	
		Extensive	4	
5	**Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	[✓ 1]	1
		Fair: Mod. Unstable	2	
		Poor: Unstable	4	
			Total Points	**5**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☑	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**West Monument B4/2c Reference**	Location:	**Pike National Forest, Colorado**								
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/6/2012**	Stream Type:	**B4/2c**	Valley Type:	**VIIIb**				
Channel Dimension	Mean Bankfull Depth (ft):	**0.81**	Bankfull Width (ft):	**7.7**	Cross-Sectional Area (ft^2):	**6.21**	Width of Flood-Prone Area (ft):	**9.51**	Entrenchment Ratio:	**2.54**	
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**6.62** **5.58-7.66**	L_m/W_{bkf}:	**7.14** **6.49-7.79**	R_c/W_{bkf}:	**1.53** **1.27-1.90**	MWR:	**2.34** **2.00-2.65**	Sinuosity:	**1.06**
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed						
	Max Bankfull Depth (ft):	Riffle **1.47**	Pool **1.72**	Depth Ratio (max to mean):	Riffle **1.81**	Pool **1.65**	Pool-to-Pool Spacing:	Ratio **20.25**	Slope Valley:	**0.0146**	Water Surface: **0.013**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Spruce, Aspen, Willows, Chok**	Potential Composition/Density: **At Potnetial**	Remarks: Condition, Vigor & Usage of Existing Reach: **Riparian zone is vigorus and healthy**							
	Flow Regime:	**P1 ,2, 7, 8**	Stream Size & Order:	**S-3(4)**	Meander Patterns:	**M3**	Depositional Patterns:	**B2**	Debris/Channel Blockages:	**D3**	
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**54 (Good)**					
	Width/depth Ratio (W/d):	**9.51**	Reference W/d Ratio (W/d$_{ref}$):	**9.51**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$):	**1**	W/d Ratio State Stability Rating:	**Stable**			
	Meander Width Ratio (MWR):	**2.34**	Reference MWR$_{ref}$:	**2.34**	Degree of confinement (MWR / MWR$_{ref}$):	**1**	MWR / MWR$_{ref}$ Stability Rating:	**Stable**			
Bank Erosion Summary	Length of Reach Studied (ft):	**115**	Annual Streambank Erosion Rate:	**0.58** (tons/yr)	**0.005** (tons/yr/ft)	Curve Used:	**Colorado**	Remarks:	**Used Yellowstone curve for very low BEHI**		
Sediment Capacity (POWERSED)	☑ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks:							
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**98**	$\tau =$	**1.183**	$\tau^* =$	**N/A**	Existing Depth:	**0.81**	Required Depth:	**0.79**	Existing Slope: **0.013** Required Slope: **0.0127**
Successional Stage Shift	→	→	→	→	→	Existing Stream State (Type):	**B2/4c**	Potential Stream State (Type):	**B2/4c**		
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:	**Stable for Lateral Stability**					
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes:	**No Deposition**					
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:	**Channel not incised**					
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:	**No increase in channel enlargment**					
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:	**Little Channel Source Sediment**					

Appendix C20

C4 Stream Type

Reference Reach

Table of Contents

Appendix C20: C4 Reference Reach

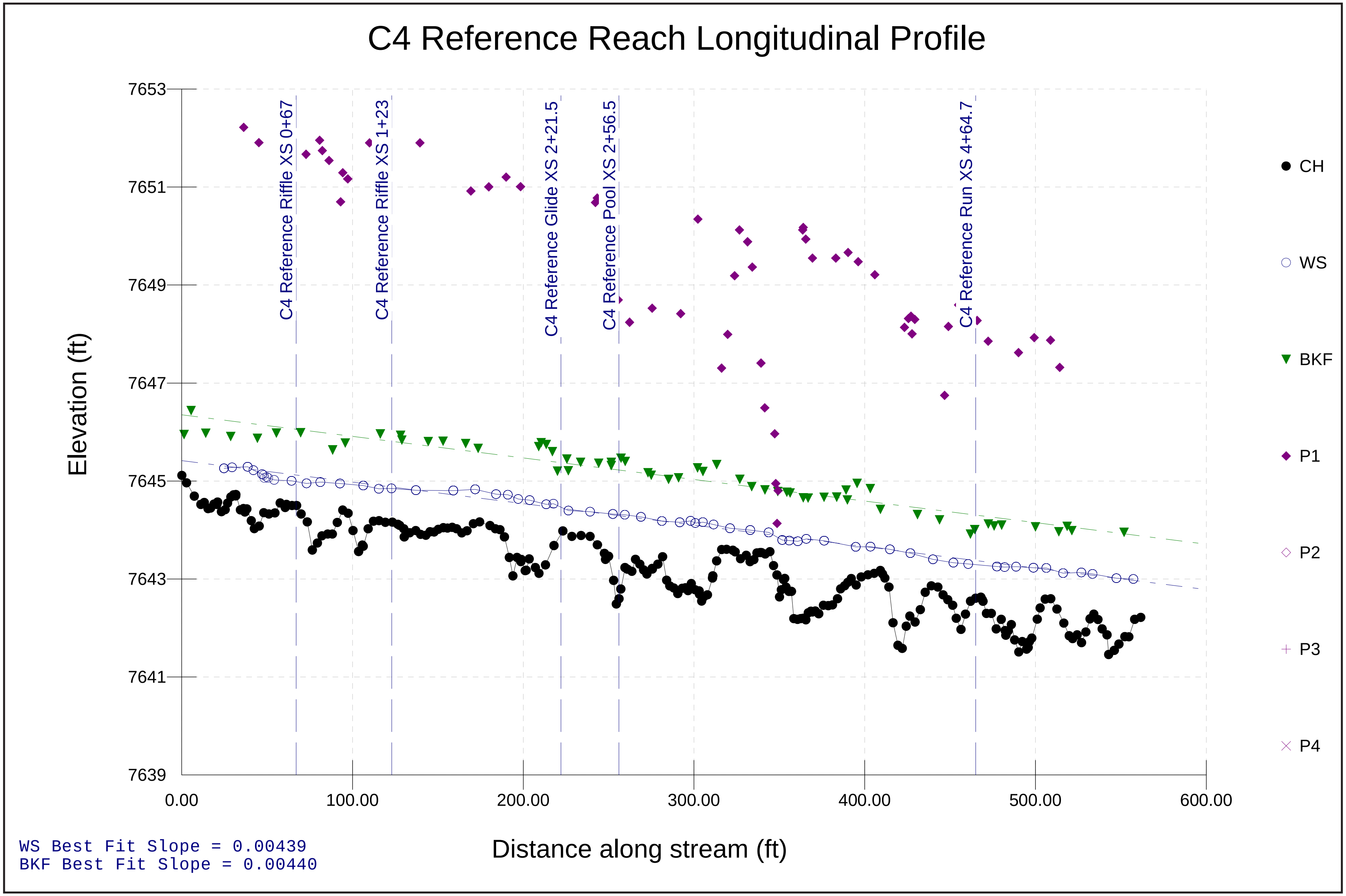
C4 Reference Reach Location & Overview

The C4 reference reach is in a terraced, alluvial Valley Type VIII and is typical of a gravel-bed stream channel. The channel bed and banks are potentially erodible, but due to the good vegetation condition, this reference reach shows little sediment yield from this reach. Bed features are dominated by riffles and pools with runs and glide features. This perennial channel is located on Trout Creek across from the Manitou Experimental Forest Headquarters. The stream is a meandering, low gradient channel with a well-developed floodplain. The morphological data from this reach will be used to develop dimension, pattern, and profile data for impaired streams that potentially should be C4 stream types in a Valley Type VIII. There is moderate sediment storage in point and central bars, typical of this stream type. The natural or geologic rate of streambank erosion is higher than the B4 reference reach; however, the excellent riparian vegetation of willow and Carex/Juncus understory has helped maintain an erosion rate of *0.0063 tons/yr/ft* (**Worksheet 5-18**). Streambank erosion rates for impaired conditions of this stream type can be associated with rates that are three orders of magnitude larger than exhibited in this reference reach.

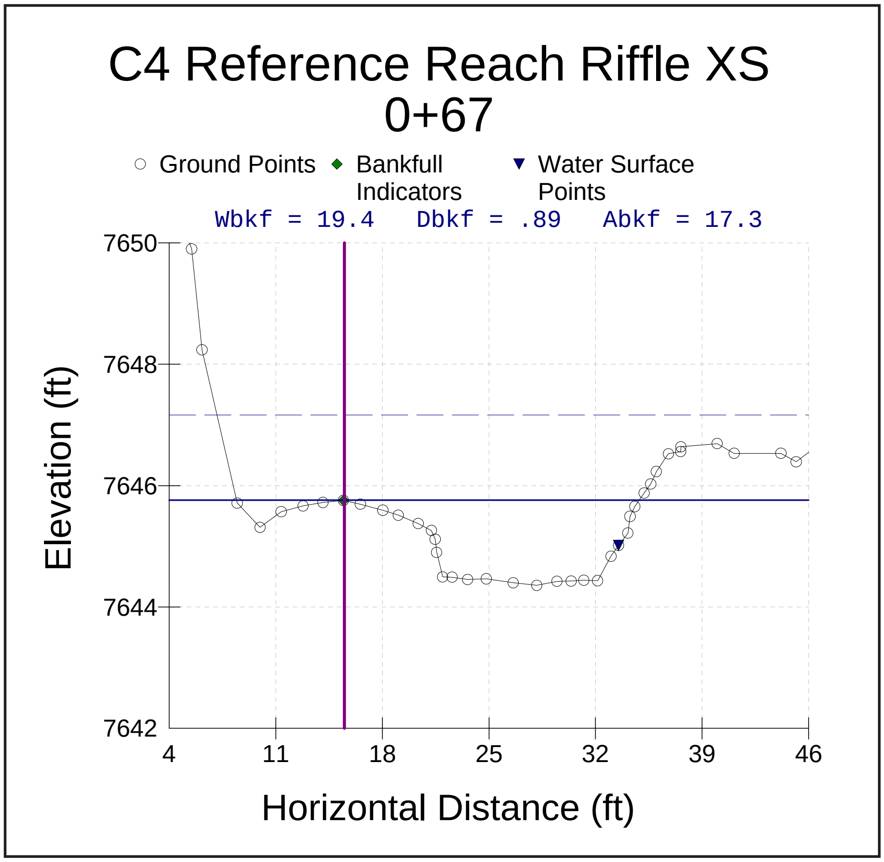
Typical of C4 stream types are large entrenchment ratios (not entrenched), low to moderate width/depth ratios, and a relatively sinuous pattern with a sinuosity greater than 1.3. The channel is not laterally contained or confined with meander width ratios greater than 5.0. There is not an acceleration of sediment supply from this reach during high runoff events due to the good riparian vegetation coverage.

The photograph depicts the good riparian community and the stable characteristics of the C4 stream type. There is little to no evidence of active channel-source sediment. The details of the dimension, pattern, profile and materials are summarized. The POWERSED model was not run on this reference reach as the bed is obviously stable. The following summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates, and stability. In the situation where impaired G4c, F4c, and some D4 stream types are located, an alternative for mitigation and sediment reduction from increased flow in these stream types is to use the data from the stable form of the C4 reference reach to extrapolate for potential implementation of natural channel design.

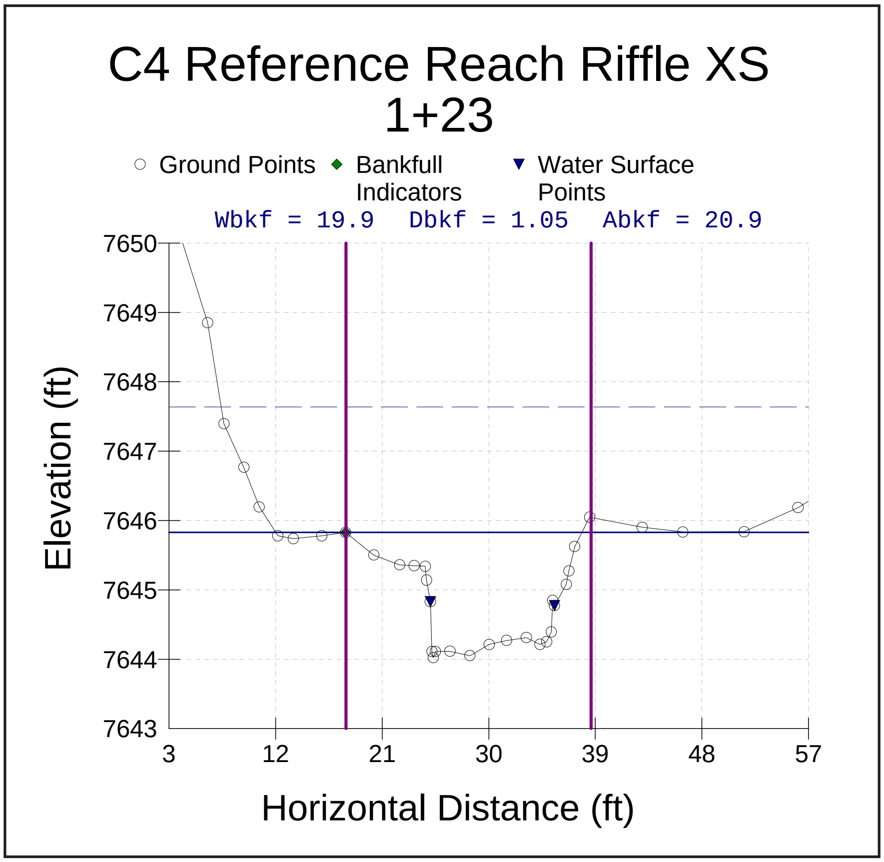
Survey Summary



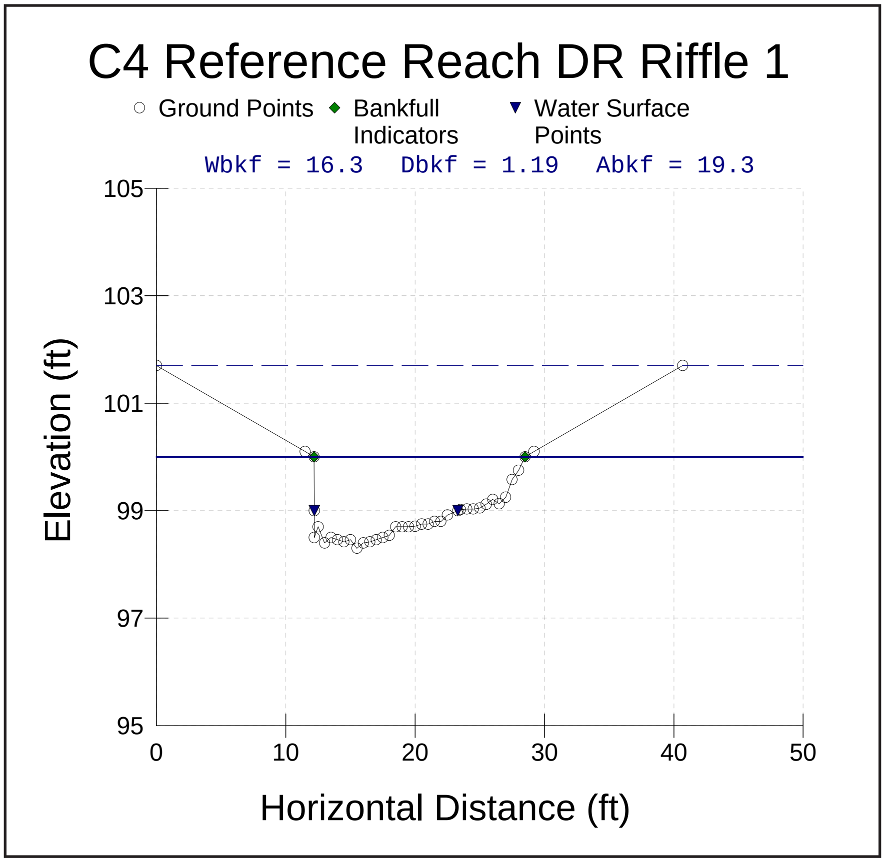
Longitudinal Profile (graph generated from RIVERMorph^{TM})



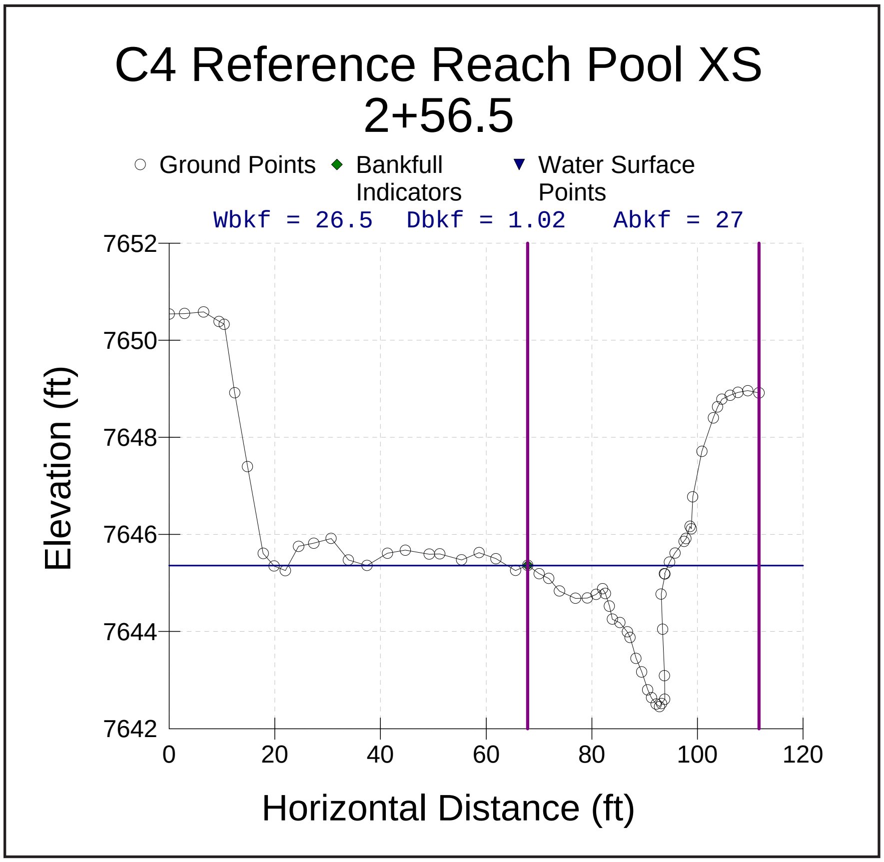
Riffle Cross-section 0+67 (graph generated from RIVERMorph^{TM})



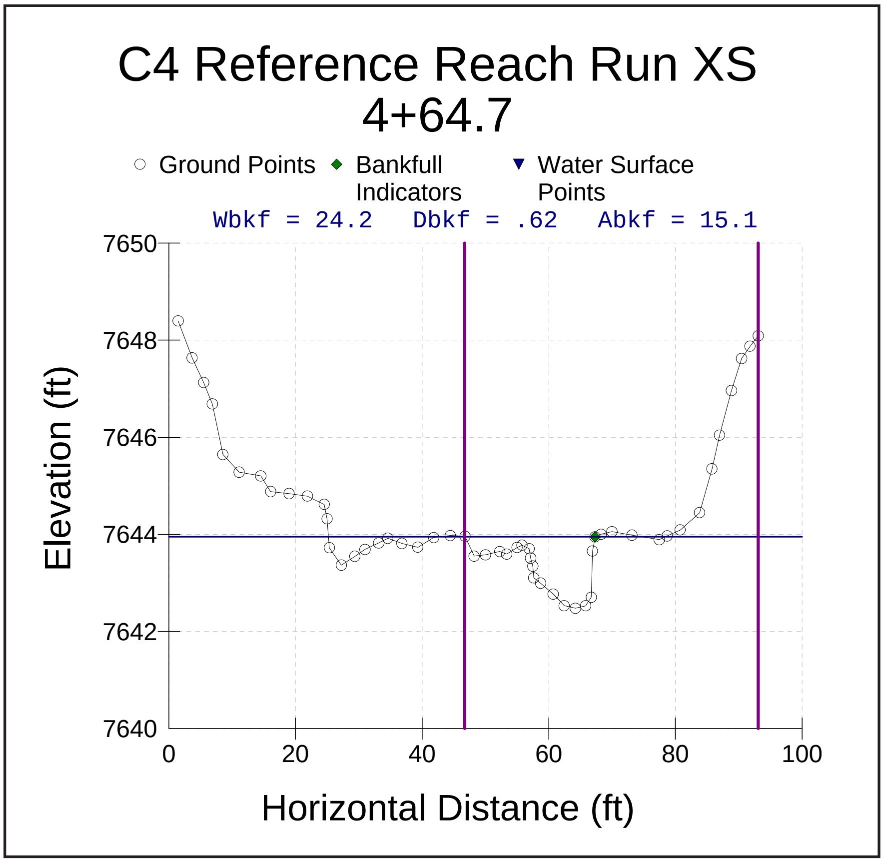
Riffle Cross-section 1+23 (graph generated from RIVERMorph^{TM})



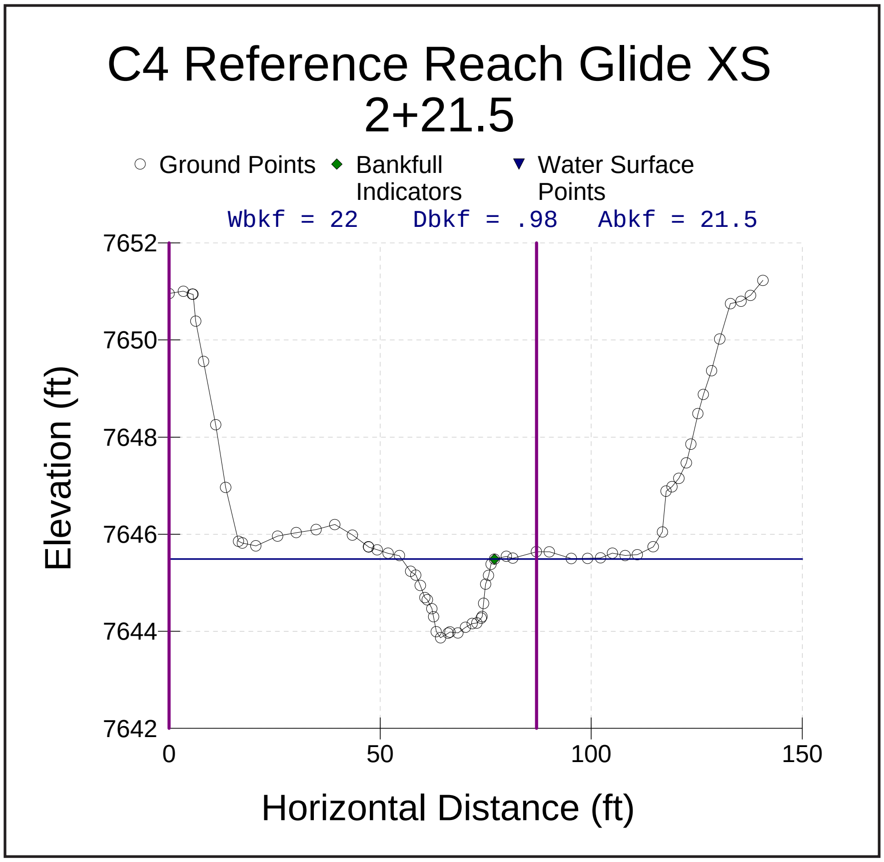
Riffle Cross-section DR_Riffle 1 (graph generated from RIVERMorph^{TM})



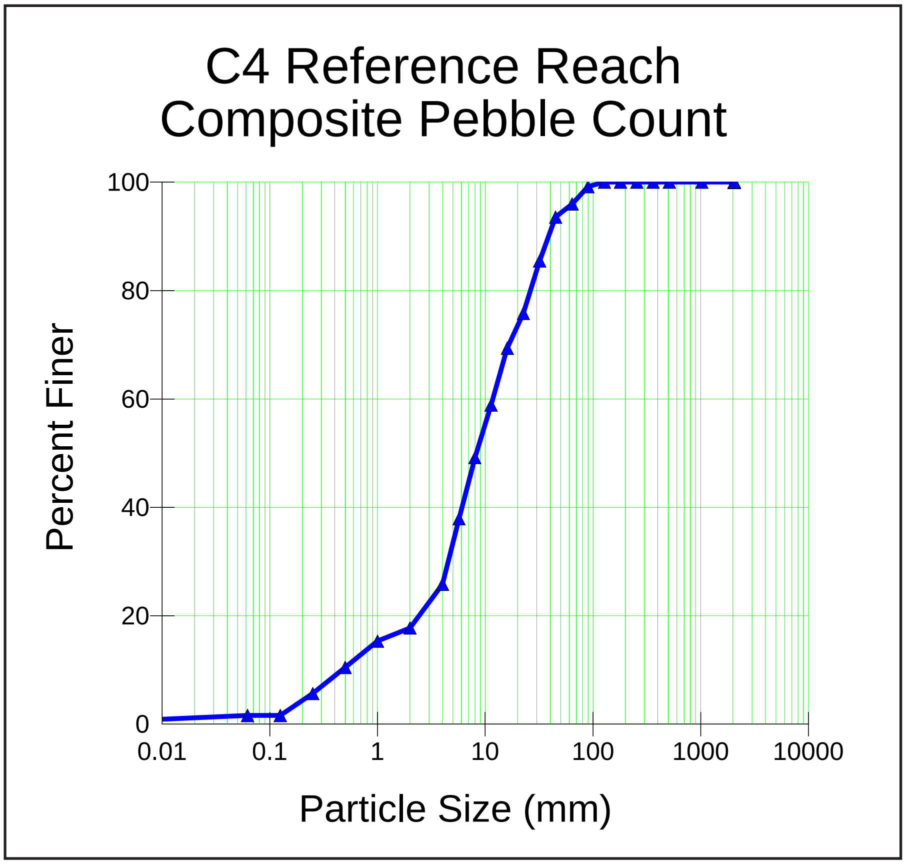
Pool Cross-section 2+56.5 (graph generated from RIVERMorph^{TM})



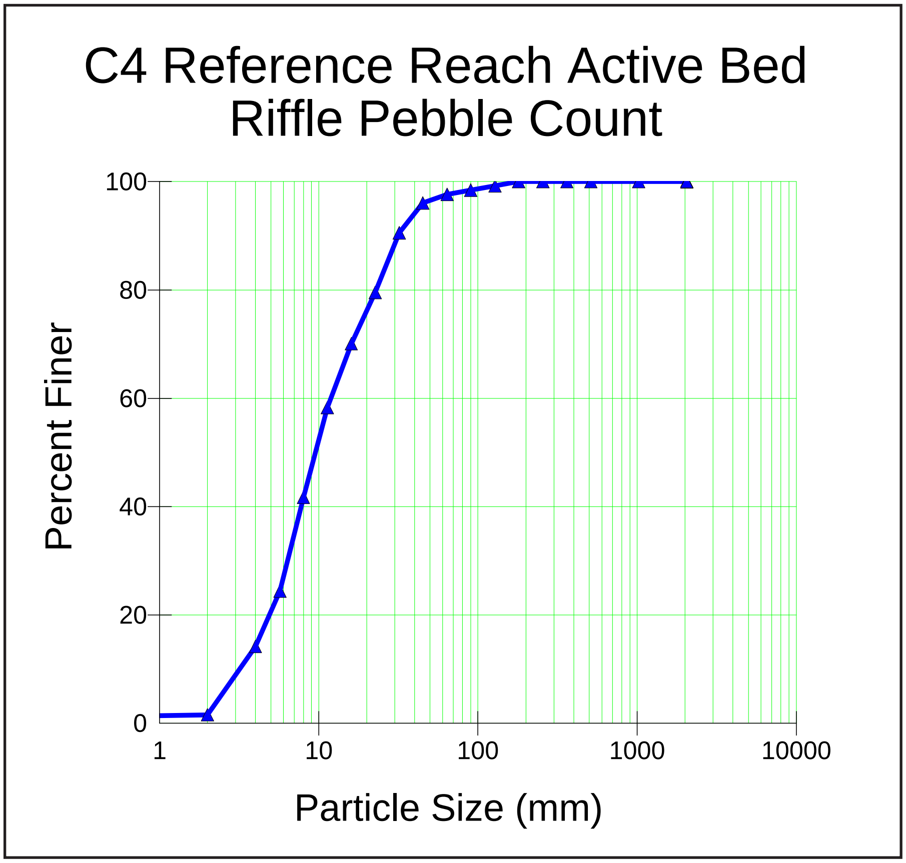
Run Cross-section 4+64.7 (graph generated from RIVERMorph^{TM})



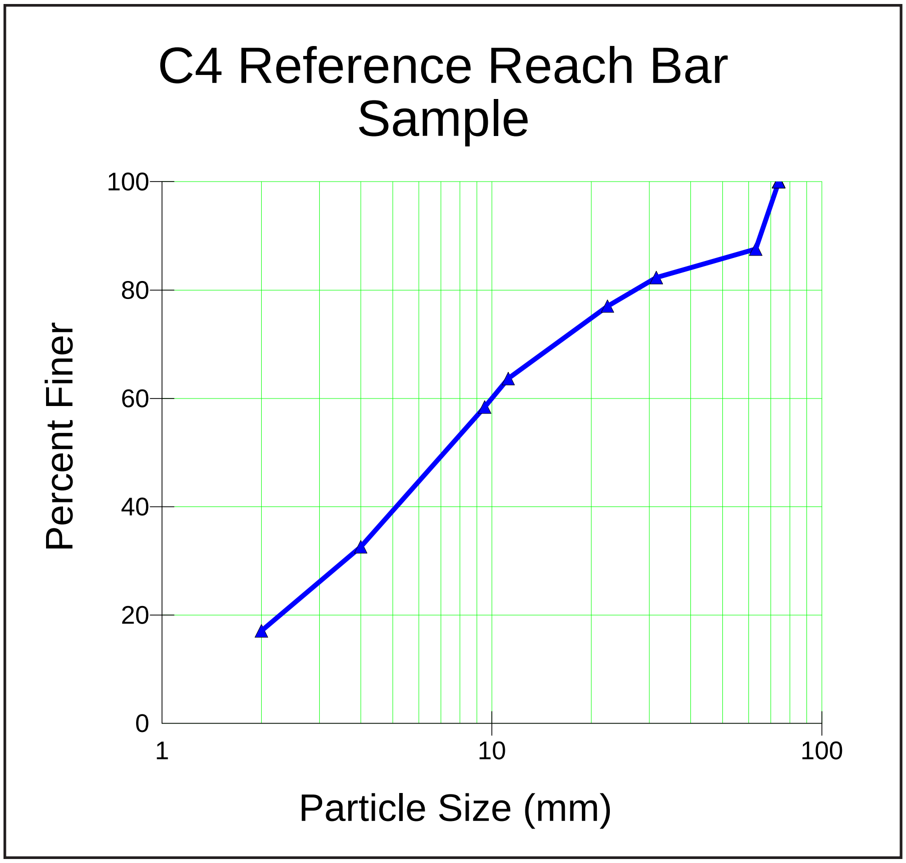
Glide Cross-section 2+21.5 (graph generated from RIVERMorph^{TM})



Composite Pebble Count (graph generated from RIVERMorph™)



Active Bed Riffle Pebble Count (graph generated from RIVERMorph™)



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trout Creek, C4 Reference Reach**			Location:	**Riffle XS 0+67, Pike N.F., Colorado**
Date:	**8/13/2010**	Stream Type:	**C4**	Valley Type:	**VIII**
Observers:	**D. Rosgen *et al*.**			HUC:	_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**17.3**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.89**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**19.4**	W_{bkf} (ft)	Wetted PERMIMETER ~ (2 * d_{bkf}) + W_{bkf}	**21.15**	W_p (ft)
D_{84} at Riffle	**26.4**	Dia. (mm)	D_{84} (mm) / 304.8	**0.09**	D_{84} (ft)
Bankfull SLOPE	**0.0044**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.82**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**9.45**	R / D_{84}
Drainage Area	**71.0**	DA (mi^2)	Shear Velocity u* = (gRS)^{½}	**0.341**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness *u = [2.83 + 5.66 * Log { R / D_{84} }] u**	**2.96**	ft / sec	**51.27**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) *u = 1.49*R$^{2/3}$ *S$^{1/2}$ / n* *n* = **0.034**	**2.54**	ft / sec	**44.07**	cfs
2. Roughness Coefficient: *u = 1.49*R$^{2/3}$ *S$^{1/2}$ / n* **b) Manning's *n* from Stream Type** (Fig. 5-9) *n* = **0.031**	**2.79**	ft / sec	**48.32**	cfs
2. Roughness Coefficient: *u = 1.49*R$^{2/3}$ *S$^{1/2}$ / n* **c) Manning's *n* from Jarrett (USGS):** *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* = **0.051**	**1.69**	ft / sec	**29.25**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Limerinos n**	**3.12**	ft / sec	**54.0**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach**	**2.98**	ft / sec	**51.6**	cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge Q =** ______ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Trout Creek, C4 Reference Reach**

Basin: **Trout Creek** Drainage Area: **45440** acres **71** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 0+67** Date: **8/13/2010**

Observers: **D. Rosgen *et al*.** Valley Type: **VIII**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**19.37**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.89**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**17.32**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**21.76**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**1.40**	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.	**41.92**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**2.16**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**8.28**	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.	**0.0044**	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 (S_{val} / S).	**1.38**	

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

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010** Valley Type: **VIII** 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})	18.5	16.3	19.9	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	19.2	17.3	20.9
Mean Riffle Depth (d_{bkf})	1.04	0.89	1.19	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	18.1	13.7	21.8
Maximum Riffle Depth (d_{max})	1.64	1.40	1.81	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.575	1.429	1.724
Width of Flood-Prone Area (W_{fpa})	58.8	41.9	69.4	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	3.21	2.16	3.99
Riffle Inner Berm Width (W_{ib})	11.4	10.4	12.9	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.619	0.522	0.668
Riffle Inner Berm Depth (d_{ib})	0.57	0.38	0.73	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.567	0.319	0.820
Riffle Inner Berm Area (A_{ib})	6.5	4.1	9.4	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.349	0.214	0.542
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	21.3	17.6	28.7					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	26.5			ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.430		
Mean Pool Depth (d_{bkfp})	1.02			ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	0.978		
Pool Cross-Sectional Area (A_{bkfp})	27.05			ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.409		
Maximum Pool Depth (d_{maxp})	2.9			ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.8		
Pool Inner Berm Width (W_{ibp})	9.4			ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.354		
Pool Inner Berm Depth (d_{ibp})	0.92			ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.902		
Pool Inner Berm Area (A_{ibp})	8.6			ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.319		
Point Bar Slope (S_{pb})	0.260			ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	10.18		

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	24.2			ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	1.307		
Mean Run Depth (d_{bkfr})	0.62			ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	0.594		
Run Cross-Sectional Area (A_{bkfr})	15.07			ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	0.785		
Maximum Run Depth (d_{maxr})	1.5			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.409		
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	39.1			ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	22.0			ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	1.189		
Mean Glide Depth (d_{bkfg})	0.98			ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.939		
Glide Cross-Sectional Area (A_{bkfg})	21.54			ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	1.122		
Maximum Glide Depth (d_{maxg})	1.62			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.553		
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	22.5			ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	26.77		
Glide Inner Berm Width (W_{ibg})	12.9			ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.583		
Glide Inner Berm Depth (d_{ibg})	0.48			ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.490		
Glide Inner Berm Area (A_{ibg})	6.18			ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.287		

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010** Valley Type: **VIII** Stream Type: **C4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	2.98	ft/sec	Estimation Method	Darcy-Weisbach	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	51.6	cfs	Drainage Area	71.0	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	84.5	62.0	114.5	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	4.56	3.35	6.18
Stream Meander Length (L_m)	104.6	72.6	161.0	ft	Stream Meander Length Ratio (L_m / W_{bkf})	5.64	3.92	8.69
Radius of Curvature (R_c)	42.8	31.1	65.0	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	2.31	1.68	3.51
Belt Width (W_{blt})	66.1	42.8	82.8	ft	Meander Width Ratio (W_{blt} / W_{bkf})	3.57	2.31	4.47
Arc Length (L_a)	37.7	20.1	46.0	ft	Arc Length to Riffle Width (L_a / W_{bkf})	2.03	1.08	2.48
Riffle Length (L_r)	23.1	8.5	82.4	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	1.25	0.46	4.45
Individual Pool Length (L_p)	17.6	8.5	27.5	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	0.95	0.46	1.48
Pool to Pool Spacing (P_s)	55.5	22.0	107.5	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	3.00	1.19	5.80

Channel Profile

Valley Slope (S_{val})	0.0061	ft/ft	Average Water Surface Slope (S)	0.0044	ft/ft	Sinuosity (S_{val} / S)	1.38
Stream Length (SL)	567.7	ft	Valley Length (VL)	783.4	ft	Sinuosity (SL / VL)	1.38

Low Bank Height (LBH)	start	1.40	ft	Max Bankfull Depth (d_{max})	start	1.40	ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start 1.0
	end	1.80	ft		end	1.80	ft		end 1.0

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	0.0045	0.0029	0.0054	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	1.0205	0.6477	1.2341
Run Slope (S_{run})	0.0113	0.0066	0.0140	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	2.5614	1.5000	3.1705
Pool Slope (S_p)	0.0023	0.0008	0.0038	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	0.5250	0.1841	0.8636
Glide Slope (S_g)	0.0034	0.0026	0.0039	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	0.7750	0.5909	0.8864
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	1.60	1.40	1.75	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	1.534	1.342	1.677
Max Run Depth (d_{maxr})	1.74	1.57	1.95	ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.668	1.505	1.869
Max Pool Depth (d_{maxp})	2.46	2.12	2.95	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.358	2.038	2.837
Max Glide Depth (d_{maxg})	1.55	1.33	1.78	ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.486	1.275	1.706
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	2	0	0	D_{16}	1.3	4.3	0.0		mm
% Sand	16	2	17	D_{35}	5.3	7.1	4.5		mm
% Gravel	78	96	72	D_{50}	8.3	9.7	7.7		mm
% Cobble	4	2	11	D_{84}	30.6	26.4	41.7		mm
% Boulder	0	0	0	D_{95}	56.4	42.5	69.6		mm
% Bedrock	0	0	0	D_{100}	128.0	180.0	74.0		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trout Creek, C4 Reference Reach**

Location: **Pike National Forest, Colorado, above Manitou Expt. Forest**

Observers: **D. Rosgen *et al*.**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **8/13/2010**

Existing species composition: **Willow, Redtop, Carex/Juncus**

Potential species composition: **Same as Existing but without Invasives**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**5-10%**	**10%**	**Willow**	**100%**
					100%
2. Understory	Shrub layer	▨	**30%**	**Willow**	**100%**
					100%
3. Ground level	Herbaceous	▨	**58%**	**Carex/juncus**	**75%**
				Hairgrass	**5%**
				Poa	**5%**
				Thistle	**10%**
				Smart weed	**1%**
				Hairgrass	**4%**
					100%
	Leaf or needle litter	▨			
	Bare ground	▨	**2%**		
			Column total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Remarks:

Condition, vigor and/or usage of existing reach:

Recovering C4 inside of an F4 stream type, naturally confined between terraces. One-half mile below reservoir, and although stream has a sediment trap, there is an ample sediment supply.

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trout Creek, C4 Reference** Location: **Pike National Forest, Colorado**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Trout Creek, C4 Reference Reach**
Location: **Pike National Forest, Colorado**
Observers: **D. Rosgen *et al*.**
Date: **8/13/2010**

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

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 5-9. Meander patterns.

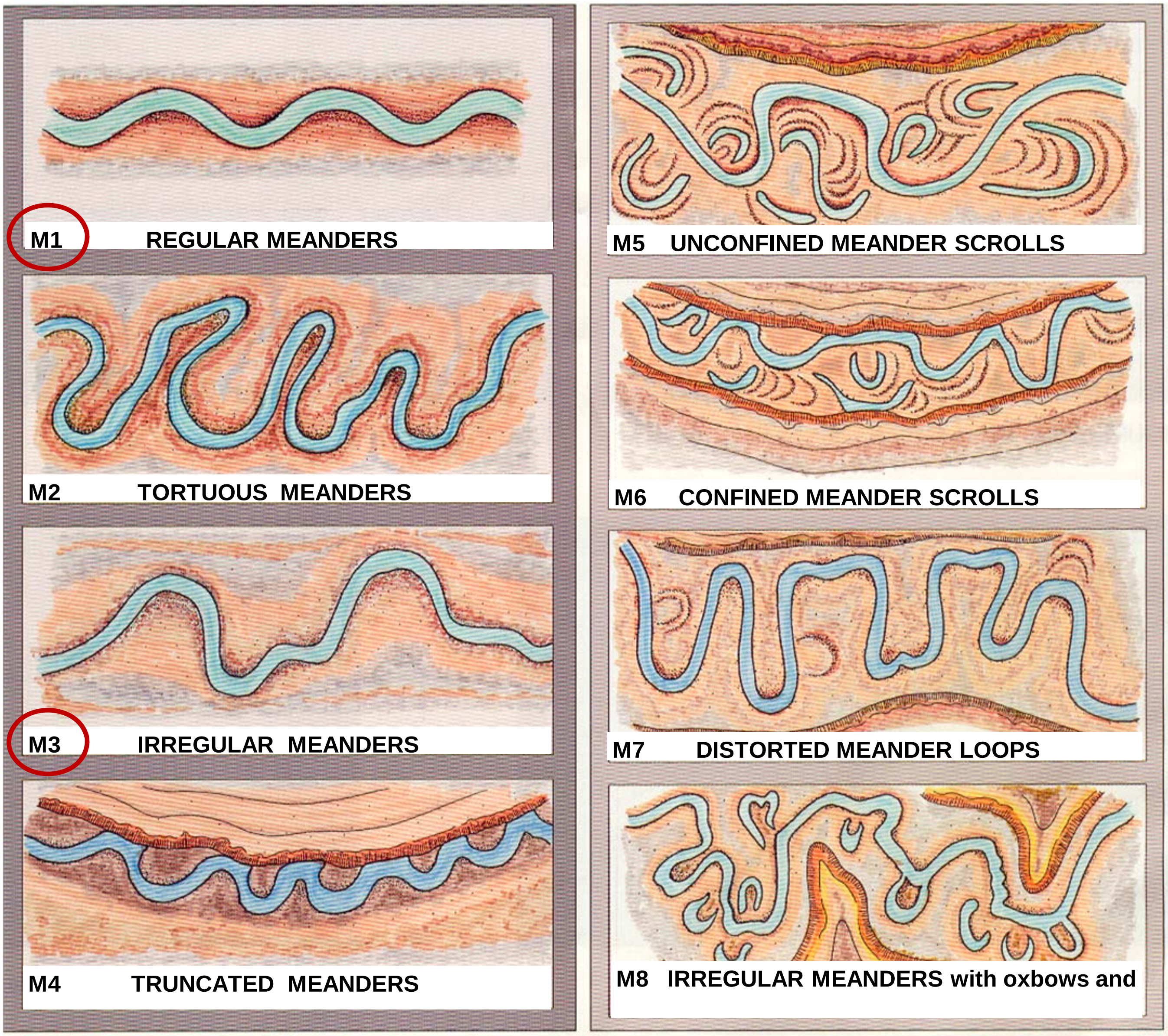
Meander Patterns

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, CO**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

List ALL CATEGORIES that APPLY ☞	**M1**	**M3**			

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



Worksheet 5-10. Depositional patterns.

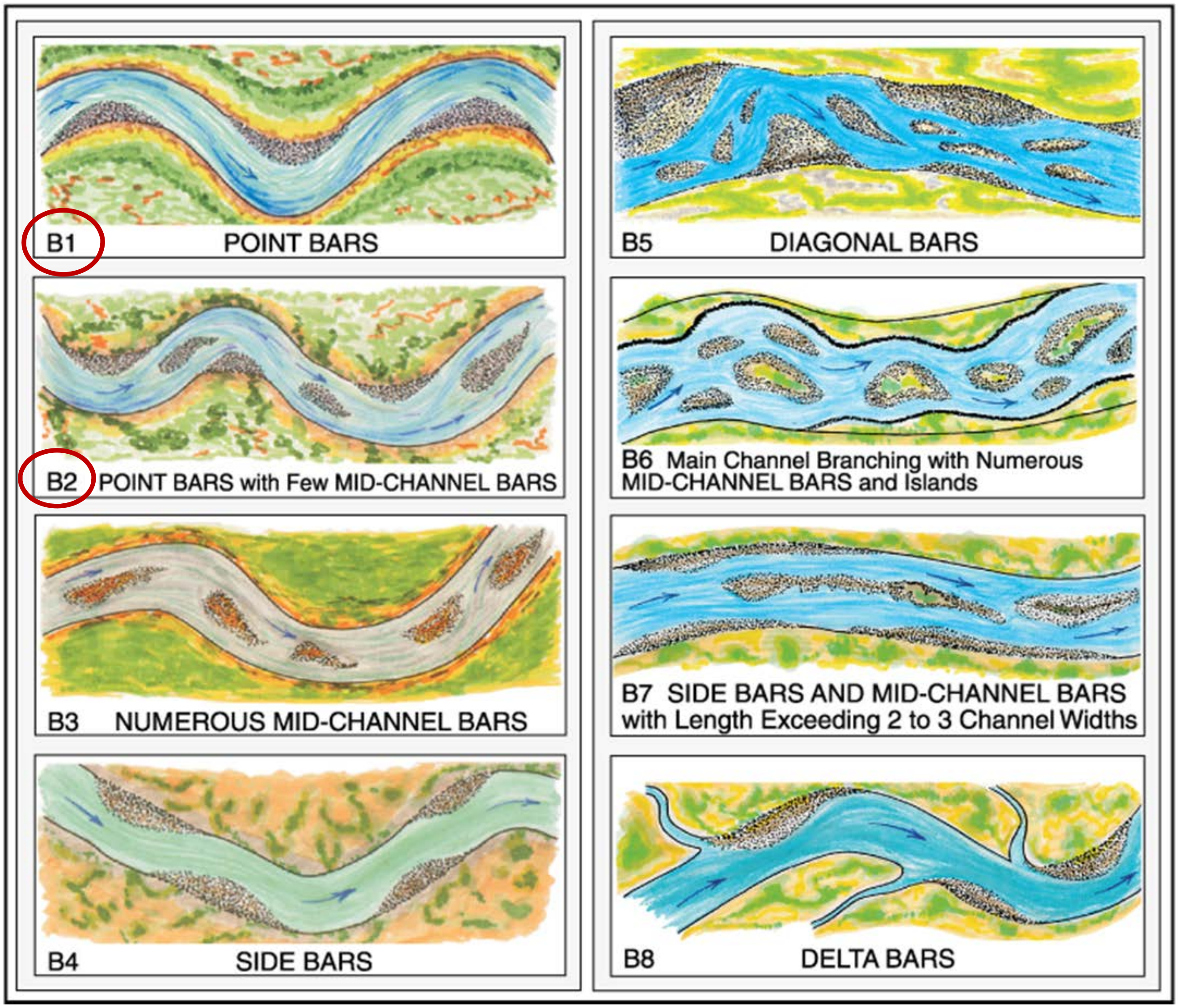
Depositional Patterns

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

List ALL CATEGORIES that APPLY ☞	**B1**	**B2**			

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

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.	☐

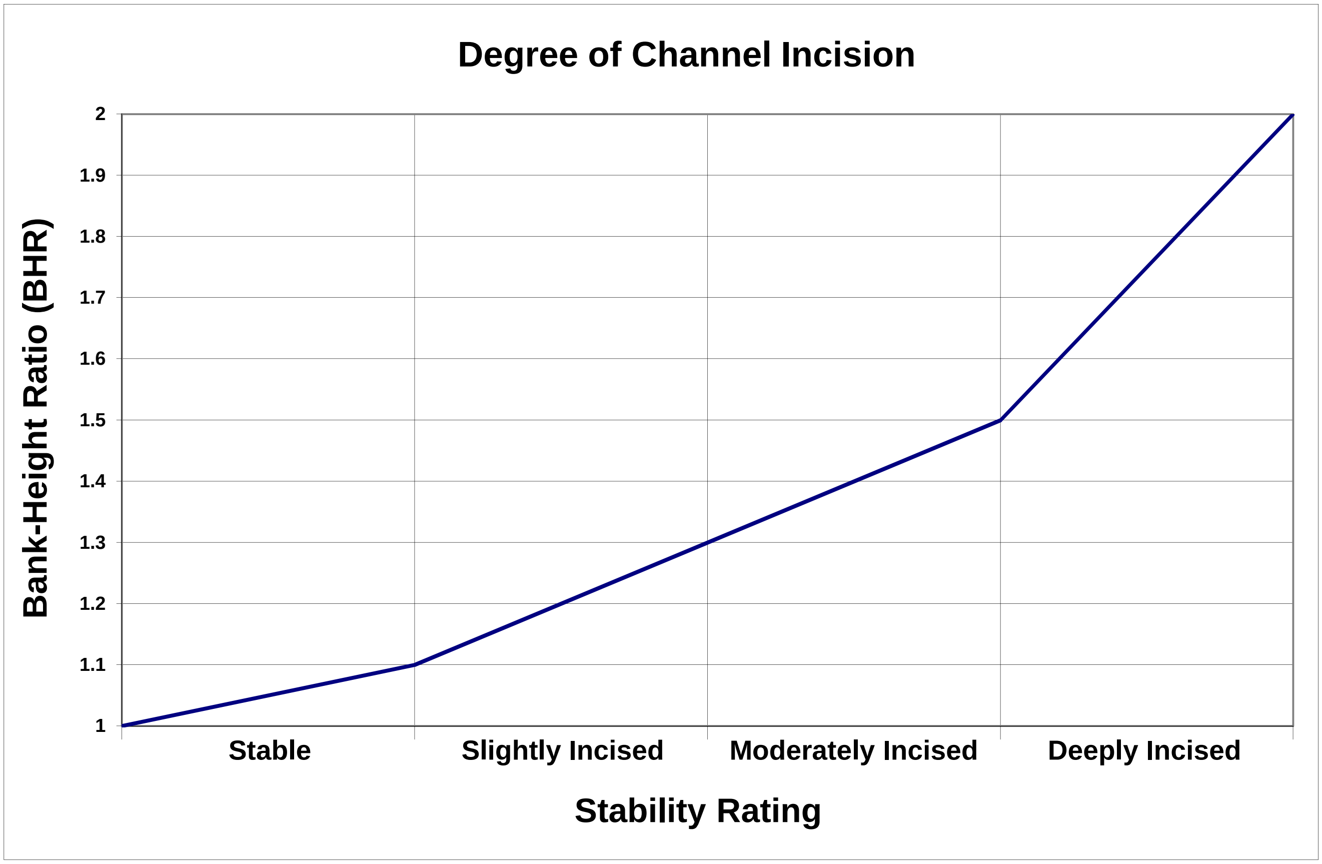
Worksheet 5-12. Degree of channel incision.

Degree of Channel Incision

Low Bank Height:	**1.4**
Max Bankfull Depth:	**1.4**

Bank-Height Ratio:	**1.0**

Degree of Channel Incision Stability Rating ☞ **Not Incised**

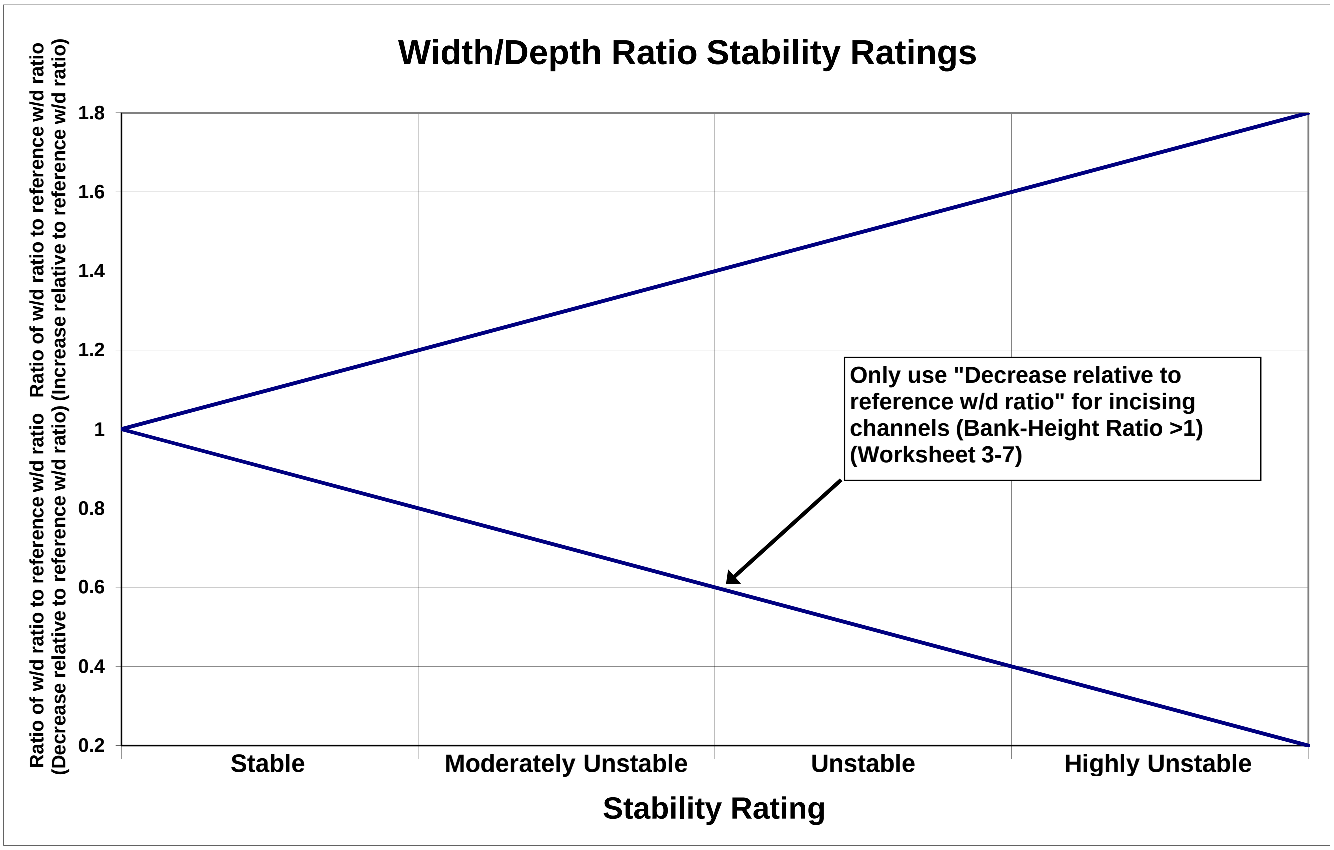


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**13.7**	Ratio of existing W/d to reference W/d:	**1.00**
Reference Width/Depth Ratio:	**13.7**		

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

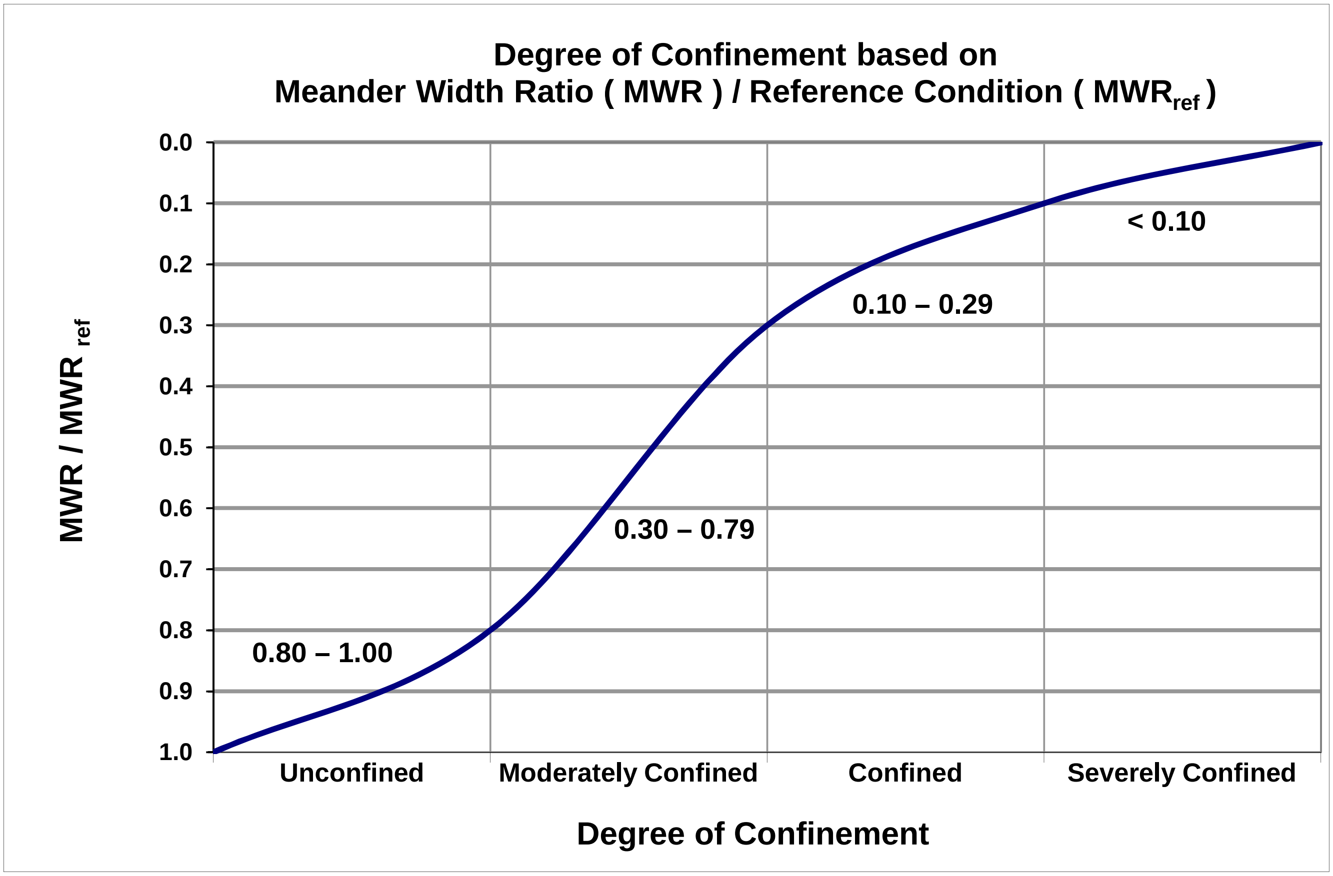


Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**4.5**	Ratio of MWR to MWR_{ref}:	**1.00**
Reference Meander Width Ratio (MWR_{ref}):	**4.5**		

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trout Creek, C4 Reference Reach **Location:** Pike National Forest, CO **Valley Type:** VIII **Observers:** D. Rosgen *et al*. **Date:** 8/13/2010

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	6	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	21	Good total =	6	Fair total =	26	Poor total =	20

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+

Stream type	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+

Grand total =	73
Existing stream type =	C4
*Potential stream type =	C4
Modified channel stability rating =	Good

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-16. The Bank Erosion Hazard Index (BEHI) rating.

Stream: **Trout Creek, C4 Reference Reach** Location: **Pike National Forest, Colorado**

Station: **above Manitou Expt. Station** Observers: **D. Rosgen *et al*.**

Date: **8/13/2010** Stream Type: **C4** Valley Type: **VIII**

BEHI Score (Fig. 5-15)

Study Bank Height / Bankfull Height (C)

Study Bank Height (ft) =	**1.40 (A)**	**Bankfull Height** (ft) =	**1.20 (B)**	(A) / (B) =	**1.17 (C)**	**1.0**

Root Depth / Study Bank Height (E)

Root Depth (ft) =	**1.30 (D)**	**Study Bank Height** (ft) =	**1.40 (A)**	(D) / (A) =	**0.93 (E)**	**2.0**

Weighted Root Density (G)

Root Density as **%** =	**70 (F)**	(F) × (E) =	**98 (G)**	**1.0**

Bank Angle (H)

Bank Angle as *Degrees* =	**70 (H)**	**5.0**

Surface Protection (I)

Surface Protection as **%** =	**90% (I)**	**1.0**

Bank Material Adjustment:

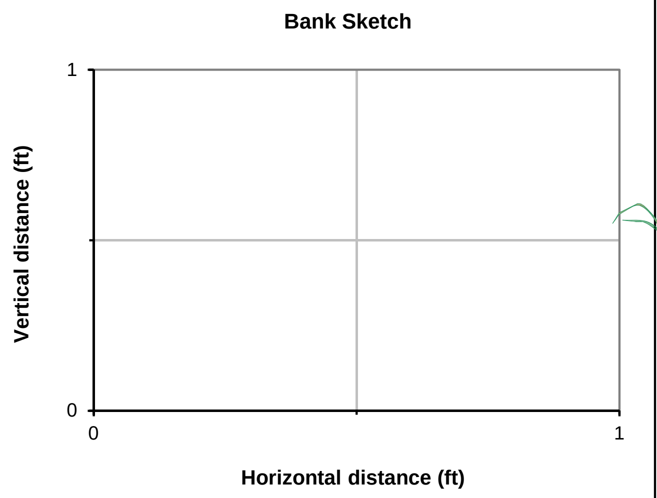
Bedrock (Overall Very Low BEHI)
Boulders (Overall Low BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment)

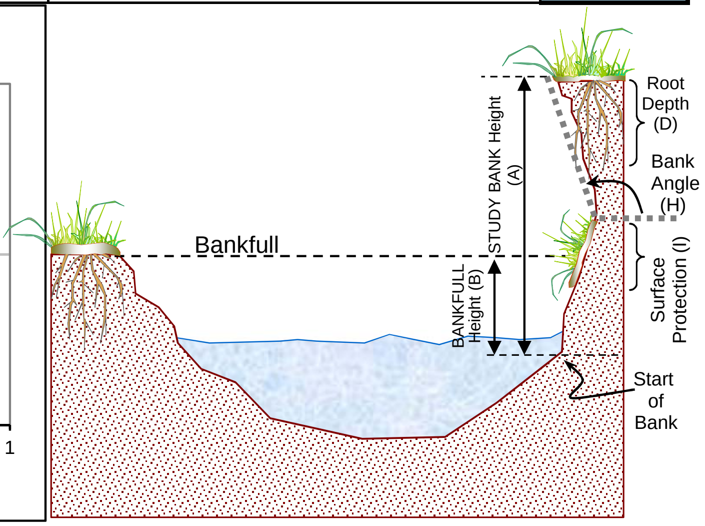
Bank Material Adjustment **5**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage **0**

Very Low	**Low**	**Moderate**	**High**	**Very High**	**Extreme**
5 – 9.5	**10 – 19.5**	**20 – 29.5**	**30 – 39.5**	**40 – 45**	**46 – 50**

Adjective Rating and Total Score **Low** **15.0**





Worksheet 5-17. Near-Bank Stress (NBS) rating.

Estimating Near-Bank Stress (NBS)

Stream: **Trout Creek, C4 Reference Reach** Location: **Trout Creek, C4 Reference Reach**

Station: **0+20R** Stream Type: **C4** Valley Type: **VIII**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

Methods for Estimating Near-Bank Stress (NBS)

(1)	Channel pattern, transverse bar or split channel/central bar creating NBS	Level I	Reconaissance
(2)	Ratio of radius of curvature to bankfull width (R_c / W_{bkf})	Level II	General prediction
(3)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General prediction
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General prediction
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed prediction
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed prediction
(7)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I

(1)

Transverse and/or central bars-short and/or discontinuous………… ……………...….NBS = High / Very High
Extensive deposition (continuous, cross-channel)…………………………...……. …………...NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow……………………..………….NBS = Extreme

Level II

(2)

Radius of Curvature R_c (ft)	Bankfull Width W_{bkf} (ft)	*Ratio* R_c / W_{bkf}	Near-Bank Stress (NBS)

(3)

Pool Slope S_p	Average Slope S	*Ratio* S_p / S	Near-Bank Stress (NBS)

(4)

Pool Slope S_p	Riffle Slope S_{rif}	*Ratio* S_p / S_{rif}	Near-Bank Stress (NBS)

Dominant Near-Bank Stress

Low

Level III

(5)

Near-Bank Max Depth d_{nb} (ft)	Mean Depth d_{bkf} (ft)	*Ratio* d_{nb} / d_{bkf}	Near-Bank Stress (NBS)
2.2	**1.4**	**1.5**	**Low**

(6)

Near-Bank Max Depth d_{nb} (ft)	Near-Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d_{bkf} (ft)	Average Slope S	Bankfull Shear Stress τ_{bkf} (lb/ft^2)	Ratio τ_{nb} / τ_{bkf}	Near-Bank Stress (NBS)

Level IV

(7)

Velocity Gradient (ft / sec / ft)	Near-Bank Stress (NBS)

Converting Values to a Near-Bank Stress (NBS) Rating

Near-Bank Stress (NBS) ratings	Method number						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
Low	N / A	2.21 – 3.00	0.20 – 0.40	0.41 – 0.60	1.00 – 1.50	0.80 – 1.05	0.50 – 1.00
Moderate	N / A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60
High	See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
Very High	(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40

Overall Near-Bank Stress (NBS) rating **Low**

Worksheet 5-18. Annual streambank erosion estimates.

Stream: **Trout Creek, C4 Reference Reach** Location: **Trout Creek, C4 Reference Reach**

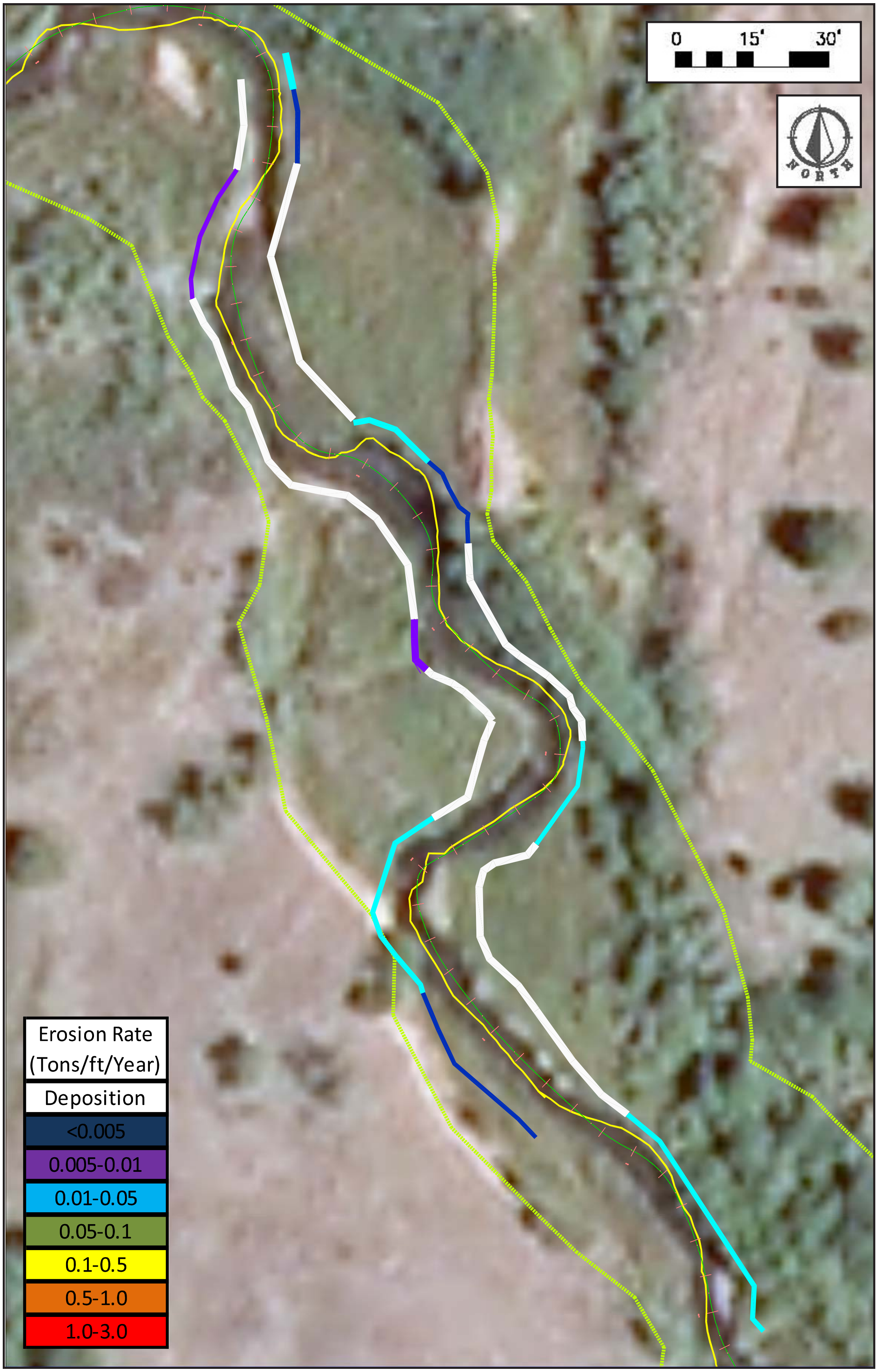
Graph Used: **Colorado** Total Bank Length (ft): **463** Date: **8/13/2010**

Observers: **D. Rosgen *et al*.** Valley Type: **VIII** Stream Type: **C4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1.	**Low**	**Very High**	**0.32332**	**40.0**	**1.4**	**18.11**	**0.02179**
2.	**Low**	**High**	**0.15505**	**20.0**	**1.4**	**4.34**	**0.01045**
3.	**Low**	**Moderate**	**0.07435**	**50.0**	**1.2**	**4.46**	**0.00430**
4.	**Low**	**High**	**0.15505**	**20.0**	**1.4**	**4.34**	**0.01045**
5.	**Low**	**High**	**0.15505**	**27.0**	**1.2**	**5.02**	**0.00896**
6.	**Low**	**Moderate**	**0.07435**	**10.0**	**1.9**	**1.41**	**0.00680**
7.	**Low**	**Moderate**	**0.07435**	**40.0**	**1.2**	**3.57**	**0.00430**
8	**Low**	**High**	**0.15505**	**16.0**	**1.5**	**3.72**	**0.01120**
9	**Low**	**High**	**0.15505**	**40.0**	**1.2**	**7.44**	**0.00896**
10	**Low**	**Moderate**	**0.07435**	**40.0**	**1.3**	**3.87**	**0.00465**
11	**Low**	**High**	**0.15505**	**16.0**	**1.9**	**4.71**	**0.01418**
12							
13							
14							
15							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	**Total Erosion (ft^3/yr)**	**61.00**
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}	**Total Erosion (yds^3/yr)**	**2.26**
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}	**Total Erosion (tons/yr)**	**2.94**
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}	**Total Erosion (tons/yr/ft)**	**0.0063**

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	$y = -0.0113+1.0139x^{2.1929}$	51.6	0.028095864	114.7625704
2. Suspended Sediment	"Good/Fair" Pagosa	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	131.2													
0.10%	112.6	0.05%	0.09%	0.34	121.9	2.363	7.461	281.87	6.670	17.85	41.8	96.71	6.13	102.83
0.25%	97.5	0.08%	0.15%	0.55	105.1	2.036	5.232	170.30	4.809	12.87	57.5	93.24	7.05	100.28
0.50%	84.2	0.13%	0.25%	0.91	90.8	1.761	3.706	104.32	3.494	9.35	82.9	95.19	8.53	103.73
0.75%	71.9	0.13%	0.25%	0.91	78.1	1.513	2.592	62.69	2.502	6.70	71.2	57.21	6.11	63.32
1%	62.2	0.13%	0.25%	0.91	67.1	1.300	1.817	37.76	1.790	4.79	61.2	34.45	4.37	38.83
1.5%	53.4	0.25%	0.50%	1.83	57.8	1.120	1.289	23.09	1.289	3.45	105.5	42.14	6.30	48.43
2%	44.6	0.25%	0.50%	1.83	49.0	0.949	0.886	13.44	0.893	2.39	89.4	24.53	4.36	28.89
3%	37.5	0.50%	1.00%	3.65	41.0	0.795	0.600	7.63	0.602	1.61	149.7	27.85	5.88	33.73
4%	32.1	0.50%	1.00%	3.65	34.8	0.674	0.424	4.57	0.415	1.11	126.9	16.68	4.06	20.74
5%	28.5	0.50%	1.00%	3.65	30.3	0.587	0.322	3.02	0.304	0.81	110.6	11.04	2.97	14.01
10%	17.9	2.50%	5.00%	18.25	23.2	0.450	0.200	1.44	0.165	0.44	423.9	26.27	8.05	34.32
20%	9.8	5.00%	10.00%	36.50	13.9	0.269	0.103	0.44	0.045	0.12	505.7	16.12	4.44	20.56
30%	6.5	5.00%	10.00%	36.50	8.2	0.158	0.075	0.19	0.006	0.02	297.5	6.87	0.63	7.50
40%	4.6	5.00%	10.00%	36.50	5.6	0.108	0.068	0.12	0.000	0.00	203.3	4.28	0.00	4.28
50%	3.5	5.00%	10.00%	36.50	4.1	0.079	0.066	0.08	0.000	0.00	148.7	3.03	0.00	3.03
60%	2.7	5.00%	10.00%	36.50	3.1	0.061	0.065	0.06	0.000	0.00	114.0	2.29	0.00	2.29
70%	2.2	5.00%	10.00%	36.50	2.4	0.047	0.064	0.05	0.000	0.00	89.2	1.78	0.00	1.78
80%	1.9	5.00%	10.00%	36.50	2.0	0.039	0.064	0.04	0.000	0.00	74.4	1.47	0.00	1.47
90%	1.4	5.00%	10.00%	36.50	1.6	0.032	0.064	0.03	0.000	0.00	59.5	1.18	0.00	1.18
100%	0.3	5.00%	10.00%	36.50	0.8	0.016	0.064	0.02	0.000	0.00	29.7	0.59	0.00	0.59
									Annual Totals:		2,842.7 (cfs) 5,638.6 (acre-ft)	562.9 (tons/yr)	68.9 (tons/yr)	631.8 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**51.6**	**0.028095864**	**114.7625704**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**131.2**													
0.10%	**112.6**	**0.05%**	**0.09%**	**0.34**	**121.9**	**2.363**	**7.461**	**281.87**	**6.670**	**17.85**	**41.8**	**96.71**	**6.13**	**102.83**
0.25%	**97.5**	**0.08%**	**0.15%**	**0.55**	**105.1**	**2.036**	**5.232**	**170.30**	**4.809**	**12.87**	**57.5**	**93.24**	**7.05**	**100.28**
0.50%	**84.2**	**0.13%**	**0.25%**	**0.91**	**90.8**	**1.761**	**3.706**	**104.32**	**3.494**	**9.35**	**82.9**	**95.19**	**8.53**	**103.73**
0.75%	**71.9**	**0.13%**	**0.25%**	**0.91**	**78.1**	**1.513**	**2.592**	**62.69**	**2.502**	**6.70**	**71.2**	**57.21**	**6.11**	**63.32**
1%	**62.2**	**0.13%**	**0.25%**	**0.91**	**67.1**	**1.300**	**1.817**	**37.76**	**1.790**	**4.79**	**61.2**	**34.45**	**4.37**	**38.83**
1.5%	**53.4**	**0.25%**	**0.50%**	**1.83**	**57.8**	**1.120**	**1.289**	**23.09**	**1.289**	**3.45**	**105.5**	**42.14**	**6.30**	**48.43**
2%	**44.6**	**0.25%**	**0.50%**	**1.83**	**49.0**	**0.949**	**0.886**	**13.44**	**0.893**	**2.39**	**89.4**	**24.53**	**4.36**	**28.89**
3%	**37.5**	**0.50%**	**1.00%**	**3.65**	**41.0**	**0.795**	**0.600**	**7.63**	**0.602**	**1.61**	**149.7**	**27.85**	**5.88**	**33.73**
4%	**32.1**	**0.50%**	**1.00%**	**3.65**	**34.8**	**0.674**	**0.424**	**4.57**	**0.415**	**1.11**	**126.9**	**16.68**	**4.06**	**20.74**
5%	**28.5**	**0.50%**	**1.00%**	**3.65**	**30.3**	**0.587**	**0.322**	**3.02**	**0.304**	**0.81**	**110.6**	**11.04**	**2.97**	**14.01**
10%	**17.9**	**2.50%**	**5.00%**	**18.25**	**23.2**	**0.450**	**0.200**	**1.44**	**0.165**	**0.44**	**423.9**	**26.27**	**8.05**	**34.32**
20%	**9.8**	**5.00%**	**10.00%**	**36.50**	**13.9**	**0.269**	**0.103**	**0.44**	**0.045**	**0.12**	**505.7**	**16.12**	**4.44**	**20.56**
30%	**6.5**	**5.00%**	**10.00%**	**36.50**	**8.2**	**0.158**	**0.075**	**0.19**	**0.006**	**0.02**	**297.5**	**6.87**	**0.63**	**7.50**
40%	**4.6**	**5.00%**	**10.00%**	**36.50**	**5.6**	**0.108**	**0.068**	**0.12**	**0.000**	**0.00**	**203.3**	**4.28**	**0.00**	**4.28**
50%	**3.5**	**5.00%**	**10.00%**	**36.50**	**4.1**	**0.079**	**0.066**	**0.08**	**0.000**	**0.00**	**148.7**	**3.03**	**0.00**	**3.03**
60%	**2.7**	**5.00%**	**10.00%**	**36.50**	**3.1**	**0.061**	**0.065**	**0.06**	**0.000**	**0.00**	**114.0**	**2.29**	**0.00**	**2.29**
70%	**2.2**	**5.00%**	**10.00%**	**36.50**	**2.4**	**0.047**	**0.064**	**0.05**	**0.000**	**0.00**	**89.2**	**1.78**	**0.00**	**1.78**
80%	**1.9**	**5.00%**	**10.00%**	**36.50**	**2.0**	**0.039**	**0.064**	**0.04**	**0.000**	**0.00**	**74.4**	**1.47**	**0.00**	**1.47**
90%	**1.4**	**5.00%**	**10.00%**	**36.50**	**1.6**	**0.032**	**0.064**	**0.03**	**0.000**	**0.00**	**59.5**	**1.18**	**0.00**	**1.18**
100%	**0.3**	**5.00%**	**10.00%**	**36.50**	**0.8**	**0.016**	**0.064**	**0.02**	**0.000**	**0.00**	**29.7**	**0.59**	**0.00**	**0.59**
									Annual Totals:		**2,842.7** (cfs) **5,638.6** (acre-ft)	**562.9** (tons/yr)	**68.9** (tons/yr)	**631.8** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trout Creek, C4 Reference Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**D. Rosgen *et al*., XS DR_Riffle 1**	Date:	**8/13/2010**

Enter Required Information for Existing Condition

9.7	D_{50}	Riffle bed material D_{50} (mm)			
7.7	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.24	D_{max}	Largest particle from bar sample (ft)	**74**	**(mm)**	304.8 mm/ft
0.0044	S	Existing bankfull water surface slope (ft/ft)			
1.19	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

1.25	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\,(D_{50}/\hat{D}_{50})^{-0.872}$
7.62	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\,(D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	**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

N/A	**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

0.327		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 **24**	CO **70**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**
Shields **1**	CO **0.35**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**
Shields **3.64**	CO **1.27**	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\mathbf{d} = \frac{\tau}{\gamma \mathbf{S}}$ τ = predicted shear stress, γ = 62.4, S = existing slope
Shields **0.0135**	CO **0.0047**	Predicted slope required to initiate movement of measured D_{max} (mm) $\mathbf{S} = \frac{\tau}{\gamma \mathbf{d}}$ τ = predicted shear stress, γ = 62.4, d = existing depth

Check: ☑ Stable ☐ Aggrading ☐ Degrading

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Trout Creek, C4 Reference**	Stream Type: **C4**
Location: **Pike National Forest, CO**	Valley Type: **VIII**
Observers: **D. Rosgen *et al*.**	Date: **8/13/2010**
Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Trout Creek, C4 Reference Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**D. Rosgen *et al*.**	Date:	**8/13/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**2**
	1.0 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Depositional Patterns (Worksheet 5-10)**	**B1, B2**	B4, B8	B3	B5, B6, B7	**1**
	B1, B2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	**M1, M3**, M4		M2, M5, M6, M7, M8		**1**
	M1, M3 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, **L/M**, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
	L/M [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	1.0 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**7**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream: **Trout Creek, C4 Reference Reach** Stream Type: **C4**
Location: **Pike National Forest, Colorado** Valley Type: **VIII**
Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
	Ref. Reach [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**1**
	1.0 [✓ **(1)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	**B1**	**B2**, B4	B3, B5	B6, B7, B8	**2**
	(1)	**B1, B2** [✓ **(2)**]	**(3)**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D1 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**10**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trout Creek, C4 Reference Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**D. Rosgen *et al*.**	Date:	**8/13/2010**

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 5-22)**	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**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	Ref. Reach **[✓ (2)]**	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 **[✓ (2)]**	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.00 **[✓ (1)]**	**(2)**	**(3)**	**(4)**	
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream: **Trout Creek, C4 Reference Reach** Stream Type: **C4**

Location: **Pike National Forest, Colorado** Valley Type: **VIII**

Observers: **D. Rosgen *et al*.** Date: **8/13/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **at potential [✓ (2)]**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **[✓ (2)]**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **[✓ (2)]**	*Moderate Deposition* **(4)**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **[✓ (2)]**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**8**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trout Creek, C4 Reference Reach**	Stream Type:	**C4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**VIII**
Observers:	**D. Rosgen *et al*.**	Date:	**8/13/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	[✓ 1]	1
	Mod. Unstable	2	
	Unstable	3	
	Highly Unstable	4	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	[✓ 1]	1
	Mod. Deposition	2	
	Excess Deposition	3	
	Aggradation	4	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	[✓ 1]	1
	Slightly Incised	2	
	Mod. Incised	3	
	Degradation	4	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	[✓ 1]	1
	Slight Increase	2	
	Mod. Increase	3	
	Extensive	4	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	[✓ 1]	1
	Fair: Mod. Unstable	2	
	Poor: Unstable	4	
		Total Points	**5**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** 5 ☑	***Moderate*** 6 – 10 ☐	***High*** 11 – 15 ☐	***Very High*** 16 – 20 ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trout Creek, C4 Reference Reach**						Location: **Pike National Forest, Colorado**							
Observers:	**D. Rosgen *et al*.**			Date: **8/14/2010**			Stream Type: **C4**		Valley Type: **VIII**					
Channel Dimension (Riffle XS 0+67)	Mean Bankfull Depth (ft):	**0.89**	Bankfull Width (ft):	**19.37**	Cross-Sectional Area (ft^2):	**17.32**	Width of Flood-Prone Area (ft):	**41.92**	Entrenchment Ratio:	**2.16**				
Channel Pattern	Mean: Range:	λ/W_{bkf}:	**4.67** **3.43-6.33**	L_m/W_{bkf}:	**5.79** **4.02-8.9**	R_c/W_{bkf}:	**1.72** **1.32-2.31**	MWR:	**3.66** **2.37-4.58**	Sinuosity:	**1.38**			
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed									
	Max Bankfull Depth (ft):	Riffle **1.6**	Pool **2.46**	Depth Ratio (max to mean):	Riffle **1.53**	Pool **2.35**	Pool-to-Pool Spacing:	Ratio **3**	Slope Valley: **0.0061**	Slope Water Surface: **0.0044**				
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Willow, Redtop, Carex/ Juncus**		Potential Composition/Density: **Same but without Invasives**		Remarks: Condition, Vigor & Usage of Existing Reach: **Recovering C4 inside of an F4 Stream Type**								
	Flow Regime:	**P1, P2, P8**	Stream Size & Order:	**S-4(4)**	Meander Patterns:	**M1, M3**	Depositional Patterns:	**B1, B2**	Debris/Channel Blockages:	**D1**				
	Degree of Incision (Bank-Height Ratio):	**1.0**	Degree of Incision Stability Rating:	**No Incision**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating):	**73 (Good)**								
	Width/depth Ratio (W/d):	**13.7**	Reference W/d Ratio (W/d_{ref}):	**13.7**	Width/Depth Ratio State (W/d) / (W/d_{ref}):	**1.0**	W/d Ratio State Stability Rating:	**Stable**						
	Meander Width Ratio (MWR):	**4.5**	Reference MWR_{ref}:	**4.5**	Degree of confinement (MWR / MWR_{ref}):	**1.0**	MWR / MWR_{ref} Stability Rating:	**Unconfined**						
Bank Erosion Summary	Length of Reach Studied (ft):	**463**	Annual Streambank Erosion Rate:	**2.94** (tons/yr)	**0.0063** (tons/yr/ft)	Curve Used: **Colorado**	Remarks:							
Sediment Capacity (POWERSED)	☑ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks: **Reference Reach**										
Entrainment/ Competence	Largest Particle from Bar Sample (mm):	**74**	$\tau =$	**0.327**	$\tau^* =$	**N/A**	Existing Depth:	**1.19**	Required Depth:	**1.27**	Existing Slope:	**0.0044**	Required Slope:	**0.0047**
Successional Stage Shift	**C** → **D** → **G** → **F** → [✓ **C**] →	Existing Stream State (Type):	**C4**	Potential Stream State (Type):	**C4**									
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes: **Reference Reach**									
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes: **Reference Reach**									
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes: **Reference Reach**									
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes: **Reference Reach**									
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes: **Reference Reach**									

Appendix C21

D4a Stream Type

Reference Reach

Table of Contents

Appendix C21: D4a Reference Reach

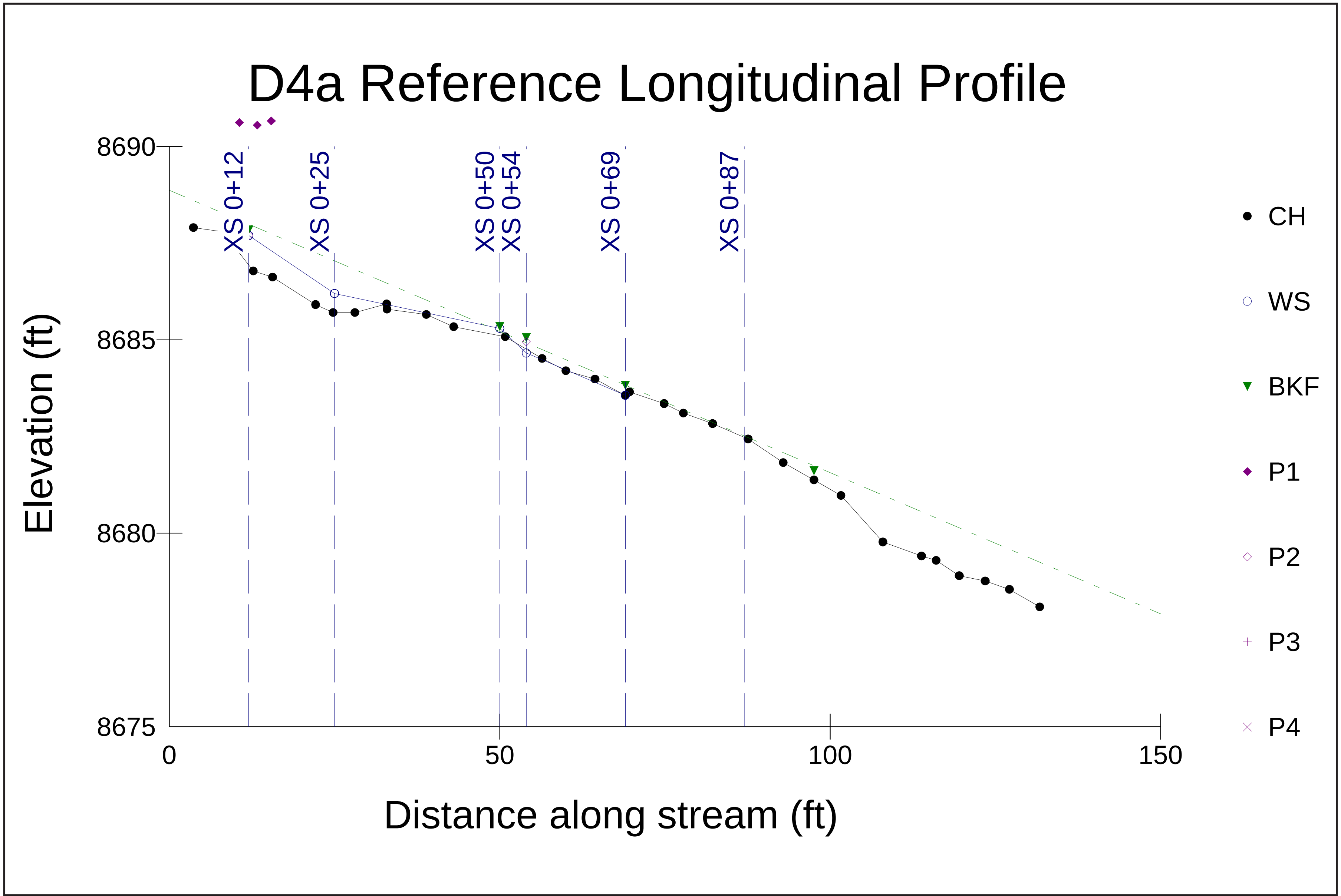
D4a Reference Reach Location & Overview

The D4a reference reach is in a Valley Type IIIa located in Northfield Gulch. This 3rd order channel is braided with large amounts of sediment depositing from upstream. The channel bed and banks show sediment deposition from upstream with riparian vegetation encouraging further deposition. Bed features are a result of a convergence/divergence process of local bed scour and sediment deposition. The channel is ephemeral and streamflow is seasonal by snowmelt and stormflow runoff. Flow is altered due to Waldo Canyon Fire.

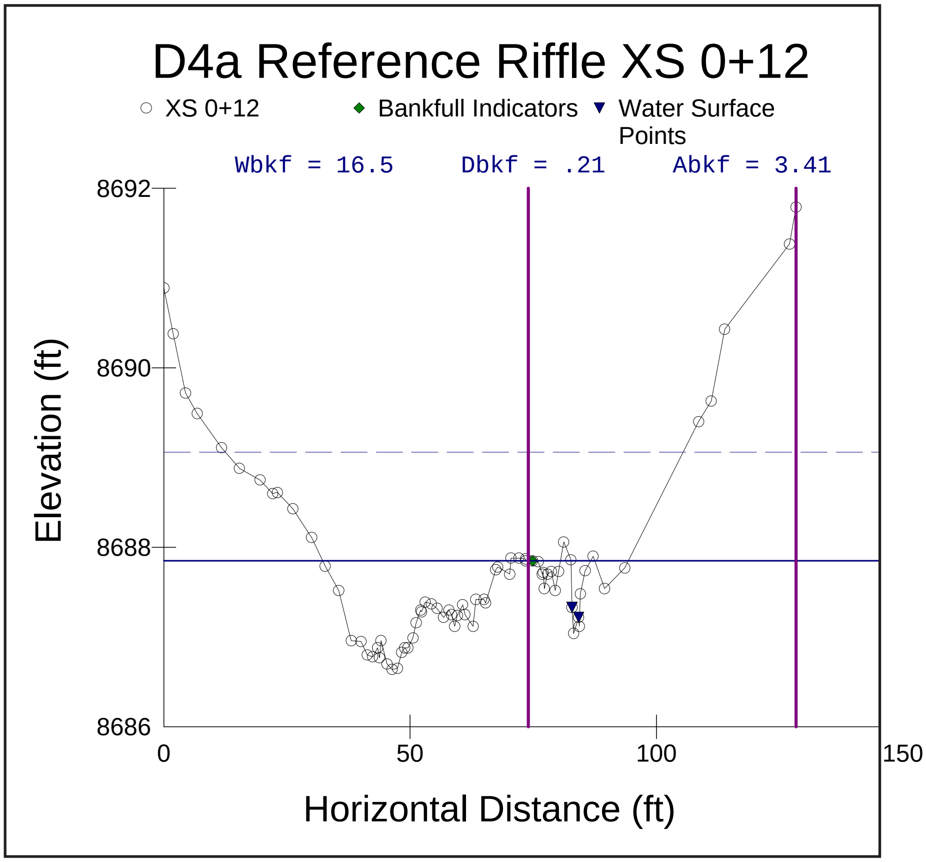
Typical of D stream types, the channel is unconfined and has a high width/depth ratio. Excess deposition in this reach is expected especially with additional sediment being deposited due to the fire. The location of this reach is shown in **Figure C-1**, and the photograph depicts the typical characteristics of this stream type. Stream types are mapped where they occur by sub-watershed as shown in **Appendix D**.

The details of the dimension, pattern, profile and materials are summarized. The following summary worksheets provide details of the morphology, hydraulics, stability, and streambank erosion rates for this reference reach. In the situation where impaired A4 and F4b stream types are located on active alluvial fans, an alternative for mitigation and sediment reduction is to use the data from the stable form to extrapolate for potential implementation of natural channel design.

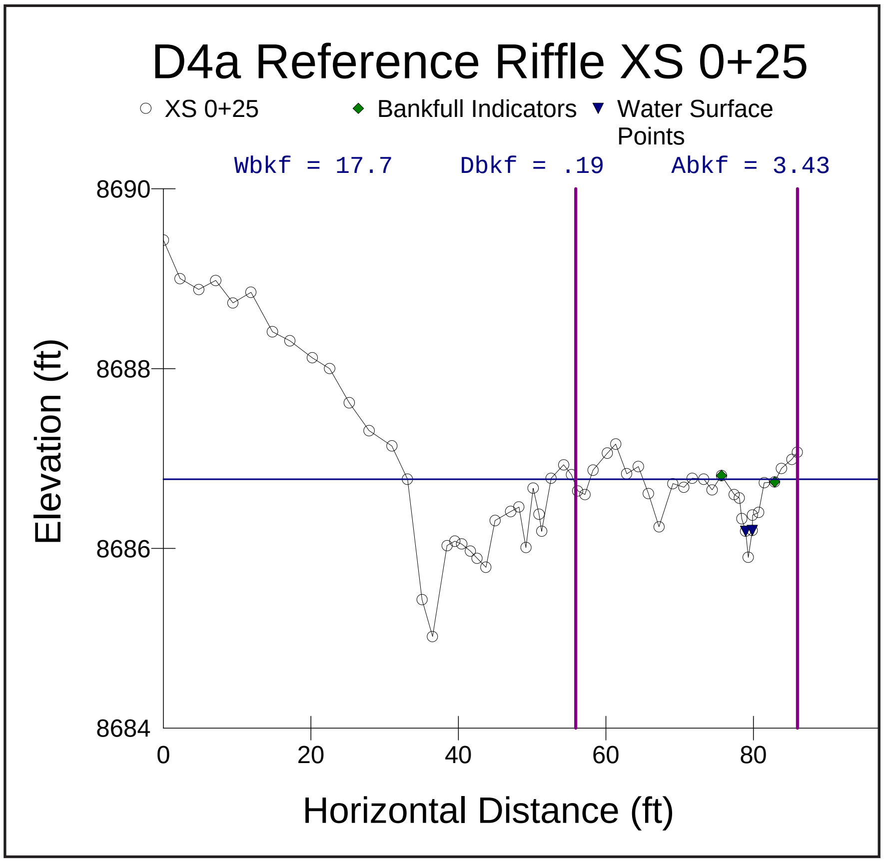
Survey Summary



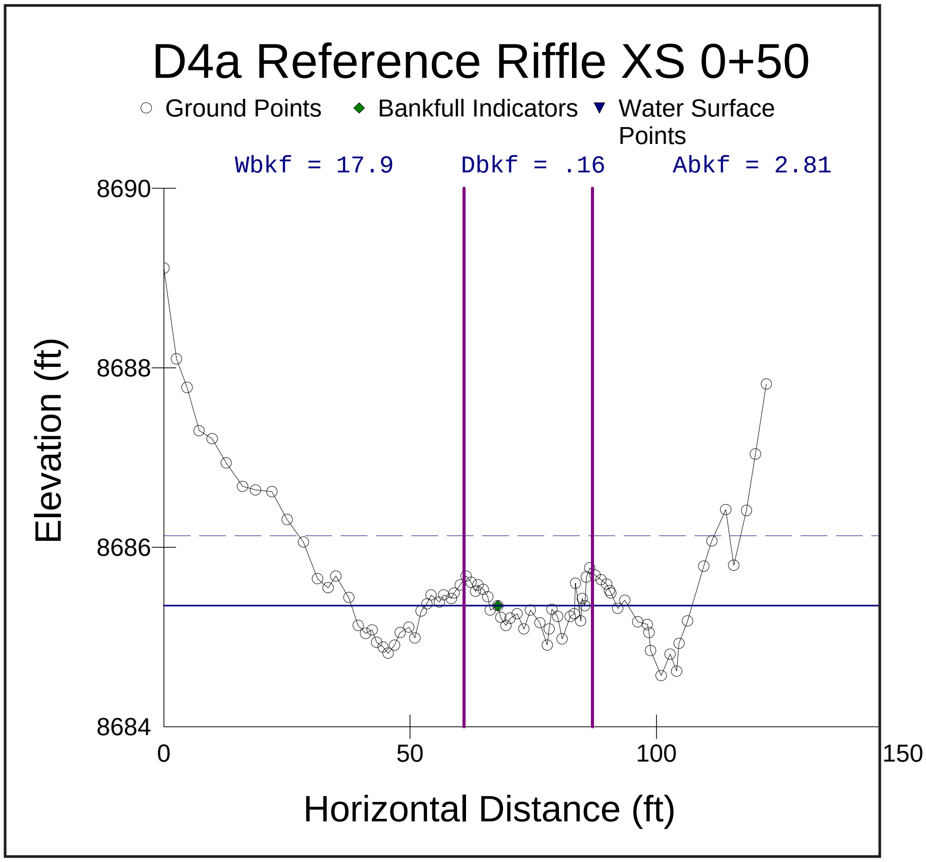
Longitudinal Profile (graph generated from RIVERMorph^{TM})



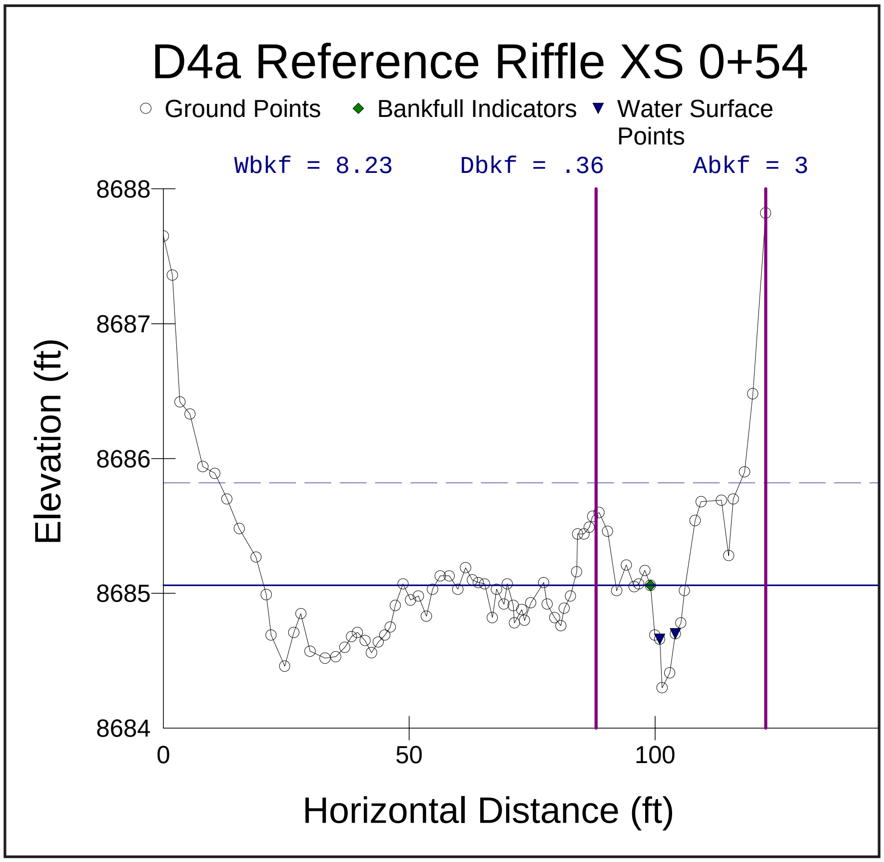
Representative Cross-section 0+12 (graph generated from RIVERMorph^{TM})



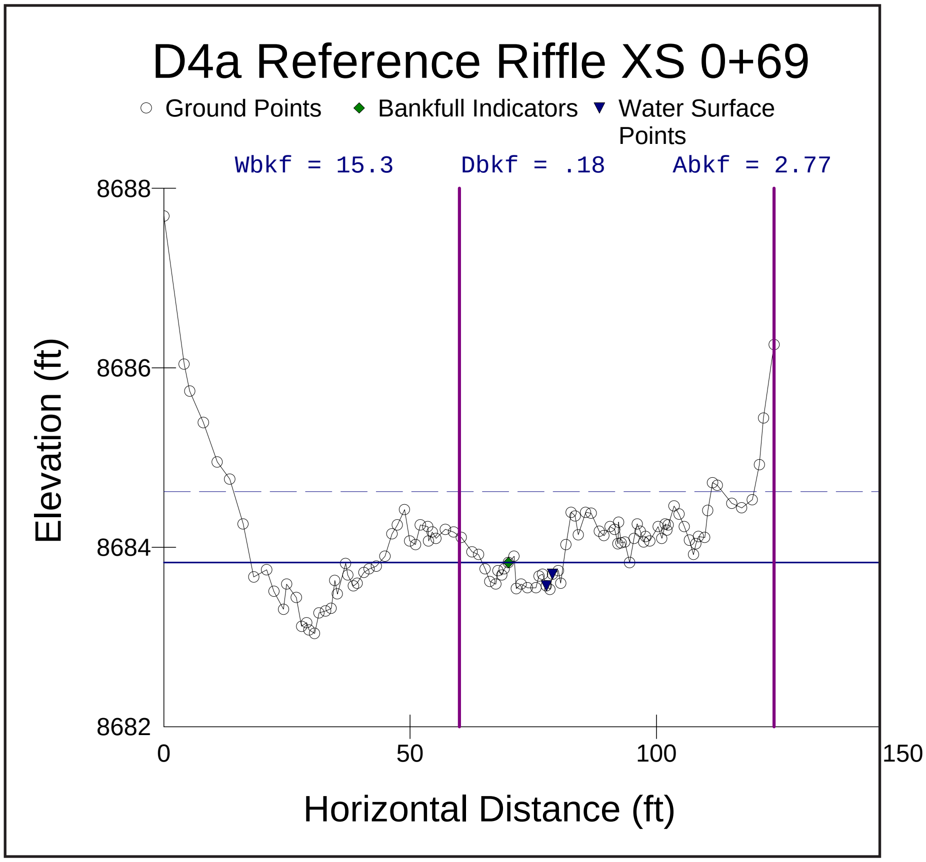
Cross-section 0+25 (graph generated from RIVERMorph^{TM})



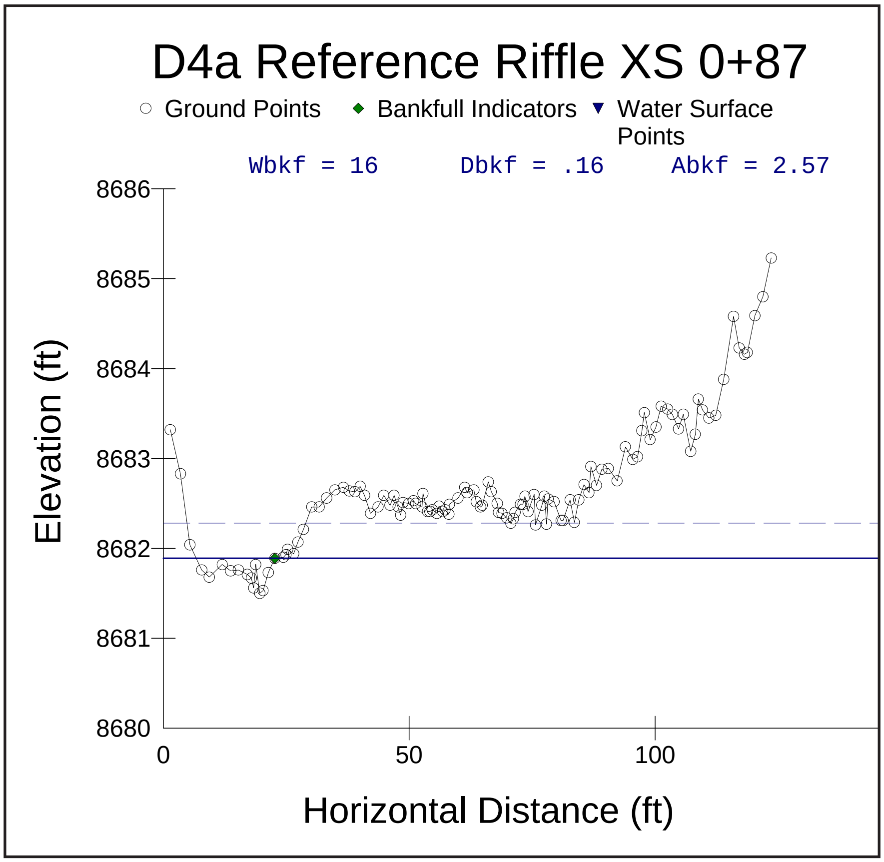
Cross-section 0+50 (graph generated from RIVERMorph^{TM})



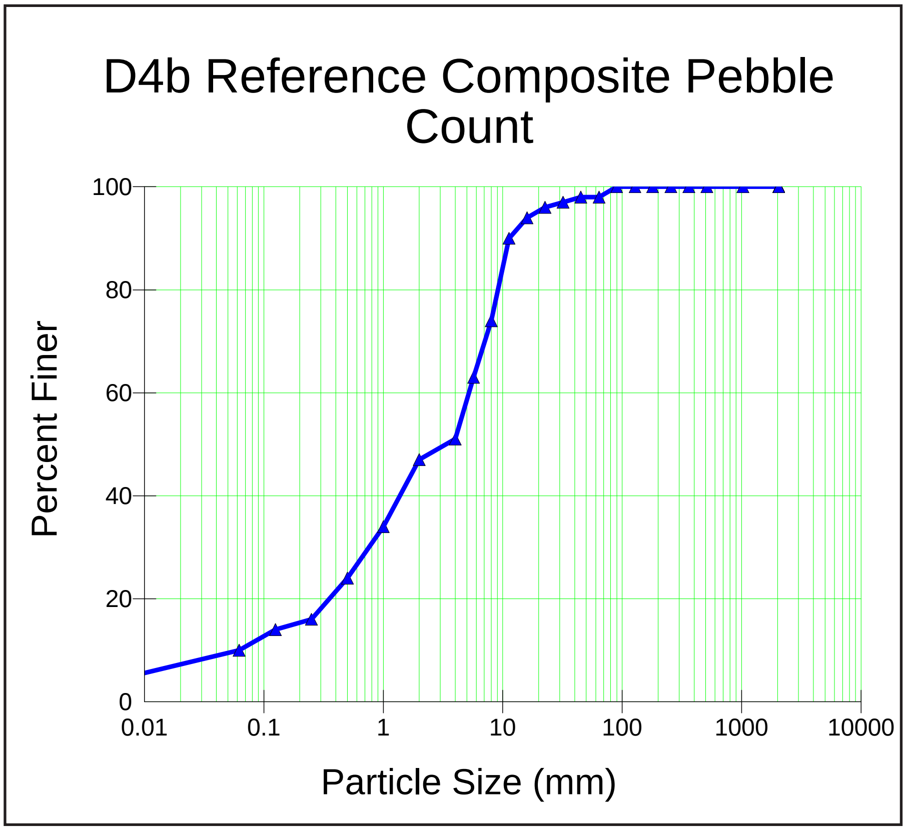
Cross-section 0+54 (graph generated from RIVERMorph^{TM})



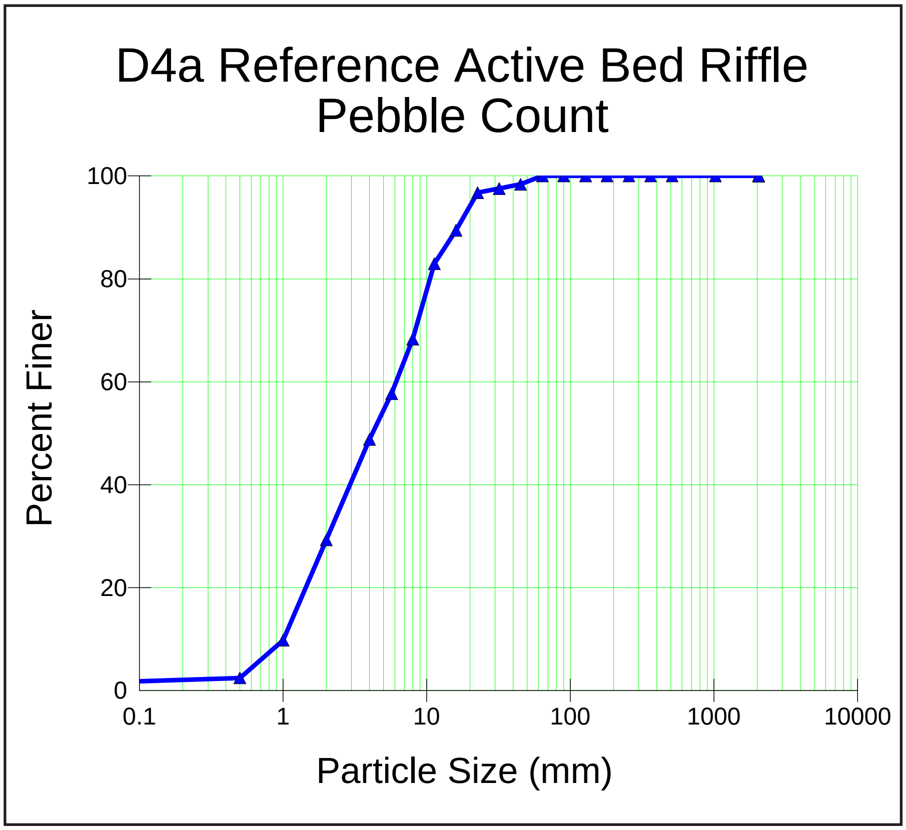
Cross-section 0+69 (graph generated from RIVERMorph™)



Cross-section 0+87 (graph generated from RIVERMorph™)



Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Pebble Count (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Northfield Gulch D4a Reference**	Location:	**Pike National Forest, Colorado**
Date:	**11/8/2012** Stream Type: **D4a**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	HUC:	__ __ __ __ __ __ __ __ __ __ __

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**2.81**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.16**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**17.9**	W_{bkf} (ft)	Wetted PERIMETER ~ (2 * d_{bkf}) + W_{bkf}	**18.24**	W_p (ft)
D_{84} at Riffle	**12.1**	Dia. (mm)	D_{84} (mm) / 304.8	**0.04**	D_{84} (ft)
Bankfull SLOPE	**0.07**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.15**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**3.89**	R / D_{84}
Drainage Area	**0.42**	DA (mi^2)	Shear Velocity $u* = (gRS)^{½}$	**0.601**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\, 2.83 + 5.66 * Log\{ R / D_{84} \}]\, u*$	**3.70**	ft / sec	**10.40**	cfs
2. Roughness Coefficient: a) Manning's *n* from Friction Factor / Relative Roughness (Figs. 5-7, 5-8) $u = 1.49*R^{2/3}*S^{1/2} / n$ $n =$ **0.064**	**1.80**	ft / sec	**5.06**	cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **b) Manning's *n* from Stream Type** (Fig. 5-9) $n =$ **0.064**	**1.80**	ft / sec	**5.06**	cfs
2. Roughness Coefficient: $u = 1.49*R^{2/3}*S^{1/2} / n$ **c) Manning's *n* from Jarrett (USGS):** $n = 0.39*S^{0.38}*R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.194**	**0.59**	ft / sec	**1.67**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach (Leopold, Wolman and Miller)**	**3.86**	ft / sec	**10.8**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.)		ft / sec		cfs
4. Continuity Equations: a) Regional Curves u = Q / A **Return Period for Bankfull Discharge** Q = ______ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data u = Q / A		ft / sec		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. Level II stream classification.

Stream: **Northfield Gulch, D4a Reference**

Basin: Drainage Area: **272** acres **0.42** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **XS 0+12** Date: **11/08/2012**

Observers: **Bones, Kyle, David, Luke, Kim** Valley Type: **IIIa**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**17.92**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.16**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**2.81**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**112**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.78**	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.	**86.58**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**4.83**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**3.5**	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.	**0.07277**	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 (S_{val} / S).	**1**	

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

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Northfield Gulch D4a Reference** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/08/12** Valley Type: **IIIa** 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})	**17.5**	**16.5**	**18.0**	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	**3.2**	**2.8**	**3.4**
Mean Riffle Depth (d_{bkf})	**0.19**	**0.16**	**0.21**	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	**95.1**	**78.5**	**112.0**
Maximum Riffle Depth (d_{max})	**1.25**	**0.78**	**1.75**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**6.579**	**4.105**	**9.211**
Width of Flood-Prone Area (W_{fpa})	**83.8**	**71.9**	**92.9**	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})			
Riffle Inner Berm Width (W_{ib})				ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})			
Riffle Inner Berm Depth (d_{ib})				ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})			
Riffle Inner Berm Area (A_{ib})				ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})			
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})								

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	**Mean**	**Min**	**Max**		**Pool Dimensions & Dimensionless Ratios********	**Mean**	**Min**	**Max**
Pool Width (W_{bkfp})				ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})			
Mean Pool Depth (d_{bkfp})				ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})			
Pool Cross-Sectional Area (A_{bkfp})				ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})			
Maximum Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Pool Inner Berm Width (W_{ibp})				ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})			
Pool Inner Berm Depth (d_{ibp})				ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})			
Pool Inner Berm Area (A_{ibp})				ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})			
Point Bar Slope (S_{pb})				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})				ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})			
Mean Run Depth (d_{bkfr})				ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})			
Run Cross-Sectional Area (A_{bkfr})				ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})			
Maximum Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})				ft				

Glide Dimensions*

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

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Northfield Gulch, D4a Reference** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/8/2012** Valley Type: **IIIa** Stream Type: **D4a**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**1.80**	ft/sec	Estimation Method	**Roughness Coefficient**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**5.05**	cfs	Drainage Area	**0.42**	mi^2

Channel Pattern

Geometry	**Mean**	**Min**	**Max**		**Dimensionless Geometry Ratios**	**Mean**	**Min**	**Max**
Linear Wavelength (λ)				ft	Linear Wavelength to Riffle Width (λ / W_{bkf})			
Stream Meander Length (L_m)				ft	Stream Meander Length Ratio (L_m / W_{bkf})			
Radius of Curvature (R_c)				ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})			
Belt Width (W_{blt})	**60.0**			ft	Meander Width Ratio (W_{blt} / W_{bkf})	**3.43**		
Arc Length (L_a)				ft	Arc Length to Riffle Width (L_a / W_{bkf})			
Riffle Length (L_r)				ft	Riffle Length to Riffle Width (L_r / W_{bkf})			
Individual Pool Length (L_p)				ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})			
Pool to Pool Spacing (P_s)				ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})			

Channel Profile

Valley Slope (S_{val})	**0.0728**	ft/ft	Average Water Surface Slope (S)	**0.0728**	ft/ft	Sinuosity (S_{val} / S)		**1.00**
Stream Length (SL)	**128.0**	ft	Valley Length (VL)	**128.0**	ft	Sinuosity (SL / VL)		**1.00**
Low Bank Height (LBH)	start **1.00** end **0.25**	ft ft	Max Bankfull Depth (d_{max})	start **1.00** end **0.25**	ft ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start end	**1.0** **1.0**

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

Max Depths[a]	**Mean**	**Min**	**Max**		**Dimensionless Depth Ratios**	**Mean**	**Min**	**Max**
Max Riffle Depth (d_{max})	**0.62**	**0.20**	**1.37**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**3.263**	**1.053**	**7.211**
Max Run Depth (d_{maxr})				ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})			
Max Pool Depth (d_{maxp})				ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})			
Max Glide Depth (d_{maxg})				ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})			
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	**Riffle**[c]	**Bar**		**Reach**[b]	**Riffle**[c]	**Bar**	**Protrusion Height**[d]	
% Silt/Clay	**10.00**	**0.00**		D_{16}	**0.25**	**1.32**			mm
% Sand	**37.00**	**29.27**		D_{35}	**1.08**	**2.59**			mm
% Gravel	**51.00**	**70.73**		D_{50}	**3.50**	**4.23**			mm
% Cobble	**2.00**	**0.00**		D_{84}	**10.06**	**12.07**			mm
% Boulder	**0.00**	**0.00**		D_{95}	**19.30**	**21.02**			mm
% Bedrock	**0.00**	**0.00**		D_{100}	**90.00**	**64.00**			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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Northfield Gulch D4a Reference**

Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **11/08/2012**

Existing species composition: **Mixed conifer, aspen, willow**

Potential species composition: **At potential**

Riparian cover categories		Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**75%**	**20%**	**Aspen**	**60%**
				Ponderosa	**15%**
				Limber Pine	**5%**
				Spruce	**20%**
					0%
					0%
					100%
2. Understory	Shrub layer	▨	**25%**	**Willow**	**80%**
				Potentilla	**20%**
					0%
					0%
					0%
					0%
					100%
3. Ground level	Herbaceous	▨	**30%**	**Grass**	**80%**
				Forbs	**20%**
				Leaf and needle litter	**0%**
					0%
					0%
					0%
					100%
	Leaf or needle litter	▨	**5%**	**Remarks:** Condition, vigor and/or usage of existing reach: **Vigorous**	
	Bare ground	▨	**20%**		
			Column Total = 100%		

*Based on crown closure.

**Based on basal area to surface area.

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Northfield Gulch A4a+ Poor** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/8/2012**

List ALL COMBINATIONS that APPLY..............☞	**E1**	**E2**	**E7**	**E8**				

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 5-8. Stream order & stream size.

Stream Size and Order

Stream: **Northfield Gulch D4a Reference**
Location: **Pike National Forest, Colorado**
Observers: **Bones, Kyle, David, Luke, Kim**
Date: **11/8/2012**

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 5-9. Meander patterns.

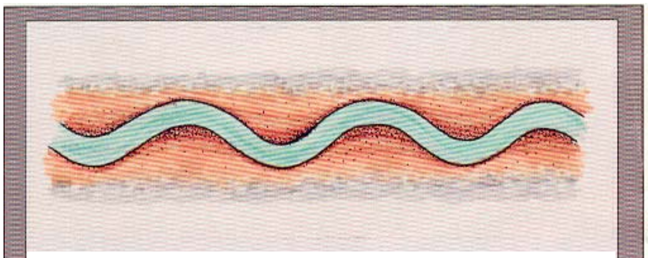
Meander Patterns

Stream: **Northfield Gulch, D4a Reference** Location: **Pike National Forest, CO**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/8/2012**

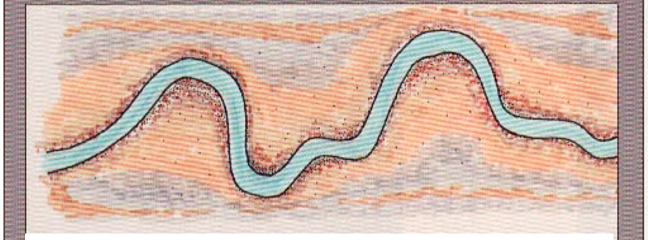
List ALL CATEGORIES that APPLY ☞	**N/A**				

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

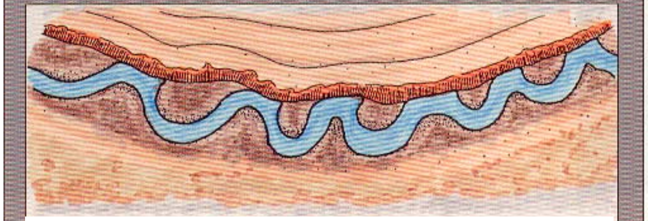


M1 REGULAR MEANDERS

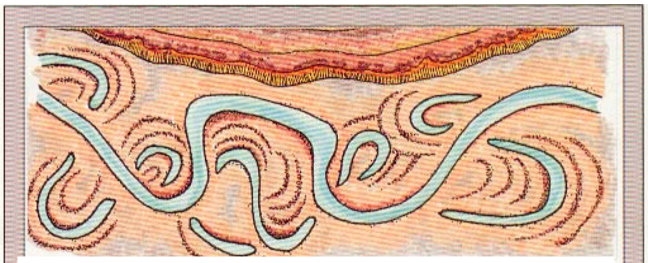
M2 TORTUOUS MEANDERS



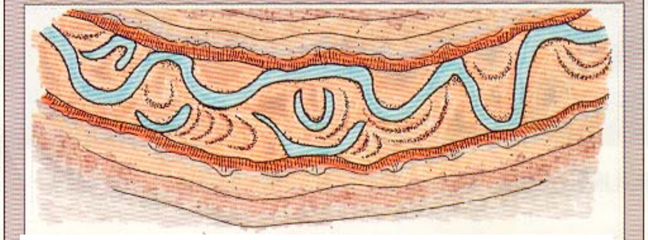
M3 IRREGULAR MEANDERS



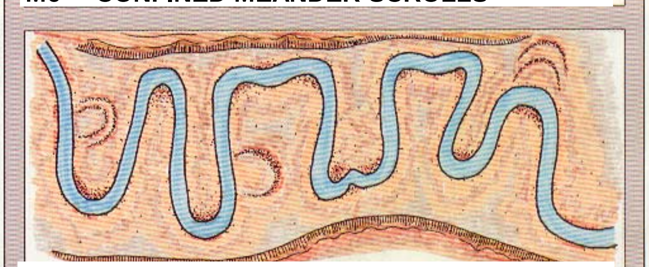
M4 TRUNCATED MEANDERS



M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and oxbow cutoffs

Worksheet 5-10. Depositional patterns.

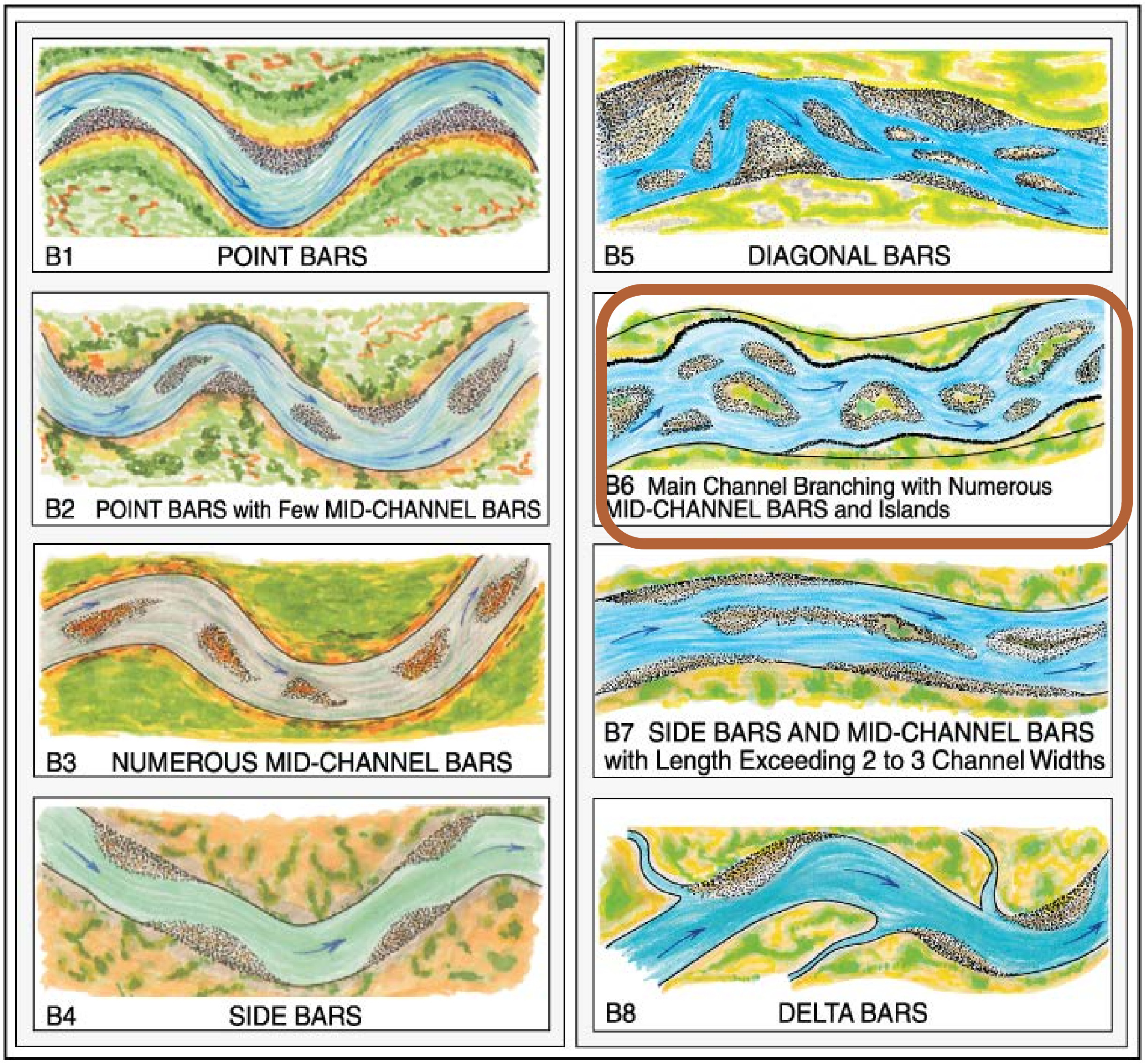
Depositional Patterns

Stream: **Northfield D4a Reference** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/8/2012**

List ALL CATEGORIES that APPLY ☞	**B6**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Northfield Gulch D4a Reference** Location: **Pike National Forest, Colorado**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/8/2012**

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 5-12. Degree of channel incision.

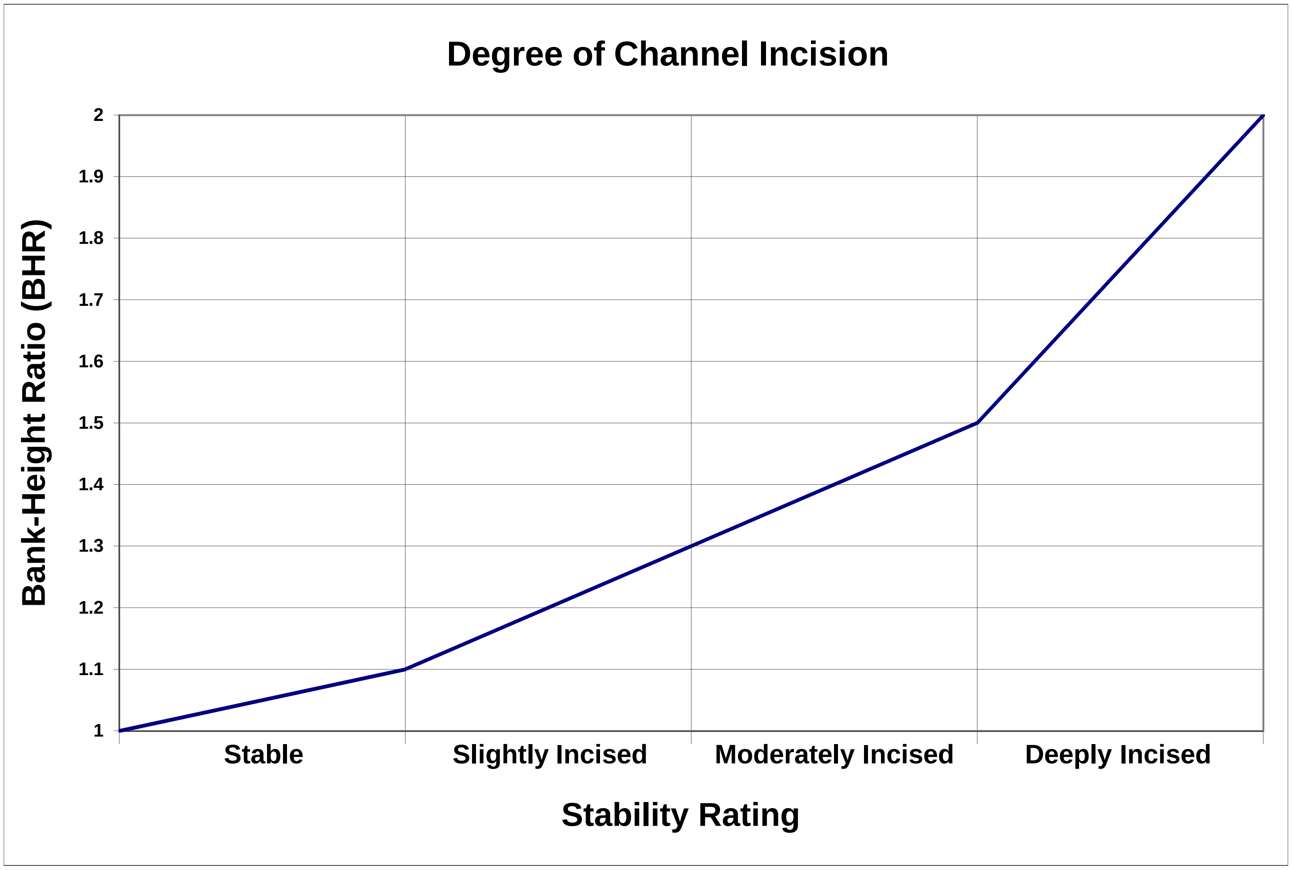
Degree of Channel Incision

Low Bank Height: **1**

Max Bankfull Depth: **1**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**

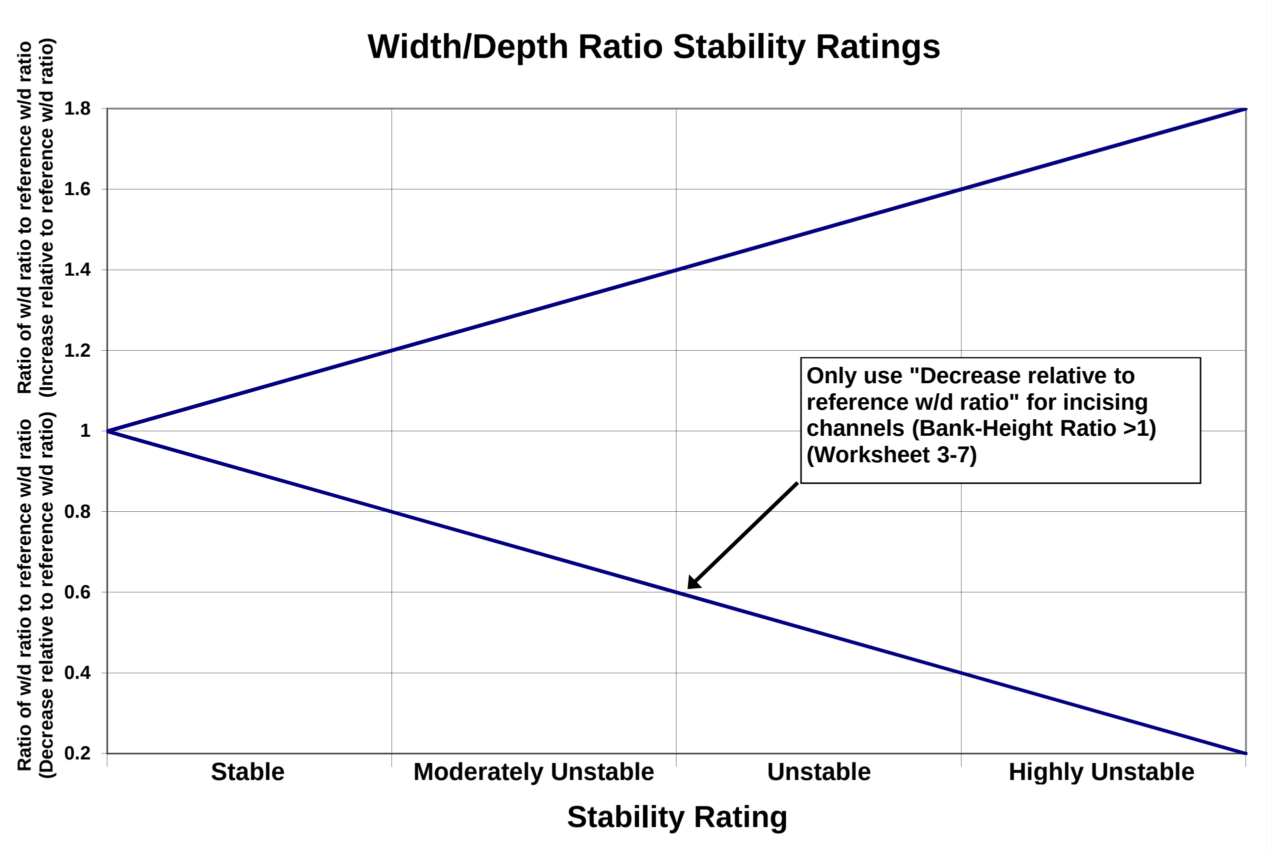


Worksheet 5-13. Width/depth ratio state.

Width/Depth Ratio State

Existing Width/Depth Ratio:	**112**	Ratio of existing W/d to reference W/d:	**1.00**
Reference Width/Depth Ratio:	**112**		

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



Width/Depth Ratio Stability Ratings

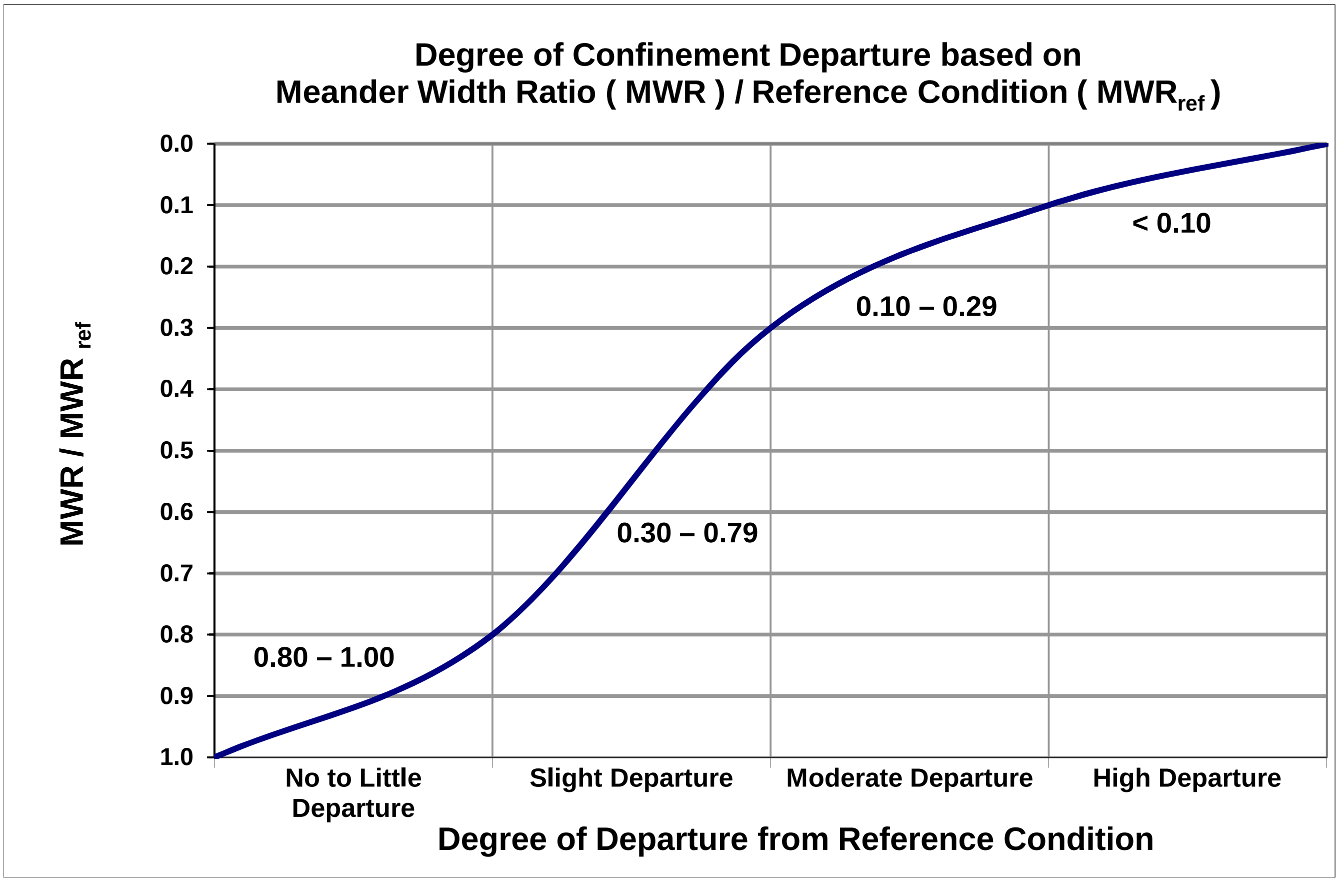
Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**0**	Ratio of MWR to MWR$_{ref}$:	**NA**
Reference Meander Width Ratio (MWR$_{ref}$):	**0**		

Degree of Confinement Stability Rating ☞ **NA**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Northfield Gulch D4a Reference **Location:** Pike National Forest, CO **Valley Type:** IIIa **Observers:** Bones, Kyle, David, Luke, Kim **Date:** 11/8/2012

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	9	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	10	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	2	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	5	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	20	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	**21**	**Good total =**	**4**	**Fair total =**	**15**	**Poor total =**	**40**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**80**
Existing stream type =	**D4a**
***Potential stream type =**	**D4a**
Modified channel stability rating =	
Good	

*Rating is adjusted to potential stream type, not existing.

FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

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**	**3.99**	**0.0064**	**1.39**
2. Suspended sediment (dimensionless)	**0.0636**	**0.9326**	**2.4085**	**Non-Linear**	**Pagosa Springs Reference Curve**			
3. User-defined relations (bedload)						Notes: **Pre-Fire Flow Duration Curve, Good/Fair Sediment Curves, Good/Fair Regional Sediment Curves**		
4. User-defined relations (suspended sediment)								

From dimensioned flow-duration curve							From sediment rating curves				Calculate	Calculate sediment yield		
(1) Flow exceedence	(2) Daily mean discharge	(3) Mid-ordinate	(4) Time increment (percent)	(5) Time increment (days)	(6) Mid-ordinate streamflow	(7) Dimension-less streamflow	(8) Dimension-less suspended sediment discharge	(9) Suspended sediment discharge	(10) Dimension-less bedload discharge	(11) Bedload	(12) Time adjusted streamflow	(13) Suspended sediment **[(5)×(9)]**	(14) Bedload sediment **[(5)×(11)]**	(15) 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	**0.0**													
90.000	**0.1**	**95.00**	**10.00**	**36.50**	**0.1**	**0.02**	**1.5**	**0.0**	**0.0000**	**0.00**	**0.80**	**0.00**	**0.00**	**0.00**
80.000	**0.2**	**85.00**	**10.00**	**36.50**	**0.2**	**0.04**	**1.5**	**0.0**	**0.0000**	**0.00**	**1.50**	**0.00**	**0.00**	**0.00**
70.000	**0.2**	**75.00**	**10.00**	**36.50**	**0.2**	**0.05**	**1.5**	**0.0**	**0.0000**	**0.00**	**2.00**	**0.00**	**0.00**	**0.00**
60.000	**0.3**	**65.00**	**10.00**	**36.50**	**0.2**	**0.06**	**1.5**	**0.0**	**0.0000**	**0.00**	**2.30**	**0.00**	**0.00**	**0.00**
50.000	**0.3**	**55.00**	**10.00**	**36.50**	**0.3**	**0.08**	**1.5**	**0.0**	**0.0000**	**0.00**	**3.00**	**0.00**	**0.00**	**0.00**
40.000	**0.5**	**45.00**	**10.00**	**36.50**	**0.4**	**0.10**	**1.5**	**0.0**	**0.0000**	**0.00**	**4.00**	**0.00**	**0.00**	**0.00**
30.000	**0.6**	**35.00**	**10.00**	**36.50**	**0.5**	**0.14**	**1.5**	**0.0**	**0.0000**	**0.00**	**5.40**	**0.00**	**0.00**	**0.00**
20.000	**1.0**	**25.00**	**10.00**	**36.50**	**0.8**	**0.20**	**1.5**	**0.0**	**0.0000**	**0.00**	**7.90**	**0.00**	**0.00**	**0.00**
10.000	**1.7**	**15.00**	**10.00**	**36.50**	**1.3**	**0.34**	**1.7**	**0.0**	**0.0004**	**0.04**	**13.40**	**0.00**	**1.46**	**1.46**
5.000	**2.8**	**7.50**	**5.00**	**18.25**	**2.3**	**0.56**	**2.3**	**0.0**	**0.0015**	**0.09**	**11.25**	**0.00**	**1.64**	**1.64**
4.000	**3.1**	**4.50**	**1.00**	**3.65**	**3.0**	**0.74**	**3.0**	**0.0**	**0.0029**	**0.17**	**2.95**	**0.00**	**0.62**	**0.62**
3.000	**3.7**	**3.50**	**1.00**	**3.65**	**3.4**	**0.85**	**3.6**	**0.0**	**0.0041**	**0.26**	**3.38**	**0.04**	**0.95**	**0.99**
2.000	**4.3**	**2.50**	**1.00**	**3.65**	**4.0**	**1.00**	**4.6**	**0.0**	**0.0060**	**0.35**	**3.99**	**0.04**	**1.28**	**1.32**
1.500	**5.0**	**1.75**	**0.50**	**1.83**	**4.7**	**1.17**	**6.0**	**0.0**	**0.0085**	**0.52**	**2.33**	**0.02**	**0.95**	**0.97**
1.000	**6.1**	**1.25**	**0.50**	**1.83**	**5.5**	**1.38**	**8.3**	**0.0**	**0.0125**	**0.73**	**2.75**	**0.05**	**1.33**	**1.38**
0.900	**6.5**	**0.95**	**0.10**	**0.37**	**6.3**	**1.57**	**10.7**	**0.0**	**0.0166**	**0.99**	**0.63**	**0.01**	**0.36**	**0.37**
0.800	**6.8**	**0.85**	**0.10**	**0.37**	**6.6**	**1.66**	**12.1**	**0.1**	**0.0190**	**1.12**	**0.66**	**0.02**	**0.41**	**0.43**
0.700	**7.2**	**0.75**	**0.10**	**0.37**	**7.0**	**1.76**	**13.6**	**0.1**	**0.0214**	**1.25**	**0.70**	**0.02**	**0.46**	**0.48**
0.600	**7.7**	**0.65**	**0.10**	**0.37**	**7.4**	**1.86**	**15.5**	**0.1**	**0.0245**	**1.43**	**0.74**	**0.03**	**0.52**	**0.55**
0.500	**8.2**	**0.55**	**0.10**	**0.37**	**7.9**	**1.99**	**17.7**	**0.1**	**0.0281**	**1.64**	**0.79**	**0.03**	**0.60**	**0.63**
0.250	**9.5**	**0.38**	**0.25**	**0.91**	**8.8**	**2.22**	**22.6**	**0.1**	**0.0358**	**2.07**	**2.21**	**0.11**	**1.89**	**2.00**
0.100	**11.0**	**0.18**	**0.15**	**0.55**	**10.2**	**2.56**	**31.6**	**0.2**	**0.0495**	**2.89**	**1.53**	**0.11**	**1.58**	**1.69**
0.050	**11.7**	**0.08**	**0.05**	**0.18**	**11.4**	**2.84**	**34.6**	**0.3**	**0.0540**	**3.63**	**0.57**	**0.05**	**0.66**	**0.71**
0.010	**12.8**	**0.03**	**0.04**	**0.15**	**12.3**	**3.07**	**34.6**	**0.4**	**0.0540**	**4.28**	**0.49**	**0.05**	**0.62**	**0.67**
0.005	**12.8**	**0.01**	**0.01**	**0.02**	**12.8**	**3.20**	**34.6**	**0.4**	**0.0540**	**4.71**	**0.06**	**0.01**	**0.09**	**0.10**
0.001	**12.8**	**0.00**	**0.00**	**0.01**	**12.8**	**3.20**	**34.6**	**0.4**	**0.0540**	**4.71**	**0.05**	**0.01**	**0.07**	**0.08**
											Annual totals:	**0.6** (tons/yr)	**15.5** (tons/yr)	**16.1** (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation type	Intercept	Coefficient	Exponent	Form (e.g., linear, non-linear, etc.)	Equation name
1. Bedload (dimensionless)	-0.0113	1.0139	2.1929	Non-Linear	Pagosa Springs Reference Curve
2. Suspended sediment (dimensionless)	0.0636	0.9326	2.4085	Non-Linear	Pagosa Springs Reference Curve
3. User-defined relations (bedload)					
4. User-defined relations (suspended sediment)					

Bankfull discharge (cfs)	Bankfull bedload (kg/s)	Bankfull suspended (mg/l)
3.99	0.0064	1.39

Notes:

Post-Fire Flow Duration Curve, Good/Fair Sediment Curves, Good/Fair Regional Sediment Curves

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	0.0													
90.000	0.1	95.00	10.00	36.50	0.1	0.02	1.5	0.0	0.0000	0.00	0.80	0.00	0.00	0.00
80.000	0.2	85.00	10.00	36.50	0.2	0.04	1.5	0.0	0.0000	0.00	1.50	0.00	0.00	0.00
70.000	0.2	75.00	10.00	36.50	0.2	0.05	1.5	0.0	0.0000	0.00	2.00	0.00	0.00	0.00
60.000	0.3	65.00	10.00	36.50	0.2	0.06	1.5	0.0	0.0000	0.00	2.30	0.00	0.00	0.00
50.000	0.3	55.00	10.00	36.50	0.3	0.08	1.5	0.0	0.0000	0.00	3.00	0.00	0.00	0.00
40.000	0.5	45.00	10.00	36.50	0.4	0.10	1.5	0.0	0.0000	0.00	4.00	0.00	0.00	0.00
30.000	0.7	35.00	10.00	36.50	0.6	0.14	1.5	0.0	0.0000	0.00	5.70	0.00	0.00	0.00
20.000	1.4	25.00	10.00	36.50	1.1	0.27	1.6	0.0	0.0001	0.00	10.60	0.00	0.00	0.00
10.000	2.9	15.00	10.00	36.50	2.2	0.55	2.2	0.0	0.0014	0.09	21.80	0.00	3.28	3.28
5.000	4.4	7.50	5.00	18.25	3.7	0.91	4.0	0.0	0.0049	0.30	18.25	0.18	5.47	5.65
4.000	4.8	4.50	1.00	3.65	4.6	1.14	5.8	0.0	0.0081	0.48	4.56	0.04	1.75	1.79
3.000	5.4	3.50	1.00	3.65	5.1	1.27	7.1	0.0	0.0104	0.60	5.07	0.07	2.19	2.26
2.000	6.1	2.50	1.00	3.65	5.7	1.44	9.0	0.0	0.0138	0.82	5.74	0.11	2.99	3.10
1.500	6.8	1.75	0.50	1.83	6.4	1.61	11.3	0.0	0.0177	1.04	3.21	0.07	1.90	1.97
1.000	7.8	1.25	0.50	1.83	7.3	1.83	14.9	0.1	0.0235	1.38	3.65	0.11	2.52	2.63
0.900	8.2	0.95	0.10	0.37	8.0	2.02	18.3	0.1	0.0291	1.68	0.80	0.03	0.61	0.64
0.800	8.6	0.85	0.10	0.37	8.4	2.11	20.4	0.1	0.0324	1.90	0.84	0.04	0.69	0.73
0.700	9.0	0.75	0.10	0.37	8.8	2.20	22.4	0.1	0.0354	2.07	0.88	0.04	0.76	0.80
0.600	9.5	0.65	0.10	0.37	9.2	2.31	25.0	0.1	0.0395	2.29	0.92	0.05	0.84	0.89
0.500	10.0	0.55	0.10	0.37	9.7	2.44	28.1	0.2	0.0442	2.59	0.97	0.06	0.95	1.01
0.250	11.3	0.38	0.25	0.91	10.6	2.66	34.5	0.2	0.0539	3.15	2.66	0.21	2.87	3.08
0.100	12.8	0.18	0.15	0.55	12.0	3.01	34.6	0.3	0.0540	4.10	1.80	0.19	2.24	2.43
0.050	13.5	0.08	0.05	0.18	13.1	3.29	34.6	0.5	0.0540	5.01	0.66	0.08	0.91	0.99
0.010	14.6	0.03	0.04	0.15	14.0	3.52	34.6	0.6	0.0540	5.79	0.56	0.08	0.85	0.93
0.005	14.6	0.01	0.01	0.02	14.6	3.65	34.6	0.7	0.0540	6.26	0.07	0.01	0.11	0.12
0.001	14.6	0.00	0.00	0.01	14.6	3.65	34.6	0.7	0.0540	6.26	0.06	0.01	0.09	0.10
											Annual totals:	1.4 (tons/yr)	31.0 (tons/yr)	32.4 (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

Enter Required Information for Existing Condition

4.2	D_{50}	Riffle bed material D_{50} (mm)			
0.0	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.210	D_{max}	Largest particle from **Bed Material** (ft)	**64**	**(mm)**	304.8 mm/ft
0.07277	S	Existing bankfull water surface slope (ft/ft)			
0.16	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

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

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

N/A	**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

N/A	**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

0.727		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 **55.89**	CO **120.2**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **0.827**	CO **0.308**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.18**	CO **0.07**	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 **0.0829**	CO **0.0309**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream: **Northfield Gulch D4a Reference** Stream Type: **D4a**

Location: **Pike National Forest, CO** Valley Type: **IIIa**

Observers: **Bones, Kyle, David, Luke, Kim** Date: **11/08/2012**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

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 5-13)**	< 1.2 [✓ **(2)**]	1.2 – 1.4 **(4)**	1.4 – 1.6 **(6)**	> 1.6 **(8)**	**2**
2 **Depositional Patterns (Worksheet 5-10)**	B1, B2 **(1)**	B4, B8 **(2)**	B3 **(3)**	B5, B6, B7 [✓ **(4)**]	**4**
3 **Meander Patterns (Worksheet 5-9)**	M1, M3, M4 **(1)**		M2, M5, M6, M7, M8 **(3)**		**N/A**
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL **(2)**	M/L, M/M, M/H, L/Ex, H/L **(4)**	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL **(6)**	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex **(8)**	**N/A**
5 **Degree of Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.8 – 1.0 [✓ **(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*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability – aggradation.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	8
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	8
	(2)	**(4)**	**(6)**	[✓ **(8)**]	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	2
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	B2, B4	B3, B5	B6, B7, B8	4
	(1)	**(2)**	**(3)**	[✓ **(4)**]	
6 **Debris / Blockages (Worksheet 5-11)**	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1
	[✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**25**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☐	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☑	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability − degradation.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

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 5-22)	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) (Worksheet 5-20)	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 5-12)	1.00 – 1.10 **[✓ (2)]**	1.11 – 1.30 **(4)**	1.31 – 1.50 **(6)**	> 1.50 **(8)**	**2**
4 Stream Succession States (Worksheets 5-12 and 5-24)	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) **(8)**	**2**
5 Confinement (MWR / MWR_{ref}) (Worksheet 5-14)	0.80 – 1.00 **[✓ (1)]**	0.30 – 0.79 **(2)**	0.10 – 0.29 **(3)**	< 0.10 **(4)**	**1**
				Total Points	**9**

	Vertical Stability Category Point Range for Channel Incision / Degradation			
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐

Worksheet 5-28. Channel enlargement.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) [✓ **(2)**]	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* [✓ **(2)**]	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **(2)**	*Moderate Deposition* **(4)**	*Excess Deposition* [✓ **(6)**]	*Aggradation* **(8)**	**6**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* [✓ **(2)**]	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**12**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☐	***Slight Increase*** **11 – 16** ☑	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Northfield Gulch D4a Reference**	Stream Type:	**D4a**
Location:	**Pike National Forest, Colorado**	Valley Type:	**IIIa**
Observers:	**Bones, Kyle, David, Luke, Kim**	Date:	**11/08/2012**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	[✓ **1**]	**1**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	**1**	**3**
	Mod. Deposition	**2**	
	Excess Deposition	[✓ **3**]	
	Aggradation	**4**	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	[✓ **1**]	**1**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	**1**	**2**
	Slight Increase	[✓ **2**]	
	Mod. Increase	**3**	
	Extensive	**4**	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	[✓ **1**]	**1**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**8**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☐	***Moderate*** **6 – 10** ☑	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Northfield Gulch D4a Reference**			Location: **Pike National Forest, Colorado**						
Observers:	**Bones, Kyle, David, Luke, Kim**	Date: **11/8/2012**		Stream Type: **D4a**		Valley Type: **IIIa**				
Channel Dimension	Mean Bankfull Depth (ft): **0.16**	Bankfull Width (ft): **17.92**	Cross-Sectional Area (ft^2): **2.81**	Width of Flood-Prone Area (ft): **8.16**	Entrenchment Ratio: **1.1**					
Channel Pattern	Mean: Range:	λ/W_{bkf}: **N/A**	L_m/W_{bkf}: **N/A**	R_c/W_{bkf}: **N/A**	MWR: **3.35**	Sinuosity: **1**				
River Profile & Bed Features	Check: ☐ Riffle/Pool	☐ Step/Pool	☑ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed					
	Max Bankfull Depth (ft):	Riffle **0.78**	Pool	Depth Ratio (max to mean):	Riffle **4.88**	Pool	Pool-to-Pool Spacing:	Ratio	Slope Valley: **0.0728**	Water Surface: **0.07277**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Mixed conifer, aspen, willow**	Potential Composition/Density: **At potential**	Remarks: Condition, Vigor & Usage of Existing Reach: **Vigorous**						
	Flow Regime: **E(1, 2, 7, 8)**	Stream Size & Order: **S-4(3)**	Meander Patterns: **N/A**	Depositional Patterns: **B6**	Debris/Channel Blockages: **D2**					
	Degree of Incision (Bank-Height Ratio): **1.0**	Degree of Incision Stability Rating: **Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **80 (Good)**							
	Width/depth Ratio (W/d): **112**	Reference W/d Ratio (W/d_{ref}): **100**	Width/Depth Ratio State $(W/d) / (W/d_{ref})$: **1**	W/d Ratio State Stability Rating: **Stable**						
	Meander Width Ratio (MWR): **0**	Reference MWR_{ref}: **0**	Degree of confinement (MWR / MWR_{ref}): **0**	MWR / MWR_{ref} Stability Rating: **Stable**						
Bank Erosion Summary	Length of Reach Studied (ft):	Annual Streambank Erosion Rate: (tons/yr)	(tons/yr/ft)	Curve Used:	Remarks: **NA for this depositional reach**					
Sediment Capacity (POWERSED)	☐ Sufficient Capacity	☑ Insufficient Capacity	☐ Excess Capacity	Remarks:						
Entrainment/ Competence	Largest Particle from Bar Sample (mm): **64**	$\tau =$ **0.308**	$\tau^* =$ **N/A**	Existing Depth: **0.16**	Required Depth: **0.07**	Existing Slope: **0.073**	Required Slope: **0.031**			
Successional Stage Shift	→	→	→	→	→	Existing Stream State (Type): **D4a**	Potential Stream State (Type): **D4a**			
Lateral Stability	☑ *Stable*	☑ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes:					
Vertical Stability (Aggradation)	☐ *No Deposition*	☐ *Mod. Deposition*	☑ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes: **Recent influx of sediment from post fire flooding**					
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes:					
Channel Enlargement	☐ *No Increase*	☑ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes:					
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes:					

Appendix C22

E4 Stream Type

Reference Reach

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Appendix C22: E4 Reference Reach

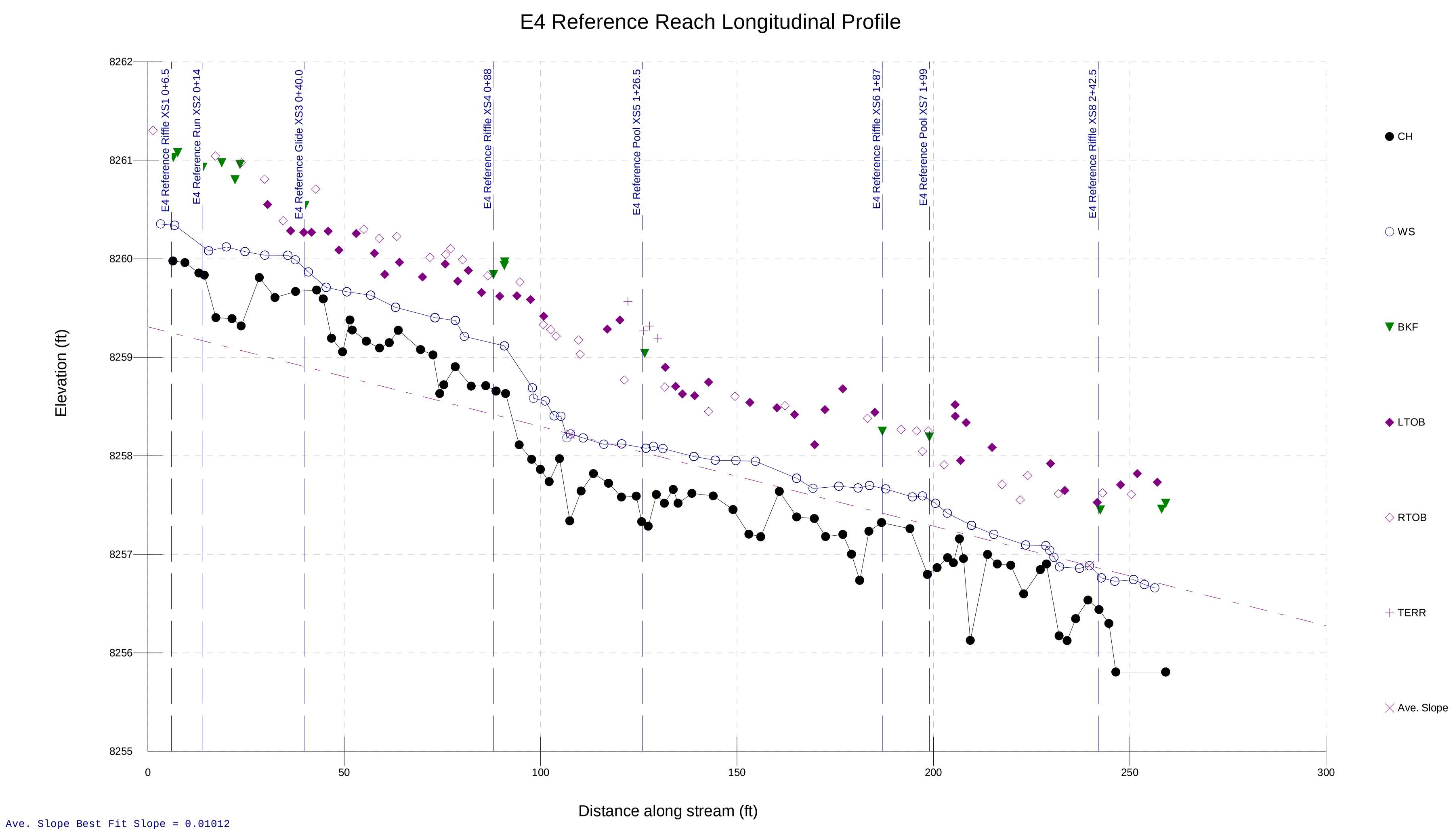
E4 Reference Reach Location & Overview

The E4 reference reach exists in a lacustrine Valley Type X and is typical of a very low width/depth ratio channel on gentle slopes with a gravel-bed. The channel bed and banks are potentially erodible, but due to the good vegetation condition, this E4 reference reach shows little sediment yield from this reach. Bed features are generally dominated by riffles and pools with runs and glide features. The channel is located on Upper Trail Creek as shown in **Figure C-2**. The stream is a perennial, meandering stream, unconfined, not entrenched with a well-developed floodplain. The morphological data from this reach will be used to develop dimension, pattern, and profile data for impaired streams that potentially should be E4 stream types. There is little sediment storage in this stream type due to the lack of point bars and other depositional features. The natural or geologic rate of streambank erosion is generally low due to the excellent riparian vegetation of willow and Carex/Juncus. An erosion rate of *0.0017 tons/yr/ft* (**Worksheet 5-18**) is typical for this stream type in a similar condition; streambank erosion rates for impaired conditions of this stream type can be associated with rates three orders of magnitude larger. This stream is sensitive to disturbance but fast to recover following impacts.

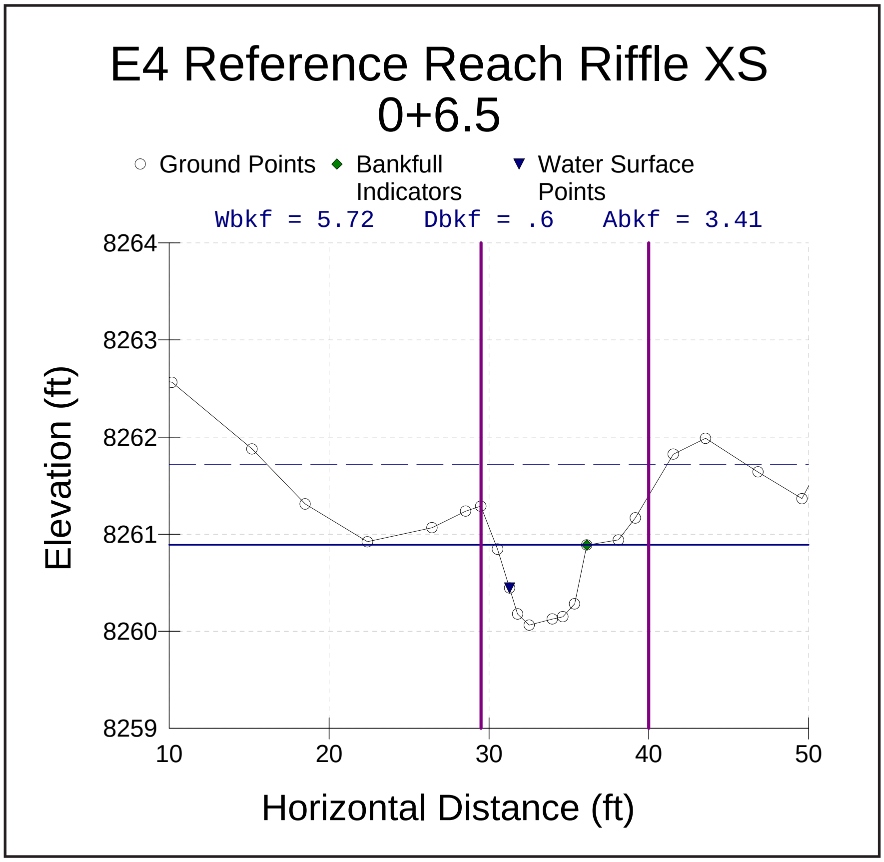
Typical of E4 stream types are large entrenchment ratios (not entrenched) that are not laterally contained or confined. There is not an acceleration of sediment supply from this reach during high runoff events due to the good riparian vegetation coverage. This stream type is critically linked to streambank vegetation to maintain its low width/depth ratio.

The photograph shows the good riparian community and the stable characteristics of this E4 stream type. There is little to no evidence of active channel-source sediment. The details of the dimension, pattern, profile, and materials are summarized. The POWERSED model was not run on this reference reach as the bed is obviously stable. The following summary worksheets provide the detail of the morphology, hydraulics, streambank erosion rates and stability. In the situation where impaired G4c, F4c, and some C4 stream types are located, an alternative for mitigation and sediment reduction from increased flow in these stream types is to use the data from the stable form of the E4 to extrapolate for potential implementation of natural channel design.

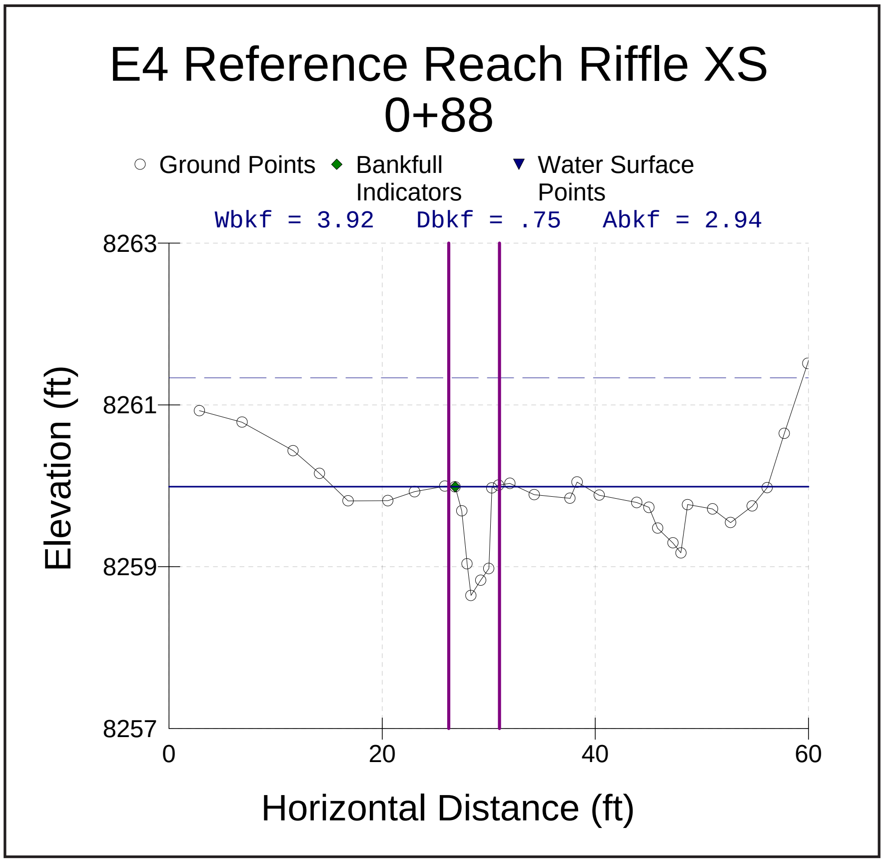
Survey Summary



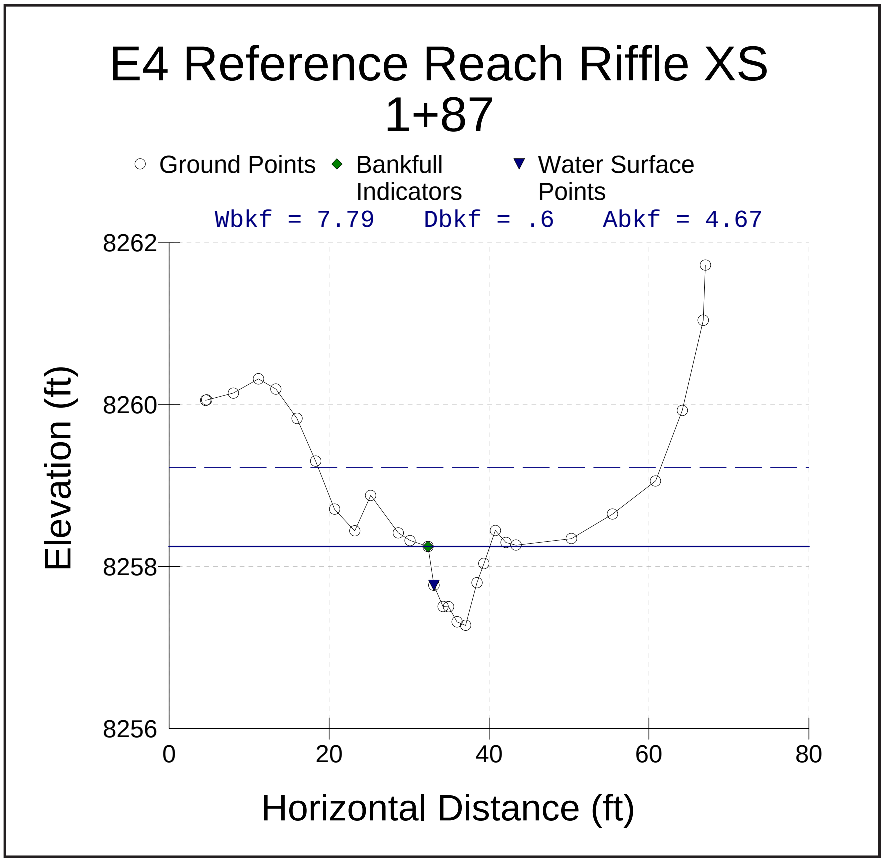
Longitudinal Profile (graph generated from RIVERMorph^{TM})



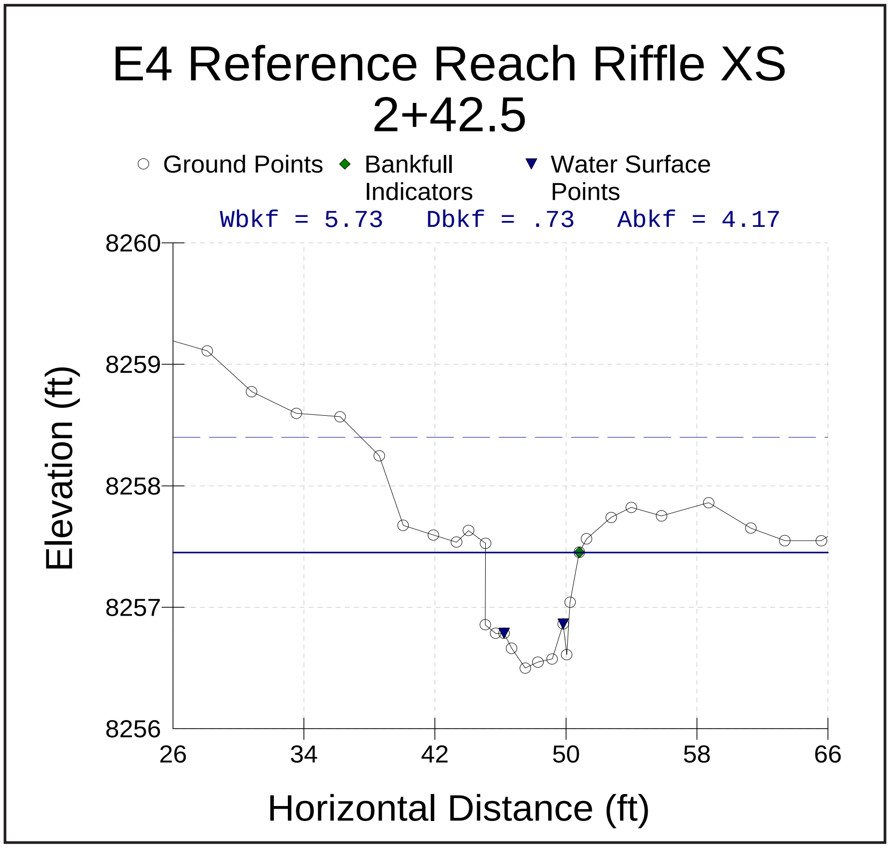
Riffle Cross-section 0+6.5 (graph generated from RIVERMorph™)



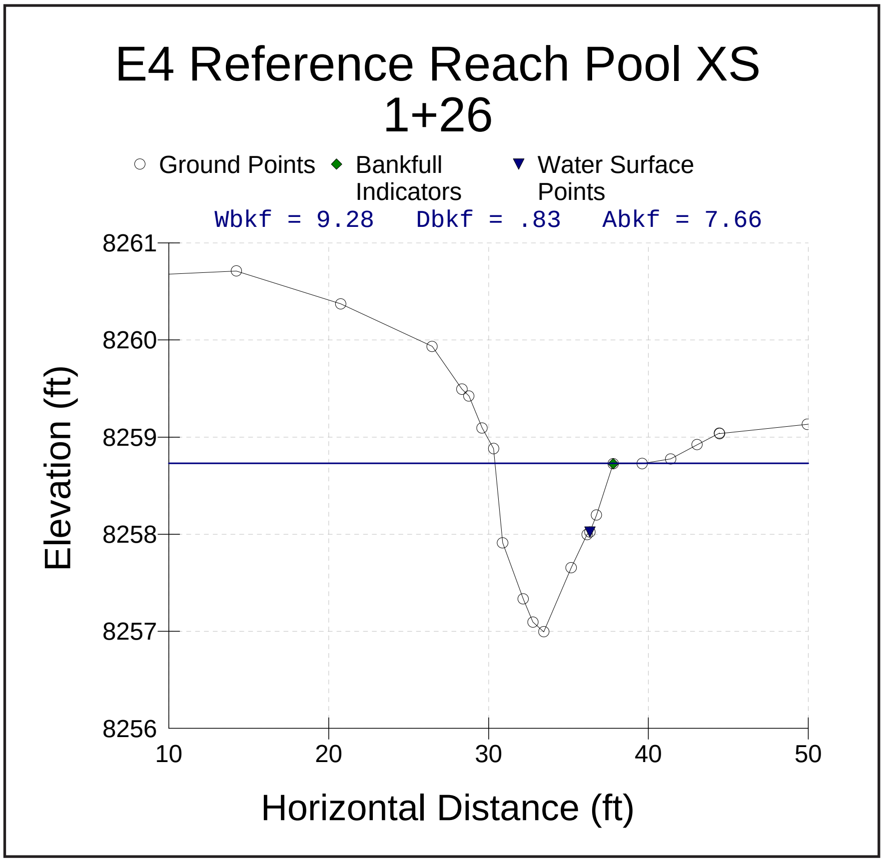
Riffle Cross-section 0+88 (graph generated from RIVERMorph™)



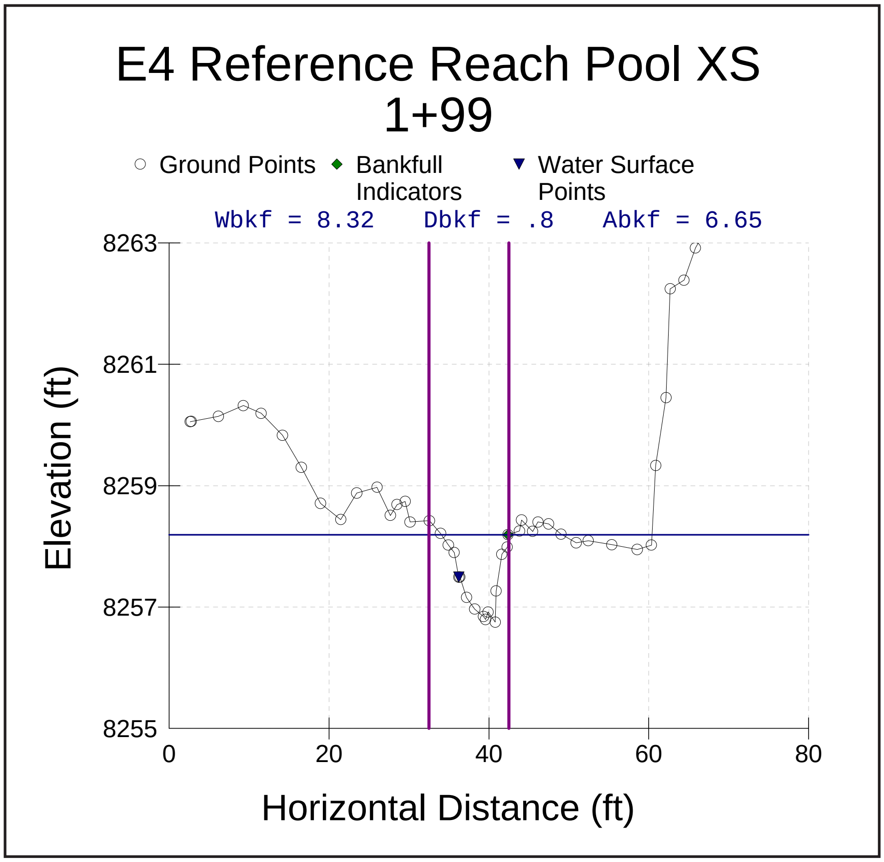
Riffle Cross-section 1+87 (graph generated from RIVERMorph^{TM})



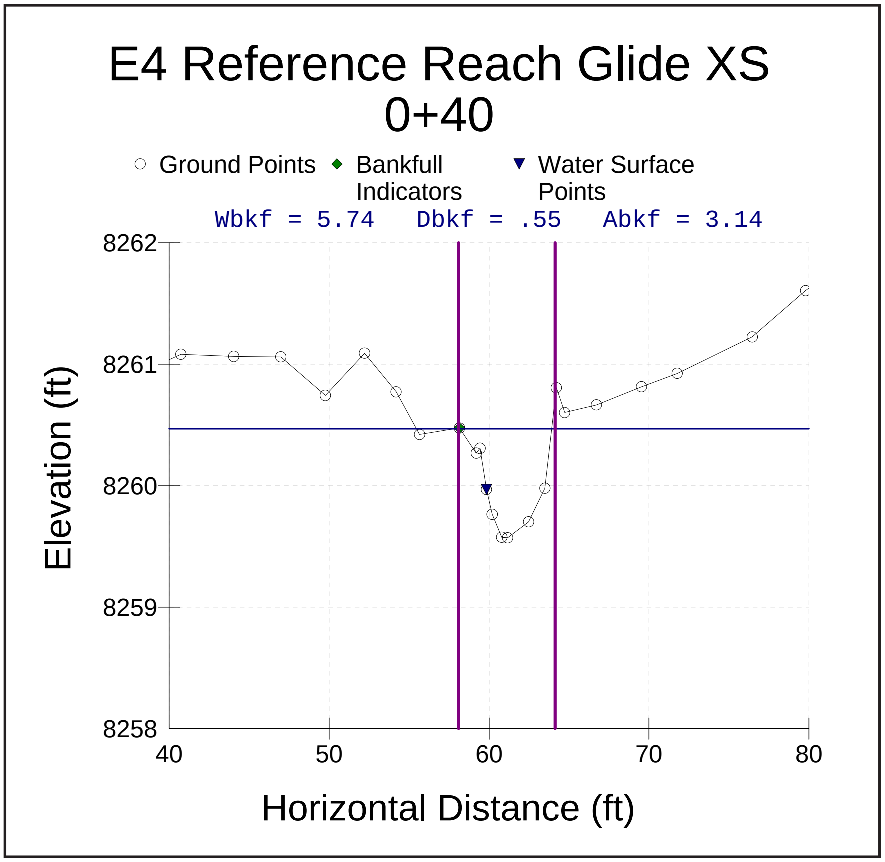
Representative Riffle Cross-section 2+42.5 (graph generated from RIVERMorph^{TM})



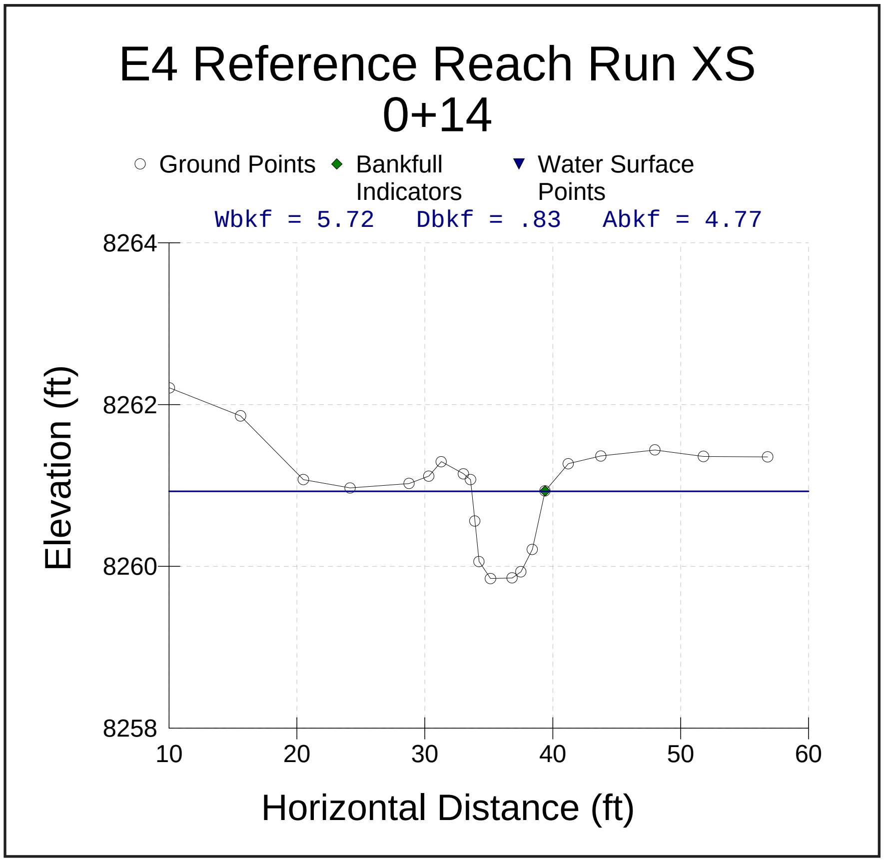
Pool Cross-section 1+26 (graph generated from RIVERMorph^{TM})



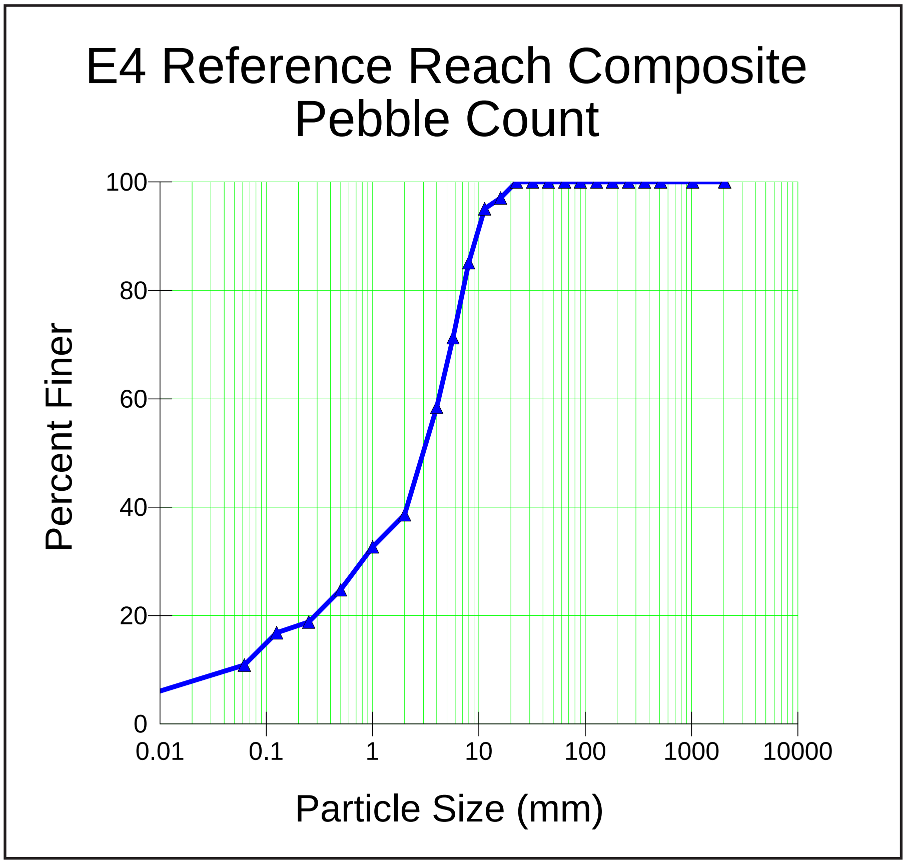
Pool Cross-section 1+99 (graph generated from RIVERMorph^{TM})



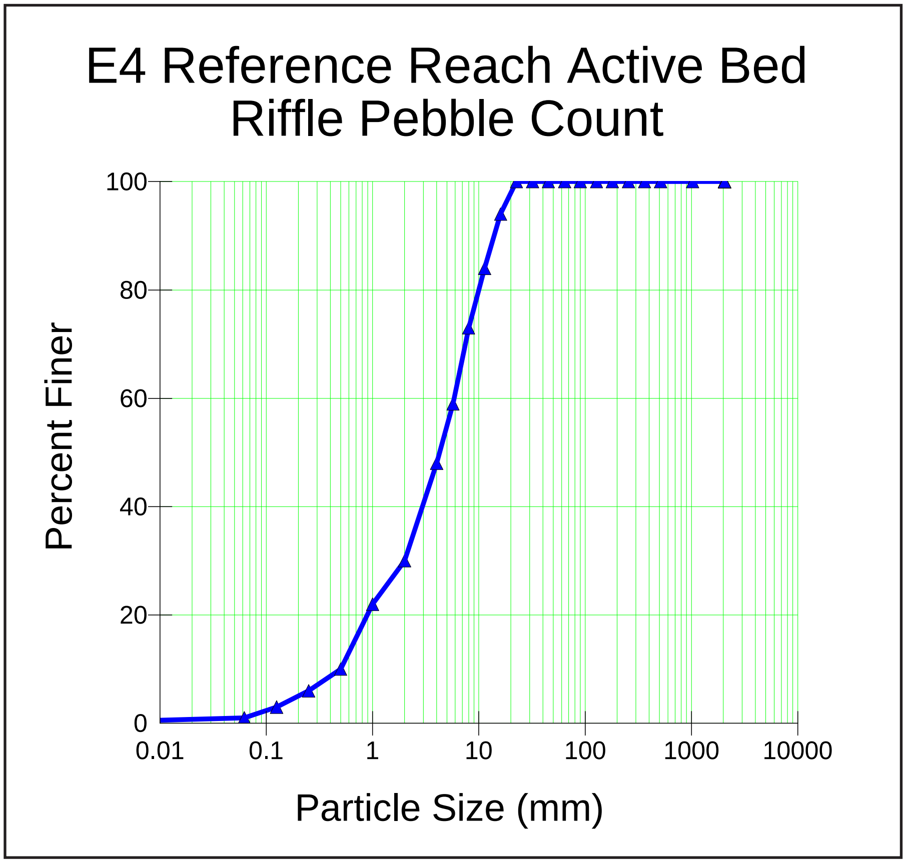
Glide Cross-section 0+40 (graph generated from RIVERMorph^{TM})



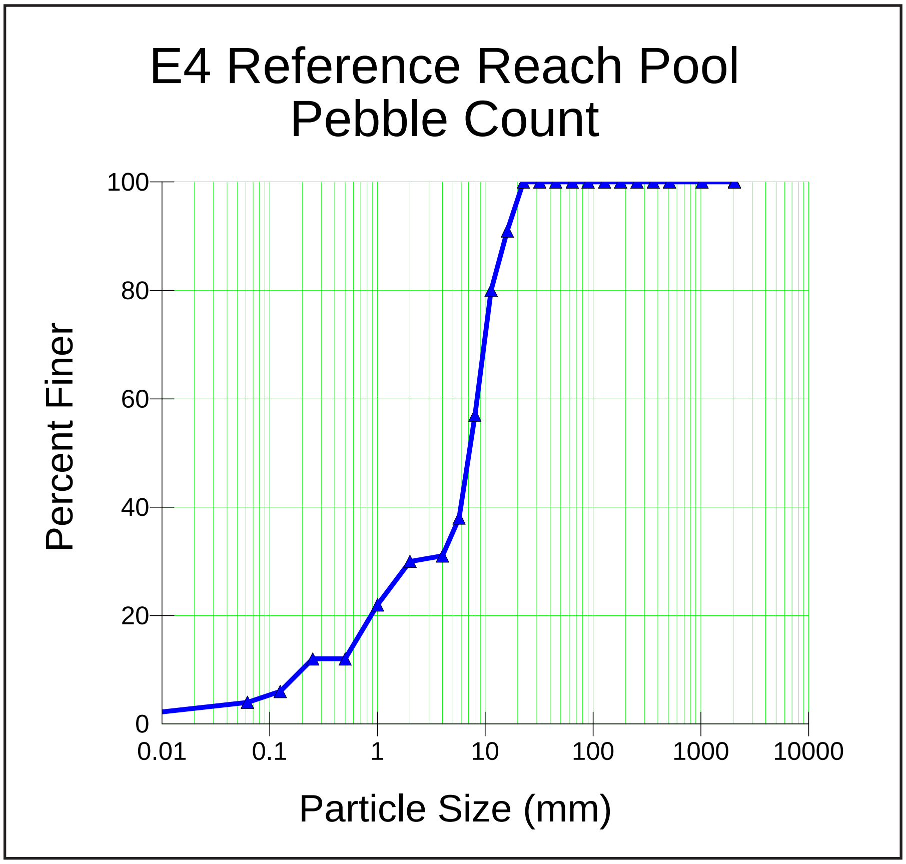
Run Cross-section 0+14 (graph generated from RIVERMorph^{TM})



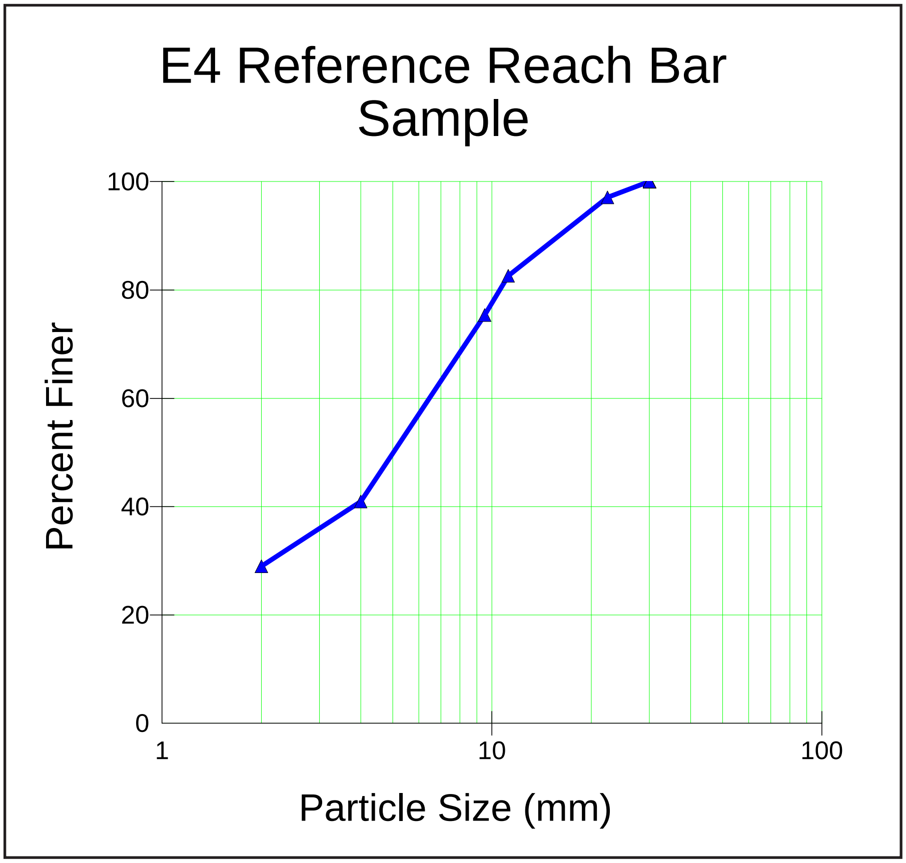
Composite Pebble Count (graph generated from RIVERMorph^{TM})



Active Bed Riffle Pebble Count (graph generated from RIVERMorph^{TM})



Pool Pebble Count (graph generated from RIVERMorph^{TM})



Bar Sample (graph generated from RIVERMorph^{TM})

WARSSS Worksheets

Velocity, Classification & Morphological Relations

Worksheet 5-2. Computations of velocity and bankfull discharge.

Bankfull VELOCITY & DISCHARGE Estimates

Stream:	**Trail Creek, E4 Reference Reach**	Location:	**Riffle XS 2+42.5, Pike N.F., CO**
Date:	**8/22/2010** Stream Type: **E4**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	HUC:	_ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _ | _ _

INPUT VARIABLES			OUTPUT VARIABLES		
Bankfull Riffle Cross-Sectional AREA	**4.17**	A_{bkf} (ft^2)	Bankfull Riffle Mean DEPTH	**0.73**	d_{bkf} (ft)
Bankfull Riffle WIDTH	**5.73**	W_{bkf} (ft)	Wetted PERMIMETER $\sim (2 * d_{bkf}) + W_{bkf}$	**7.19**	W_p (ft)
D_{84} at Riffle	**11.3**	Dia. (mm)	D_{84} (mm) / 304.8	**0.04**	D_{84} (ft)
Bankfull SLOPE	**0.0101**	S_{bkf} (ft / ft)	Hydraulic RADIUS A_{bkf} / W_p	**0.58**	R (ft)
Gravitational Acceleration	**32.2**	g (ft / sec^2)	Relative Roughness R(ft) / D_{84} (ft)	**15.64**	R / D_{84}
Drainage Area	**7.9**	DA (mi^2)	Shear Velocity $u^* = (gRS)^{½}$	**0.435**	u* (ft/sec)

ESTIMATION METHODS	Bankfull VELOCITY		Bankfull DISCHARGE	
1. Friction Factor / Relative Roughness $u = [\, 2.83 + 5.66 * \text{Log}\, \{ R / D_{84} \}\,]\, u^*$	**4.27**	ft / sec	**17.81**	cfs
2. Roughness Coefficient: **a) Manning's *n* from Friction Factor / Relative Roughness** (Figs. 5-7, 5-8) $u = 1.49 * R^{2/3} * S^{1/2} / n$ $n =$ **0.028**	**3.72**	ft / sec	**15.52**	cfs
2. Roughness Coefficient: $u = 1.49 * R^{2/3} * S^{1/2} / n$ **b) Manning's *n* from Stream Type** (Fig. 5-9) $n =$ **0.048**	**3.42**	ft / sec	**14.26**	cfs
2. Roughness Coefficient: $u = 1.49 * R^{2/3} * S^{1/2} / n$ **c) Manning's *n* from Jarrett (USGS):** $n = 0.39 * S^{0.38} * R^{-0.16}$ **Note:** This equation is applicable to **steep, step/pool, high boundary roughness, cobble- and boulder-dominated stream systems**; i.e., for Stream Types A1, A2, A3, B1, B2, B3, C2 & E3 $n =$ **0.074**	**1.40**	ft / sec	**5.85**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Limerinos**	**4.47**	ft / sec	**18.6**	cfs
3. Other Methods (Hey, Darcy-Weisbach, Chezy C, etc.) **Darcy-Weisbach**	**4.32**	ft / sec	**18.0**	cfs
4. Continuity Equations: a) Regional Curves **u = Q / A** **Return Period for Bankfull Discharge** **Q =** ____ **year**		ft / sec		cfs
4. Continuity Equations: b) USGS Gage Data **u = Q / A**		ft / sec		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. Level II stream classification.

Stream: **Trail Creek, E4 Reference Reach**

Basin: Drainage Area: **5056** acres **7.9** mi^2

Location: **Pike National Forest, Colorado**

Twp.&Rge: Sec.&Qtr.:

Cross-Section Monuments (Lat./Long.): **Riffle XS 2+42.5** Date: **8/22/2010**

Observers: **K. Wright & B. Kasun** Valley Type: **X**

Bankfull WIDTH (W_{bkf}) WIDTH of the stream channel at bankfull stage elevation, in a riffle section.	**5.73**	ft
Bankfull DEPTH (d_{bkf}) Mean DEPTH of the stream channel cross-section, at bankfull stage elevation, in a riffle section ($d_{bkf} = A_{bkf} / W_{bkf}$).	**0.73**	ft
Bankfull X-Section AREA (A_{bkf}) AREA of the stream channel cross-section, at bankfull stage elevation, in a riffle section.	**4.17**	ft^2
Width/Depth Ratio (W_{bkf} / d_{bkf}) Bankfull WIDTH divided by bankfull mean DEPTH, in a riffle section.	**7.8**	ft/ft
Maximum DEPTH (d_{max}) Maximum depth of the bankfull channel cross-section, or distance between the bankfull stage and Thalweg elevations, in a riffle section.	**0.95**	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.	**35.78**	ft
Entrenchment Ratio (ER) The ratio of flood-prone area WIDTH divided by bankfull channel WIDTH (W_{fpa} / W_{bkf}) (riffle section).	**6.24**	ft/ft
Channel Materials (Particle Size Index) D_{50} The D_{50} particle size index represents the median or dominant diameter of channel materials, as sampled proportionately from the channel surface, between the bankfull stage and Thalweg elevations.	**3**	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.	**0.0101**	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 (S_{val} / S).	**1.23**	

Stream Type **E4** **See Classification Key (Figure 2-14)**

Worksheet 5-4a. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010** Valley Type: **X** Stream Type: **E4**

River Reach Dimension Summary Data…..1

Riffle Dimensions*, **, ***

Riffle Dimensions*, **, ***	Mean	Min	Max		Riffle Dimensions & Dimensionless Ratios****	Mean	Min	Max
Riffle Width (W_{bkf})	5.8	3.9	7.8	ft	Riffle Cross-Sectional Area (A_{bkf}) (ft^2)	3.8	2.9	4.7
Mean Riffle Depth (d_{bkf})	0.67	0.60	0.75	ft	Riffle Width/Depth Ratio (W_{bkf} / d_{bkf})	8.9	5.2	13.0
Maximum Riffle Depth (d_{max})	1.03	0.83	1.34	ft	Max Riffle Depth to Mean Riffle Depth (d_{max}/d_{bkf})	1.526	1.301	1.787
Width of Flood-Prone Area (W_{fpa})	41.2	29.6	56.6	ft	Entrenchment Ratio (W_{fpa} / W_{bkf})	7.8	5.2	14.4
Riffle Inner Berm Width (W_{ib})	2.8	2.0	3.7	ft	Riffle Inner Berm Width to Riffle Width (W_{ib} / W_{bkf})	0.500	0.348	0.642
Riffle Inner Berm Depth (d_{ib})	0.15	0.14	0.17	ft	Riffle Inner Berm Depth to Mean Depth (d_{ib} / d_{bkf})	0.231	0.227	0.233
Riffle Inner Berm Area (A_{ib})	0.4	0.4	0.5	ft^2	Riffle Inner Berm Area to Riffle Area (A_{ib} / A_{bkf})	0.116	0.081	0.147
Riffle Inner Berm W/D Ratio (W_{ib} / d_{ib})	19.1	11.8	26.2					

Pool Dimensions*, **, ***

Pool Dimensions*, **, ***	Mean	Min	Max		Pool Dimensions & Dimensionless Ratios****	Mean	Min	Max
Pool Width (W_{bkfp})	8.8	8.3	9.3	ft	Pool Width to Riffle Width (W_{bkfp} / W_{bkf})	1.520	1.437	1.603
Mean Pool Depth (d_{bkfp})	0.82	0.80	0.83	ft	Mean Pool Depth to Mean Riffle Depth (d_{bkfp} / d_{bkf})	1.216	1.194	1.239
Pool Cross-Sectional Area (A_{bkfp})	7.2	6.7	7.7	ft	Pool Area to Riffle Area (A_{bkfp} / A_{bkf})	1.884	1.751	2.017
Maximum Pool Depth (d_{maxp})	1.59	1.44	1.73	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	2.366	2.149	2.582
Pool Inner Berm Width (W_{ibp})	4.4	3.7	5.1	ft	Pool Inner Berm Width to Pool Width (W_{ibp} / W_{bkfp})	0.496	0.442	0.550
Pool Inner Berm Depth (d_{ibp})	0.38	0.24	0.51	ft	Pool Inner Berm Depth to Pool Depth (d_{ibp} / d_{bkfp})	0.457	0.300	0.614
Pool Inner Berm Area (A_{ibp})	1.7	0.9	2.6	ft^2	Pool Inner Berm Area to Pool Area (A_{ibp} / A_{bkfp})	0.234	0.131	0.337
Point Bar Slope (S_{pb})	0.322	0.276	0.368	ft/ft	Pool Inner Berm Width/Depth Ratio (W_{ibp} / d_{ibp})	12.7	10.0	15.3

Run Dimensions*

Run Dimensions*	Mean	Min	Max		Run Dimensionless Ratios****	Mean	Min	Max
Run Width (W_{bkfr})	5.7			ft	Run Width to Riffle Width (W_{bkfr} / W_{bkf})	0.988		
Mean Run Depth (d_{bkfr})	0.83			ft	Mean Run Depth to Mean Riffle Depth (d_{bkfr} / d_{bkf})	1.239		
Run Cross-Sectional Area (A_{bkfr})	4.8			ft	Run Area to Riffle Area (A_{bkfr} / A_{bkf})	1.256		
Maximum Run Depth (d_{maxr})	1.08			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	1.612		
Run Width/Depth Ratio (W_{bkfr} / d_{bkfr})	6.9			ft				

Glide Dimensions*

Glide Dimensions*	Mean	Min	Max		Glide Dimensions & Dimensionless Ratios****	Mean	Min	Max
Glide Width (W_{bkfg})	5.7			ft	Glide Width to Riffle Width (W_{bkfg} / W_{bkf})	0.991		
Mean Glide Depth (d_{bkfg})	0.55			ft	Mean Glide Depth to Mean Riffle Depth (d_{bkfg} / d_{bkf})	0.821		
Glide Cross-Sectional Area (A_{bkfg})	10.4			ft	Glide Area to Riffle Area (A_{bkfg} / A_{bkf})	2.749		
Maximum Glide Depth (d_{maxg})	0.90			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	1.343		
Glide Width/Depth Ratio (W_{bkfg} / d_{bkfg})	10.4			ft/ft	Glide Inner Berm Width/Depth Ratio (W_{ibg} / d_{ibg})	14.08		
Glide Inner Berm Width (W_{ibg})	3.7			ft	Glide Inner Berm Width to Glide Width (W_{ibg}/W_{bkfg})	0.638		
Glide Inner Berm Depth (d_{ibg})	0.26			ft	Glide Inner Berm Depth to Glide Depth (d_{ibg} / d_{bkfg})	0.260		
Glide Inner Berm Area (A_{ibg})	1.0			ft^2	Glide Inner Berm Area to Glide Area (A_{ibg} / A_{bkfg})	0.309		

Step**

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

Worksheet 5-4b. Morphological relations (modified from Rosgen, 2006/2009).

Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/23/2010** Valley Type: **X** Stream Type: **E4**

River Reach Summary Data…..2

Hydraulics

Streamflow: Estimated Mean Velocity at Bankfull Stage (u_{bkf})	**4.3**	ft/sec	Estimation Method	**Darcy-Weisbach**	
Streamflow: Estimated Discharge at Bankfull Stage (Q_{bkf})	**18.0**	cfs	Drainage Area	**7.9**	mi^2

Channel Pattern

Geometry	Mean	Min	Max		Dimensionless Geometry Ratios	Mean	Min	Max
Linear Wavelength (λ)	**31.3**	**28.9**	**36.3**	ft	Linear Wavelength to Riffle Width (λ / W_{bkf})	**5.40**	**4.99**	**6.27**
Stream Meander Length (L_m)	**35.2**	**29.5**	**42.1**	ft	Stream Meander Length Ratio (L_m / W_{bkf})	**6.08**	**5.09**	**7.27**
Radius of Curvature (R_c)	**17.9**	**10.2**	**27.8**	ft	Radius of Curvature to Riffle Width (R_c / W_{bkf})	**3.09**	**1.76**	**4.80**
Belt Width (W_{blt})	**19.3**	**16.0**	**22.0**	ft	Meander Width Ratio (W_{blt} / W_{bkf})	**3.33**	**2.76**	**3.80**
Arc Length (L_a)	**15.6**	**7.0**	**25.7**	ft	Arc Length to Riffle Width (L_a / W_{bkf})	**2.69**	**1.21**	**4.44**
Riffle Length (L_r)	**13.9**	**12.3**	**16.9**	ft	Riffle Length to Riffle Width (L_r / W_{bkf})	**2.40**	**2.12**	**2.92**
Individual Pool Length (L_p)	**8.3**	**5.4**	**14.6**	ft	Individual Pool Length to Riffle Width (L_p / W_{bkf})	**1.42**	**0.94**	**2.52**
Pool to Pool Spacing (P_s)	**31.6**	**12.3**	**48.4**	ft	Pool to Pool Spacing to Riffle Width (P_s / W_{bkf})	**5.46**	**2.12**	**8.36**

Channel Profile

Valley Slope (S_{val})	**0.0124**	ft/ft	Average Water Surface Slope (S)	**0.0101**	ft/ft	Sinuosity (S_{val} / S)		**1.23**
Stream Length (SL)	**261.5**	ft	Valley Length (VL)	**212.7**	ft	Sinuosity (SL / VL)		**1.23**
Low Bank Height (LBH)	start **0.83** end **1.71**	ft ft	Max Bankfull Depth (d_{max})	start **0.83** end **1.71**	ft ft	Bank-Height Ratio (BHR) (LBH / d_{max})	start end	**1.0** **1.0**

Facet Slopes	Mean	Min	Max		Dimensionless Facet Slope Ratios	Mean	Min	Max
Riffle Slope (S_{rif})	**0.0230**	**0.0140**	**0.0300**	ft/ft	Riffle Slope to Average Water Surface Slope (S_{rif} / S)	**2.2727**	**1.3834**	**2.9644**
Run Slope (S_{run})	**0.0550**	**0.0340**	**0.0720**	ft/ft	Run Slope to Average Water Surface Slope (S_{run} / S)	**5.4348**	**3.3597**	**7.1146**
Pool Slope (S_p)	**0.0018**	**0.0010**	**0.0070**	ft/ft	Pool Slope to Average Water Surface Slope (S_p / S)	**0.1729**	**0.0988**	**0.6917**
Glide Slope (S_g)	**0.0050**	**0.0010**	**0.0080**	ft/ft	Glide Slope to Average Water Surface Slope (S_g / S)	**0.4941**	**0.0988**	**0.7905**
Step Slope (S_s)				ft/ft	Step Slope to Average Water Surface Slope (S_s / S)			

Max Depths[a]	Mean	Min	Max		Dimensionless Depth Ratios	Mean	Min	Max
Max Riffle Depth (d_{max})	**1.02**	**0.95**	**1.19**	ft	Max Riffle Depth to Mean Riffle Depth (d_{max} / d_{bkf})	**1.522**	**1.418**	**1.776**
Max Run Depth (d_{maxr})	**1.08**			ft	Max Run Depth to Mean Riffle Depth (d_{maxr} / d_{bkf})	**1.612**		
Max Pool Depth (d_{maxp})	**1.74**	**1.44**	**2.94**	ft	Max Pool Depth to Mean Riffle Depth (d_{maxp} / d_{bkf})	**2.597**	**2.149**	**4.388**
Max Glide Depth (d_{maxg})	**0.97**			ft	Max Glide Depth to Mean Riffle Depth (d_{maxg} / d_{bkf})	**1.448**		
Max Step Depth (d_{maxs})				ft	Max Step Depth to Mean Riffle Depth (d_{maxs} / d_{bkf})			

Channel Materials

	Reach[b]	Riffle[c]	Bar		Reach[b]	Riffle[c]	Bar	Protrusion Height[d]	
% Silt/Clay	**11**	**1**	**0**	D_{16}	**0.1**	**0.8**	**0.0**		mm
% Sand	**28**	**29**	**29**	D_{35}	**1.4**	**2.6**	**3.0**		mm
% Gravel	**61**	**70**	**71**	D_{50}	**3.2**	**4.3**	**5.5**		mm
% Cobble				D_{84}	**7.8**	**11.3**	**12.3**		mm
% Boulder				D_{95}	**11.3**	**17.1**	**20.8**		mm
% Bedrock				D_{100}	**22.6**	**22.6**	**30.0**		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.

Stability Indices

Worksheet 5-6. Riparian vegetation.

Riparian Vegetation

Stream: **Trail Creek, E4 Reference Reach**

Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun**

Reference reach ☒

Disturbed (impacted reach) ☐

Date: **8/22/10**

Existing species composition: **Willow, Carex, Ponderosa Pine, Spruce, Grasses**

Potential species composition: **Same as Existing Composition but without Invasives**

	Riparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	**85%**	**60%**	**Willow**	**50%**
				Carex	**40%**
				Conifers	**10%**
					100%
2. Understory	Shrub layer	▨	**25%**	**Willow**	**95%**
				Grasses	**5%**
					100%
3. Ground level	Herbaceous	▨	**12%**	**Carex**	**50%**
				Juncus	**25%**
				Annuals	**20%**
				Thistle	**5%**
					100%
	Leaf or needle litter	▨	**2%**		
	Bare ground	▨	**1%**		
			Column total = 100%		

Remarks:
Condition, vigor and/or usage of existing reach:
Excellent riparian vegetative protection; needs some eradication of invasives.

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

Worksheet 5-7. Flow regime.

FLOW REGIME

Stream: **Trail Creek, E4 Reference** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

List ALL COMBINATIONS that APPLY..............☞	**P1**	**P2**	**P8**					

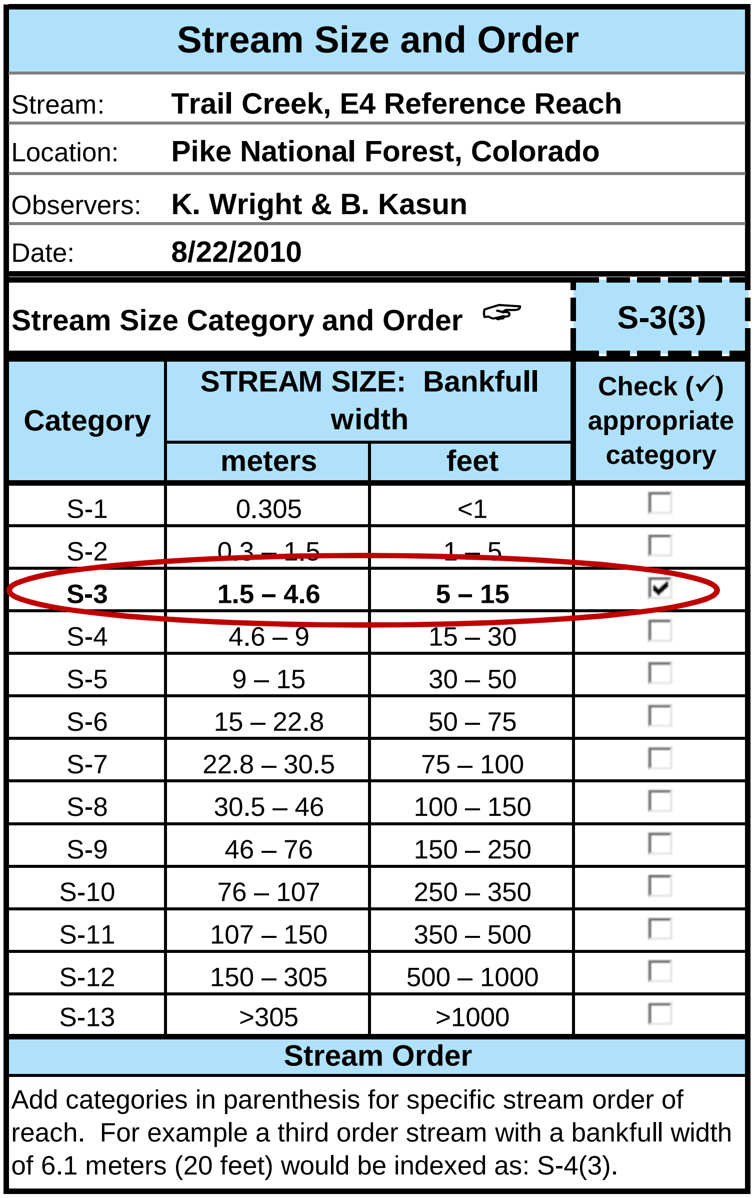
General Category

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 5-8. Stream order & stream size.



Stream Size and Order

Stream: **Trail Creek, E4 Reference Reach**
Location: **Pike National Forest, Colorado**
Observers: **K. Wright & B. Kasun**
Date: **8/22/2010**

Stream Size Category and Order ☞ **S-3(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 5-9. Meander patterns.

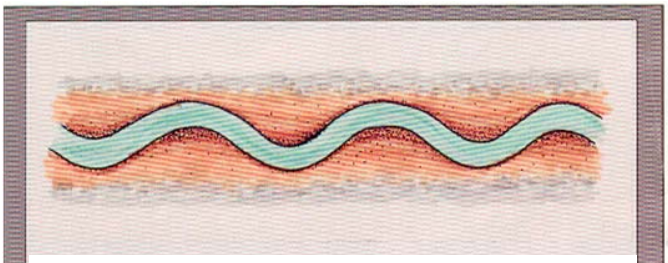
Meander Patterns

Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, CO**

Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

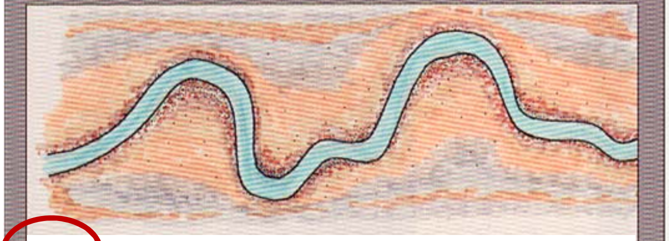
List ALL CATEGORIES that APPLY ☞	**M3**				

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

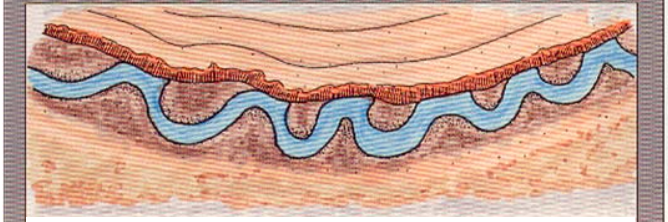


M1 REGULAR MEANDERS

M2 TORTUOUS MEANDERS

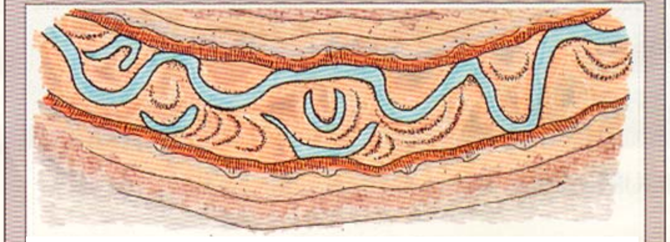


[✓ M3] IRREGULAR MEANDERS

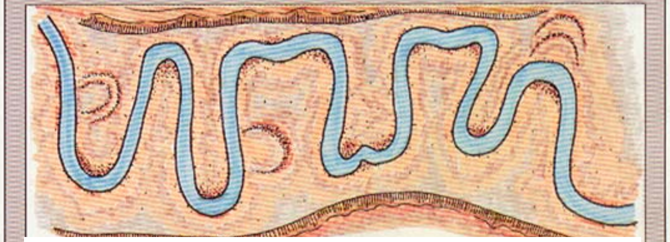


M4 TRUNCATED MEANDERS

M5 UNCONFINED MEANDER SCROLLS



M6 CONFINED MEANDER SCROLLS



M7 DISTORTED MEANDER LOOPS

M8 IRREGULAR MEANDERS with oxbows and

Worksheet 5-10. Depositional patterns.

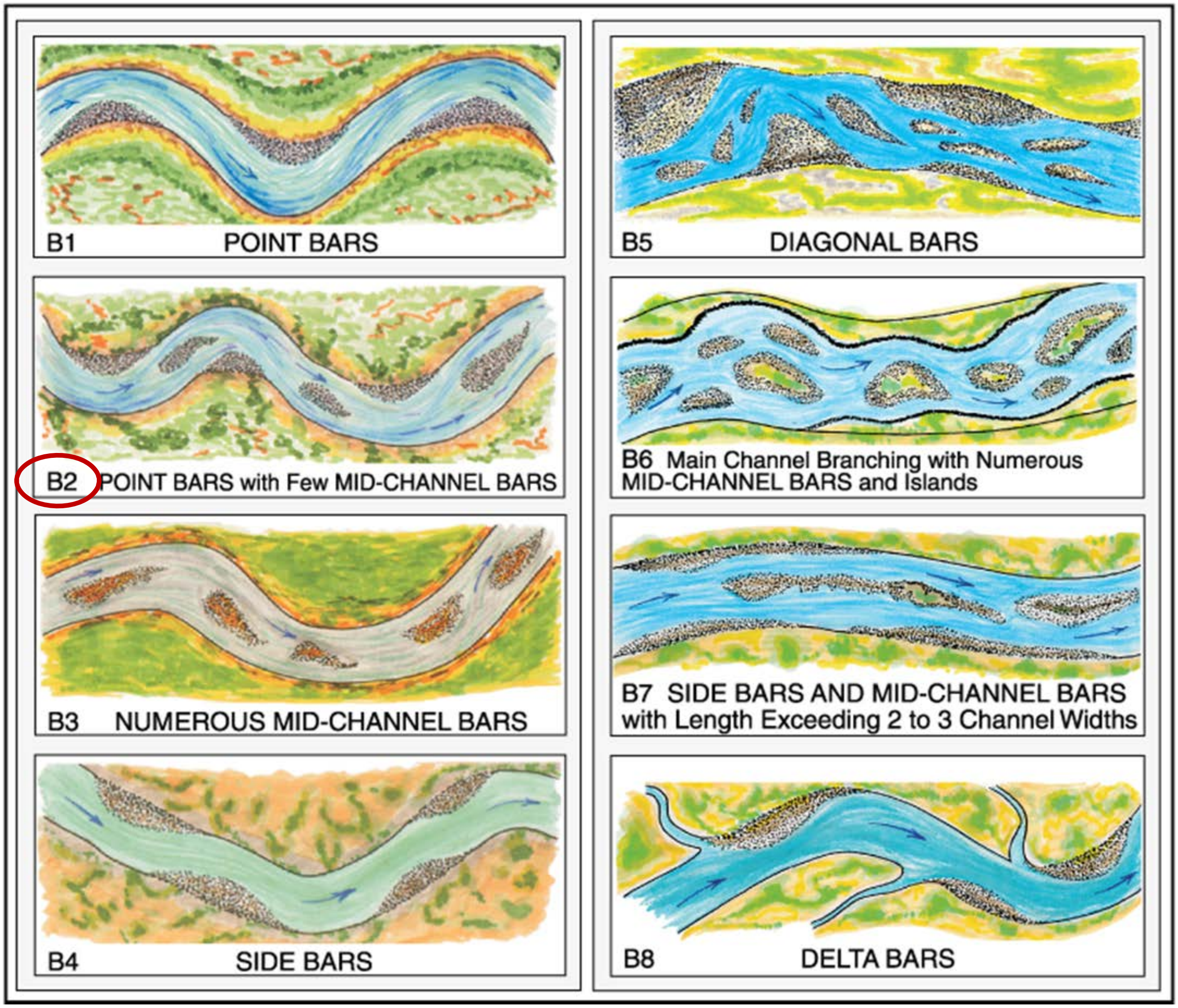
Depositional Patterns

Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

List ALL CATEGORIES that APPLY ☞	**B2**				

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



Worksheet 5-11. Channel blockages.

Channel Blockages

Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, Colorado**

Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

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 5-12. Degree of channel incision.

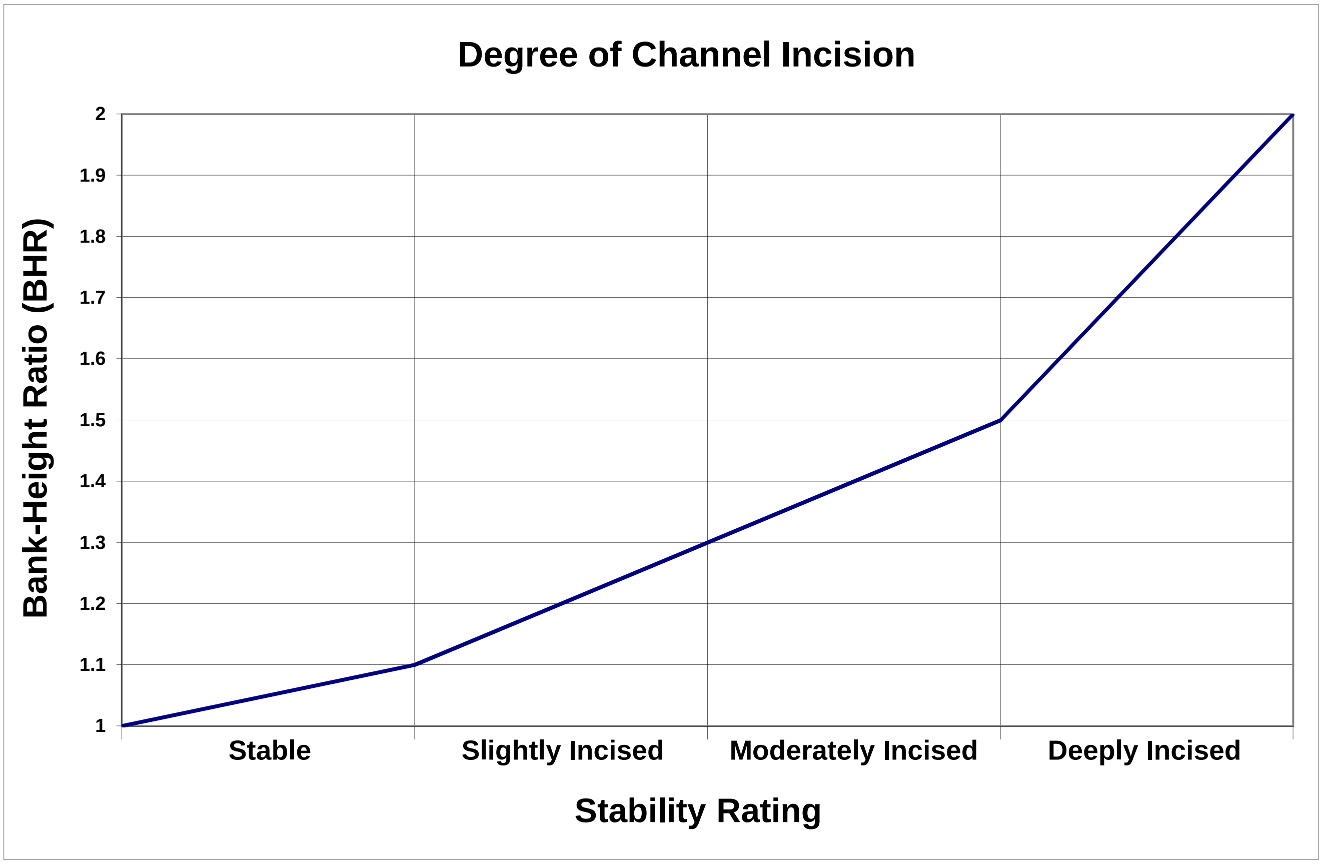
Degree of Channel Incision

Low Bank Height: **0.95**

Max Bankfull Depth: **0.95**

Bank-Height Ratio: **1.0**

Degree of Channel Incision Stability Rating ☞ **Stable**



Worksheet 5-13. Width/depth ratio state.

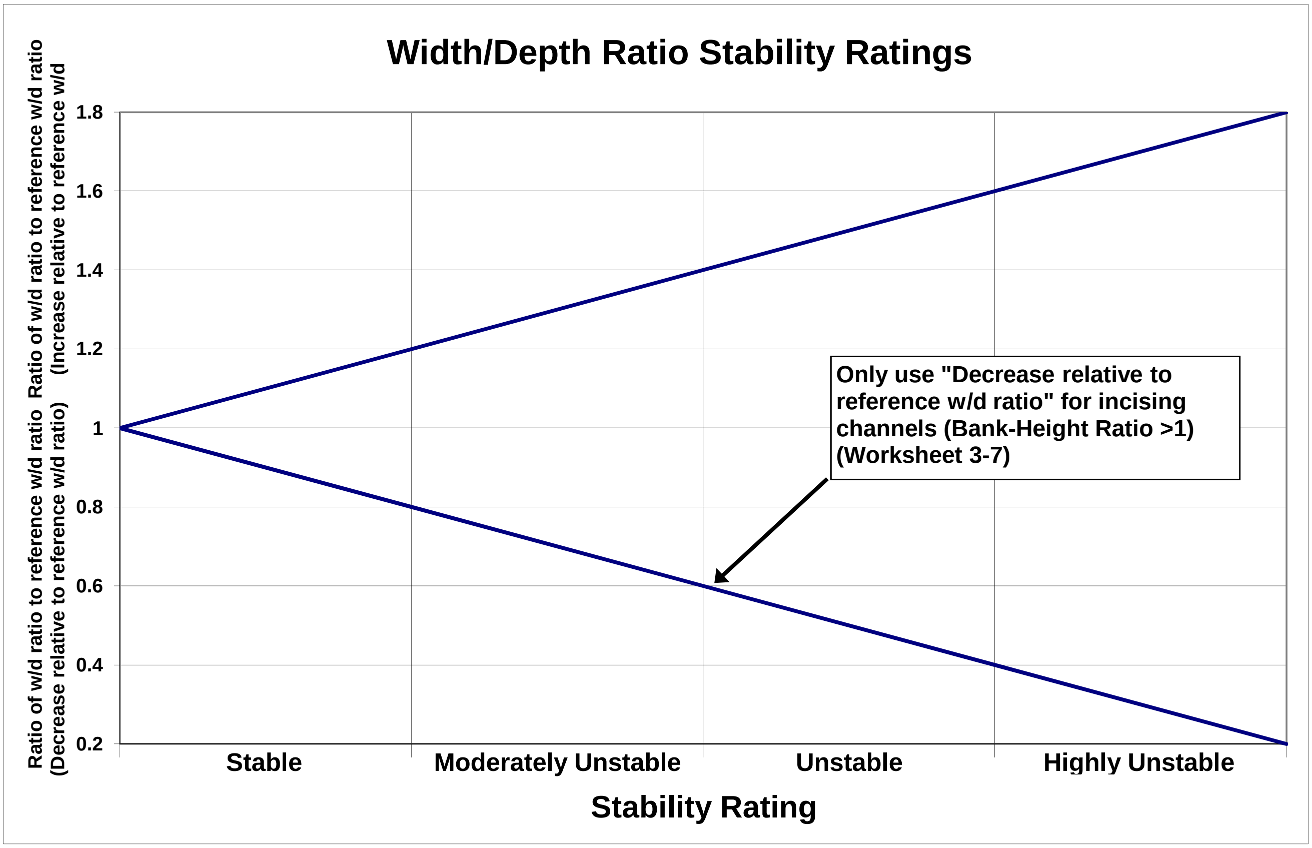
Width/Depth Ratio State

Existing Width/Depth Ratio: **7.85**

Reference Width/Depth Ratio: **7.85**

Ratio of existing W/d to reference W/d: **1.00**

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



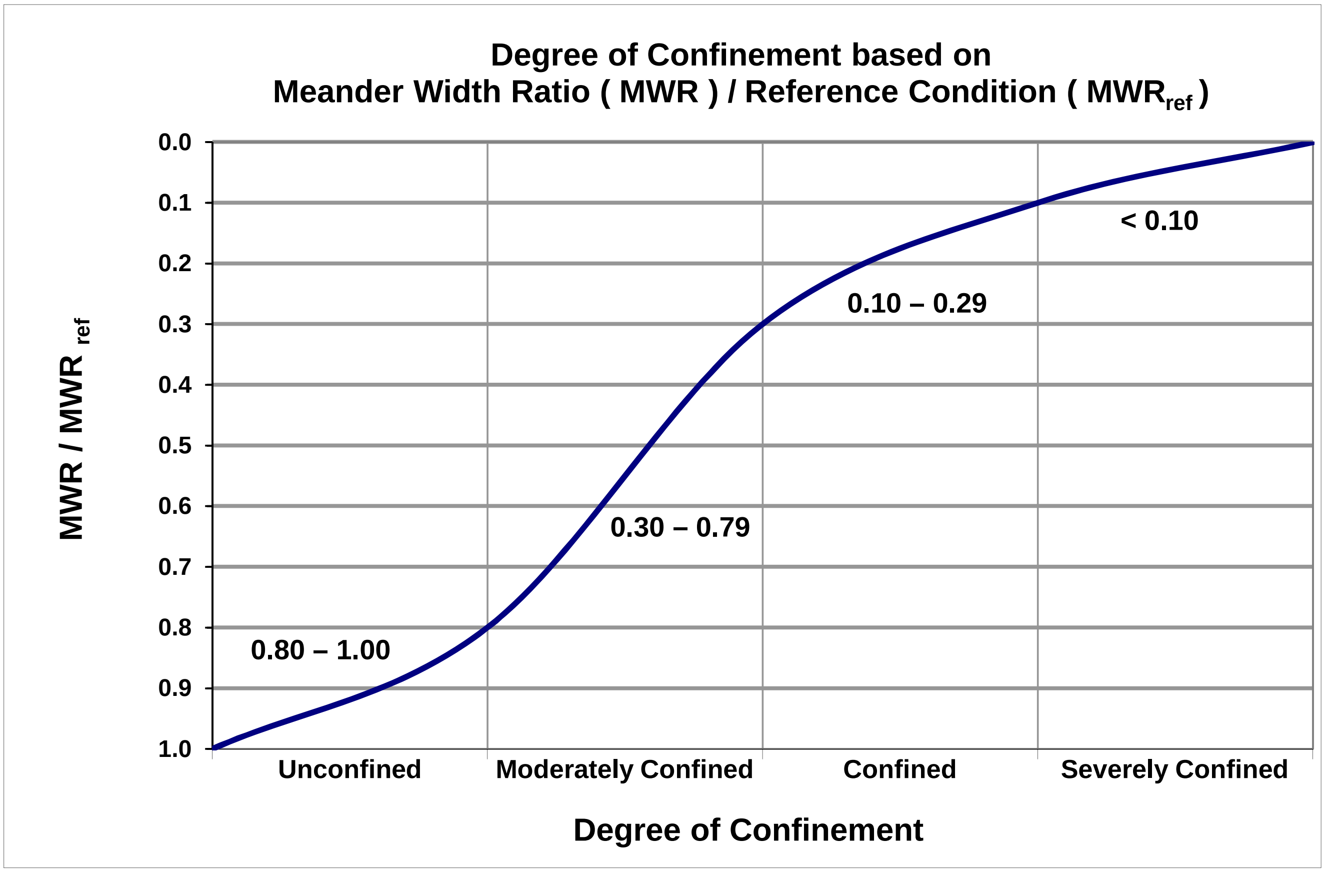
Only use "Decrease relative to reference w/d ratio" for incising channels (Bank-Height Ratio >1) (Worksheet 3-7)

Worksheet 5-14. Degree of channel confinement (lateral containment).

Degree of Confinement

Existing Meander Width Ratio (MWR):	**3.33**	Ratio of MWR to MWR_{ref}:	**1.00**
Reference Meander Width Ratio (MWR_{ref}):	**3.33**		

Degree of Confinement Stability Rating ☞ **Unconfined**



Worksheet 5-15. Pfankuch channel stability rating.

Stream: Trail Creek, E4 Reference Reach **Location: Pike National Forest, CO** **Valley Type: X** **Observers: K. Wright & B. Kasun** **Date: 8/22/2010**

Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	[✓ 2]	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	[✓ 3]	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	[✓ 2]	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.	[✓ 3]	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	[✓ 1]	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	[✓ 8]
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	[✓ 3]	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	[✓ 5]	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	[✓ 6]	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	[✓ 2]	Corners and edges well rounded in 2 dimensions.	3	Well rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	[✓ 4]
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	[✓ 5]	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	[✓ 6]	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	[✓ 8]	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	[✓ 2]	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
			Excellent total =	**22**	**Good total =**	**21**	**Fair total =**	**5**	**Poor total =**	**12**

Stream type	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**D3**	**D4**	**D5**	**D6**
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	[✓ **E4**]	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand total =	**60**
Existing stream type =	**E4**
***Potential stream type =**	**E4**
Modified channel stability rating =	**Good**

*Rating is adjusted to potential stream type, not existing.

BANCS Model – Streambank Erosion

Worksheet 5-18. Annual streambank erosion estimates.

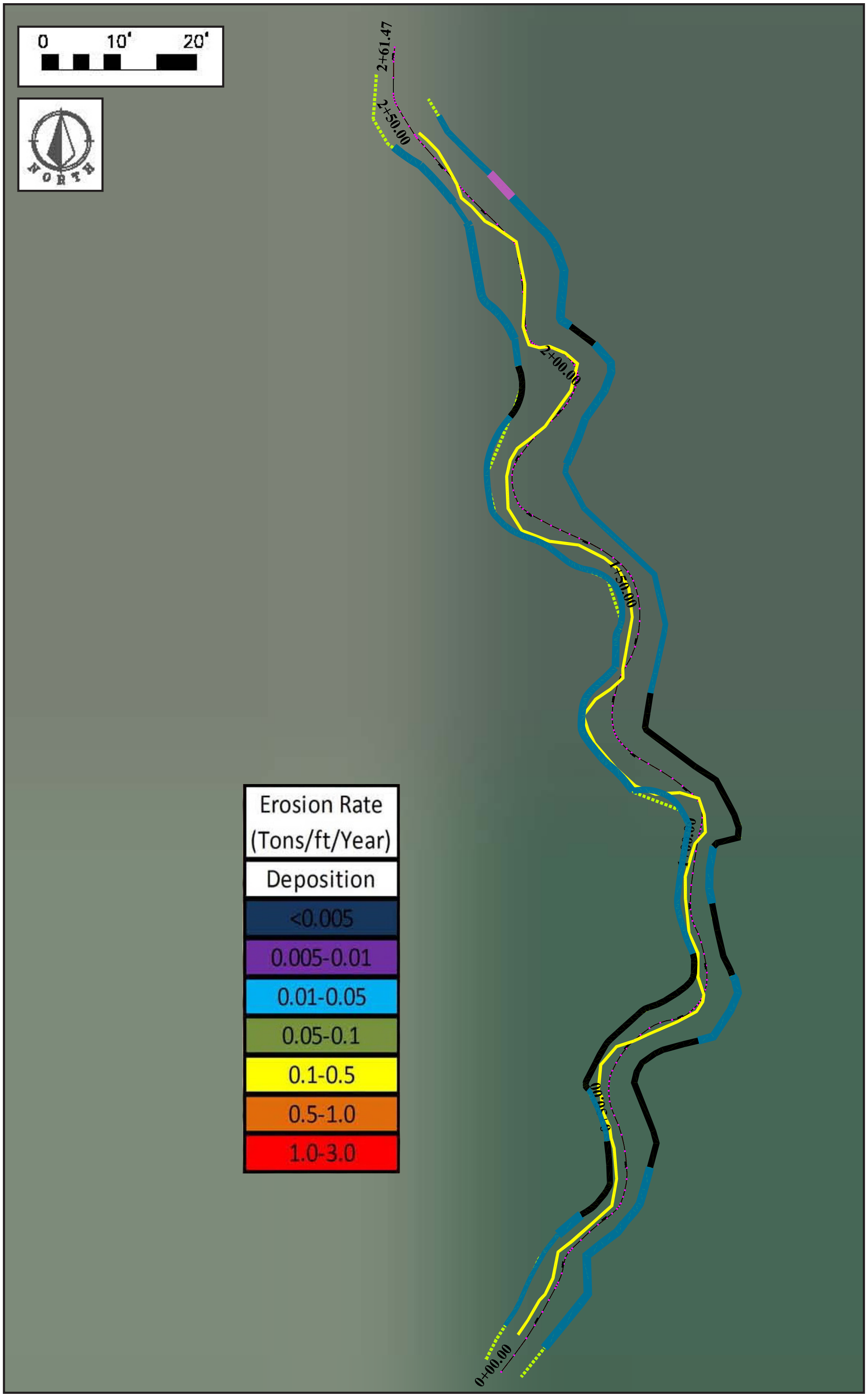
Stream: **Trail Creek, E4 Reference Reach** Location: **Pike National Forest, Colorado**

Graph Used: **Colorado** Total Stream Length (ft): **250** Date: **8/22/2010**

Observers: **K. Wright & B. Kasun** Valley Type: **X** Stream Type: **E4**

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Station (ft)	**BEHI rating (Worksheet 5-16) (adjective)**	**NBS rating (Worksheet 5-17) (adjective)**	**Bank erosion rate (Figure 5-34 or 5-35) (ft/yr)**	**Length of bank (ft)**	**Study bank height (ft)**	**Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)**	**Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}**
1. **0+00 to 0+18 Left Bank**	**Low**	**Low**	**0.03566**	**16.0**	**0.8**	**0.43**	**0.00129**
2. **0+00 to 0+27 Right Bank**	**Very Low**	**Very Low**	**0.00164**	**27.0**	**1.4**	**0.06**	**0.00011**
3. **0+18 to 0+23 Left Bank**	**Very Low**	**High**	**0.02130**	**5.0**	**1.5**	**0.16**	**0.00154**
4. **0+27 to 0+39 Right Bank**	**Very Low**	**High**	**0.02130**	**12.0**	**1.3**	**0.33**	**0.00133**
5. **0+41 to 0+52 Left Bank**	**Very Low**	**Low**	**0.00386**	**11.0**	**0.8**	**0.03**	**0.00015**
6. **0+56 to 0+71 Right Bank**	**Very Low**	**High**	**0.02130**	**15.0**	**1.3**	**0.42**	**0.00133**
7. **0+81 to 1+09 Right Bank**	**Low**	**Low**	**0.03566**	**28.0**	**1.0**	**1.00**	**0.00172**
8 **0+85 to 0+99 Right Bank**	**Low**	**Low**	**0.03566**	**14.0**	**1.3**	**0.65**	**0.00223**
9 **1+09 to 1+28 Left Bank**	**Very Low**	**Moderate**	**0.00907**	**18.0**	**1.2**	**0.20**	**0.00052**
10 **1+24 to 1+68 Right Bank**	**Very Low**	**Low**	**0.00386**	**44.0**	**0.9**	**0.15**	**0.00017**
11 **1+28 to 1+70 Left Bank**	**Very Low**	**Low**	**0.00386**	**42.0**	**1.0**	**0.16**	**0.00019**
12 **1+70 to 1+88 Left Bank**	**Very Low**	**Low**	**0.00386**	**18.0**	**0.9**	**0.06**	**0.00017**
13 **1+80 to 1+88 Right Bank**	**Low**	**Moderate**	**0.07435**	**8.0**	**1.3**	**0.77**	**0.00465**
14 **1+98 to 2+02 Right Bank**	**Low**	**Low**	**0.03566**	**4.0**	**0.7**	**0.10**	**0.00120**
15 **1+88 to 1+94 Left Bank**	**Low**	**Moderate**	**0.07435**	**6.0**	**1.1**	**0.49**	**0.00394**
16 **1+94 to 2+19 Left Bank**	**Very Low**	**Low**	**0.00386**	**23.0**	**1.4**	**0.12**	**0.00026**
17 **2+02 to 2+23 Right Bank**	**Low**	**Low**	**0.03566**	**21.0**	**1.1**	**0.82**	**0.00189**
18 **2+23 to 2+29 Right Bank**	**Low**	**High**	**0.15505**	**6.0**	**1.4**	**1.30**	**0.01045**
19 **2+29 to 2+50 Right Bank**	**Very Low**	**Low**	**0.00386**	**21.0**	**1.0**	**0.08**	**0.00019**
20 **2+19 to 2+28 Left Bank**	**Very Low**	**Very Low**	**0.00164**	**9.0**	**0.8**	**0.01**	**0.00006**
21 **2+28 to 2+41 Left Bank**	**Low**	**Moderate**	**0.07435**	**13.0**	**1.3**	**1.26**	**0.00465**
22 **2+41 to 2+50 Left Bank**	**Very Low**	**Low**	**0.00386**	**9.0**	**1.1**	**0.04**	**0.00020**
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					**Total Erosion (ft^3/yr)**	**8.65**	
Convert erosion in ft^3/yr to yds^3/yr {divide Total Erosion (ft^3/yr) by 27}					**Total Erosion (yds^3/yr)**	**0.32**	
Convert erosion in yds^3/yr to tons/yr {multiply Total Erosion (yds^3/yr) by 1.3}					**Total Erosion (tons/yr)**	**0.42**	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed}					**Total Erosion (tons/yr/ft)**	**0.0017**	

Streambank Erosion Map



FLOWSED Model – Total Annual Sediment Yield

Worksheet 19a. Total annual sediment yield prediction for the pre-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	"Good/Fair" Pagosa	y = -0.0113+1.0139$x^{2.1929}$	18	0.014898355	17.37654682
2. Suspended Sediment	"Good/Fair" Pagosa	y = 0.0636+0.9326$x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow [(5)×(6)]	Suspended Sediment [(5)×(9)]	Bedload Sediment [(5)×(11)]	Suspended + Bedload Sediment [(13)+(14)]
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	45.8													
0.10%	39.3	0.05%	0.09%	0.34	42.5	2.363	7.461	14.89	6.670	9.47	14.6	5.11	3.25	8.36
0.25%	34.0	0.08%	0.15%	0.55	36.6	2.036	5.232	8.99	4.809	6.83	20.1	4.92	3.74	8.66
0.50%	29.4	0.13%	0.25%	0.91	31.7	1.761	3.706	5.51	3.494	4.96	28.9	5.03	4.53	9.55
0.75%	25.1	0.13%	0.25%	0.91	27.2	1.513	2.592	3.31	2.502	3.55	24.8	3.02	3.24	6.26
1%	21.7	0.13%	0.25%	0.91	23.4	1.300	1.817	1.99	1.790	2.54	21.3	1.82	2.32	4.14
1.5%	18.6	0.25%	0.50%	1.83	20.2	1.120	1.289	1.22	1.289	1.83	36.8	2.23	3.34	5.56
2%	15.5	0.25%	0.50%	1.83	17.1	0.949	0.886	0.71	0.893	1.27	31.2	1.30	2.31	3.61
3%	13.1	0.50%	1.00%	3.65	14.3	0.795	0.600	0.40	0.602	0.85	52.2	1.47	3.12	4.59
4%	11.2	0.50%	1.00%	3.65	12.1	0.674	0.424	0.24	0.415	0.59	44.3	0.88	2.15	3.03
5%	10.0	0.50%	1.00%	3.65	10.6	0.587	0.322	0.16	0.304	0.43	38.6	0.58	1.57	2.16
10%	6.3	2.50%	5.00%	18.25	8.1	0.450	0.200	0.08	0.165	0.23	147.9	1.39	4.27	5.66
20%	3.4	5.00%	10.00%	36.50	4.8	0.269	0.103	0.02	0.045	0.06	176.4	0.85	2.35	3.20
30%	2.3	5.00%	10.00%	36.50	2.8	0.158	0.075	0.01	0.006	0.01	103.8	0.36	0.33	0.70
40%	1.6	5.00%	10.00%	36.50	1.9	0.108	0.068	0.01	0.000	0.00	70.9	0.23	0.00	0.23
50%	1.2	5.00%	10.00%	36.50	1.4	0.079	0.066	0.00	0.000	0.00	51.9	0.16	0.00	0.16
60%	0.9	5.00%	10.00%	36.50	1.1	0.061	0.065	0.00	0.000	0.00	39.8	0.12	0.00	0.12
70%	0.8	5.00%	10.00%	36.50	0.9	0.047	0.064	0.00	0.000	0.00	31.1	0.09	0.00	0.09
80%	0.7	5.00%	10.00%	36.50	0.7	0.039	0.064	0.00	0.000	0.00	25.9	0.08	0.00	0.08
90%	0.5	5.00%	10.00%	36.50	0.6	0.032	0.064	0.00	0.000	0.00	20.8	0.06	0.00	0.06
100%	0.1	5.00%	10.00%	36.50	0.3	0.016	0.064	0.00	0.000	0.00	10.4	0.03	0.00	0.03
									Annual Totals:		991.7 (cfs) 1,966.9 (acre-ft)	29.7 (tons/yr)	36.5 (tons/yr)	66.3 (tons/yr)

Worksheet 19b. Total annual sediment yield prediction for the post-fire condition using the FLOWSED model.

Equation Type	Equation Source	Equation	Bankfull Discharge (cfs)	Bankfull Bedload Sediment (kg/s)	Bankfull Suspended Sediment (mg/l)
1. Bedload Sediment	**"Good/Fair" Pagosa**	$y = -0.0113+1.0139x^{2.1929}$	**18**	**0.014898355**	**17.37654682**
2. Suspended Sediment	**"Good/Fair" Pagosa**	$y = 0.0636+0.9326x^{2.4085}$			

From Dimensional 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)
Percentage of Time	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 Sediment Discharge	Time Adjusted Streamflow **[(5)×(6)]**	Suspended Sediment **[(5)×(9)]**	Bedload Sediment **[(5)×(11)]**	Suspended + Bedload Sediment **[(13)+(14)]**
(%)	(cfs)	(%)	(%)	(days)	(cfs)	(Q/Q_{bkf})	(S/S_{bkf})	(tons/day)	(b_s/b_{bkf})	(tons/day)	(cfs)	(tons)	(tons)	(tons)
0%	**62.5**													
0.10%	**56.0**	**0.05%**	**0.09%**	**0.34**	**59.2**	**3.290**	**16.487**	**45.81**	**13.801**	**19.59**	**20.3**	**15.72**	**6.72**	**22.44**
0.25%	**50.7**	**0.08%**	**0.15%**	**0.55**	**53.3**	**2.963**	**12.829**	**32.11**	**10.969**	**15.57**	**29.2**	**17.58**	**8.52**	**26.10**
0.50%	**46.1**	**0.13%**	**0.25%**	**0.91**	**48.4**	**2.688**	**10.157**	**23.06**	**8.855**	**12.57**	**44.2**	**21.04**	**11.47**	**32.51**
0.75%	**41.8**	**0.13%**	**0.25%**	**0.91**	**43.9**	**2.440**	**8.061**	**16.61**	**7.162**	**10.16**	**40.1**	**15.16**	**9.28**	**24.44**
1%	**38.4**	**0.13%**	**0.25%**	**0.91**	**40.1**	**2.227**	**6.480**	**12.19**	**5.859**	**8.32**	**36.6**	**11.12**	**7.59**	**18.71**
1.5%	**35.1**	**0.25%**	**0.50%**	**1.83**	**36.7**	**2.041**	**5.264**	**9.07**	**4.836**	**6.86**	**67.1**	**16.56**	**12.53**	**29.09**
2%	**31.8**	**0.25%**	**0.50%**	**1.83**	**33.4**	**1.857**	**4.204**	**6.59**	**3.928**	**5.58**	**61.0**	**12.03**	**10.18**	**22.21**
3%	**29.3**	**0.50%**	**1.00%**	**3.65**	**30.5**	**1.696**	**3.394**	**4.86**	**3.219**	**4.57**	**111.5**	**17.75**	**16.68**	**34.43**
4%	**26.1**	**0.50%**	**1.00%**	**3.65**	**27.7**	**1.539**	**2.696**	**3.50**	**2.597**	**3.69**	**101.1**	**12.79**	**13.45**	**26.24**
5%	**23.1**	**0.50%**	**1.00%**	**3.65**	**24.6**	**1.365**	**2.038**	**2.35**	**1.995**	**2.83**	**89.7**	**8.57**	**10.34**	**18.91**
10%	**14.4**	**2.50%**	**5.00%**	**18.25**	**18.7**	**1.040**	**1.088**	**0.96**	**1.093**	**1.55**	**341.5**	**17.43**	**28.31**	**45.74**
20%	**4.8**	**5.00%**	**10.00%**	**36.50**	**9.6**	**0.533**	**0.269**	**0.12**	**0.244**	**0.35**	**350.3**	**4.41**	**12.64**	**17.05**
30%	**2.4**	**5.00%**	**10.00%**	**36.50**	**3.6**	**0.200**	**0.083**	**0.01**	**0.018**	**0.03**	**131.3**	**0.51**	**0.95**	**1.46**
40%	**1.6**	**5.00%**	**10.00%**	**36.50**	**2.0**	**0.111**	**0.068**	**0.01**	**0.000**	**0.00**	**72.6**	**0.23**	**0.00**	**0.23**
50%	**1.2**	**5.00%**	**10.00%**	**36.50**	**1.4**	**0.079**	**0.066**	**0.00**	**0.000**	**0.00**	**51.9**	**0.16**	**0.00**	**0.16**
60%	**0.9**	**5.00%**	**10.00%**	**36.50**	**1.1**	**0.061**	**0.065**	**0.00**	**0.000**	**0.00**	**39.8**	**0.12**	**0.00**	**0.12**
70%	**0.8**	**5.00%**	**10.00%**	**36.50**	**0.9**	**0.047**	**0.064**	**0.00**	**0.000**	**0.00**	**31.1**	**0.09**	**0.00**	**0.09**
80%	**0.7**	**5.00%**	**10.00%**	**36.50**	**0.7**	**0.039**	**0.064**	**0.00**	**0.000**	**0.00**	**25.9**	**0.08**	**0.00**	**0.08**
90%	**0.5**	**5.00%**	**10.00%**	**36.50**	**0.6**	**0.032**	**0.064**	**0.00**	**0.000**	**0.00**	**20.8**	**0.06**	**0.00**	**0.06**
100%	**0.1**	**5.00%**	**10.00%**	**36.50**	**0.3**	**0.016**	**0.064**	**0.00**	**0.000**	**0.00**	**10.4**	**0.03**	**0.00**	**0.03**
									Annual Totals:		**1,676.3** (cfs) **3,324.9** (acre-ft)	**171.5** (tons/yr)	**148.7** (tons/yr)	**320.1** (tons/yr)

Sediment Competence/Entrainment

Worksheet 5-22. Sediment competence calculations.

Stream:	**Trail Creek, E4 Reference Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/22/2010**

Enter Required Information for Existing Condition

4.3	D_{50}	Riffle bed material D_{50} (mm)			
5.5	$\hat{D}_{50}$	Bar sample D_{50} (mm)			
0.10	D_{max}	Largest particle from bar sample (ft)	**30**	**(mm)**	304.8 mm/ft
0.01012	S	Existing bankfull water surface slope (ft/ft)			
0.73	d	Existing bankfull mean depth (ft)			
1.65	$\gamma_s - 1$	Immersed specific gravity of sediment			

Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress

0.79	$D_{50}/\hat{D}_{50}$	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.0834\ (D_{50}/\hat{D}_{50})^{-0.872}$
6.96	D_{max}/D_{50}	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.0384\ (D_{max}/D_{50})^{-0.887}$
N/A	τ^*	Bankfull Dimensionless Shear Stress	EQUATION USED:	

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

N/A	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

N/A	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

0.461		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 **32**	CO **62**	Predicted largest moveable particle size (mm) at bankfull shear stress τ **(Figure 5-49)**	
Shields **0.44**	CO **0.12**	Predicted shear stress required to initiate movement of measured D_{max} (mm) **(Figure 5-49)**	
Shields **0.70**	CO **0.19**	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 **0.0097**	CO **0.0026**	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

Channel Stability Ratings

Worksheet 5-24. Successional stage shifts.

Stream:	**Trail Creek, E4 Reference**	Stream Type:	**E4**
Location:	**Pike National Forest, CO**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/22/2010**

Stream Type Changes Due to Successional Stage Shifts (Figure 5-52)	**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), (C→High W/d C)	☐ Moderately Unstable
(G→F), (F→D), (C→F)	☐ Unstable
(C→D), (B→G), (D→G), (C→G), (E→G)	☐ Highly Unstable

Worksheet 5-25. Lateral stability.

Stream: **Trail Creek, E4 Reference Reach** Stream Type: **E4**
Location: **Pike National Forest, Colorado** Valley Type: **X**
Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

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 5-13)**	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	**2**
	1.0 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Depositional Patterns (Worksheet 5-10)**	B1, **B2**	B4, B8	B3	B5, B6, B7	**1**
	B2 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
3 **Meander Patterns (Worksheet 5-9)**	M1, **M3**, M4		M2, M5, M6, M7, M8		**1**
	M3 [✓ **(1)**]		**(3)**		
4 **Dominant BEHI / NBS (Worksheet 5-18)**	L/VL, L/L, L/M, L/H, L/VH, M/VL	M/L, M/M, M/H, L/Ex, H/L	M/VH, M/Ex, H/L, H/M, H/H, VH/VL, Ex/VL	H/H, H/Ex, Ex/M, Ex/H, Ex/VH, VH/VH, Ex/Ex	**2**
	VL/L [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Degree of Confinement (MWR / MWR$_{ref}$) (Worksheet 5-14)**	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	**1**
	1.0 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**7**

	Lateral Stability Category Point Range			
Overall Lateral Stability Category (use total points and check stability rating)	***Stable*** **7 – 9** ☑	***Moderately Unstable*** **10 – 12** ☐	***Unstable*** **13 – 21** ☐	***Highly Unstable*** **> 21** ☐

Worksheet 5-26. Vertical stability − aggradation.

Stream:	**Trail Creek, E4 Reference Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/22/2010**

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 5-22)**	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slope-slightly incompetent	Cannot move D_{35} of bed material and/or D_{100} of bar material	Cannot move D_{16} of bed material and/or D_{100} of bar or sub-pavement size	**2**
	[✓ **(2)**]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	Sufficient capacity to transport annual load	Trend toward insufficient sediment capacity	Reduction up to 25% of annual sediment yield of bedload and/or suspended sand	Reduction over 25% of annual sediment yield for bedload and/or suspended sand	**2**
	Ref. Reach [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
3 **W/d Ratio State (Worksheet 5-13)**	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	**2**
	1.0 [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheet 5-24)**	Current stream type at potential or does not indicate deposition/ aggradation	(E→C)	(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	**2**
	at potential [✓ **(2)**]	**(4)**	**(6)**	**(8)**	
5 **Depositional Patterns (Worksheet 5-10)**	B1	**B2**, B4	B3, B5	B6, B7, B8	**2**
	(1)	**B2** [✓ **(2)**]	**(3)**	**(4)**	
6 **Debris / Blockages (Worksheet 5-11)**	**D1**, D2, D3	D4, D7	D5, D8	D6, D9, D10	**1**
	D1 [✓ **(1)**]	**(2)**	**(3)**	**(4)**	
				Total Points	**11**

	Vertical Stability Category Point Range for Excess Deposition / Aggradation			
Vertical Stability for Excess Deposition / Aggradation (use total points and check stability rating)	***No Deposition*** **10 – 14** ☑	***Moderate Deposition*** **15 – 20** ☐	***Excess Deposition*** **21 – 30** ☐	***Aggradation*** **> 30** ☐

Worksheet 5-27. Vertical stability – degradation.

Stream:	**Trail Creek, E4 Reference Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/22/2010**

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 5-22)**	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**
	[✓ (2)]	**(4)**	**(6)**	**(8)**	
2 **Sediment Capacity (POWERSED) (Worksheet 5-20)**	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**
	Ref. Reach [✓ (2)]	**(4)**	**(6)**	**(8)**	
3 **Degree of Channel Incision (BHR) (Worksheet 5-12)**	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	**2**
	1.00 [✓ (2)]	**(4)**	**(6)**	**(8)**	
4 **Stream Succession States (Worksheets 5-12 and 5-24)**	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)	**2**
	at potential [✓ (2)]	**(4)**	**(6)**	**(8)**	
5 **Confinement (MWR / MWR_{ref}) (Worksheet 5-14)**	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	**1**
	1.00 [✓ (1)]	**(2)**	**(3)**	**(4)**	
				Total Points	**9**
	Vertical Stability Category Point Range for Channel Incision / Degradation				
Vertical Stability for Channel Incision/ Degradation (use total points and check stability rating)	***Not Incised*** **9 – 11** ☑	***Slightly Incised*** **12 – 18** ☐	***Moderately Incised*** **19 – 27** ☐	***Degradation*** **> 27** ☐	

Worksheet 5-28. Channel enlargement.

Stream: **Trail Creek, E4 Reference Reach** Stream Type: **E4**
Location: **Pike National Forest, Colorado** Valley Type: **X**
Observers: **K. Wright & B. Kasun** Date: **8/22/2010**

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 5-24)**	Stream Type at Potential, (C→E), (F_b→B), (G→B), (F→B_c), (F→C), (D→C) **at potential [✓ (2)]**	(C→High W/d C), (E→C) **(4)**	(G→F), (F→D) **(6)**	(C→D), (B→G), (D→G), (C→G), (E→G), (C→F) **(8)**	**2**
2 **Lateral Stability (Worksheet 5-25)**	*Stable* **[✓ (2)]**	*Moderately Unstable* **(4)**	*Unstable* **(6)**	*Highly Unstable* **(8)**	**2**
3 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	*No Deposition* **[✓ (2)]**	*Moderate Deposition* **3**	*Excess Deposition* **(6)**	*Aggradation* **(8)**	**2**
4 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	*Not Incised* **[✓ (2)]**	*Slightly Incised* **(4)**	*Moderately Incised* **(6)**	*Degradation* **(8)**	**2**
				Total Points	**8**

	Category Point Range			
Channel Enlargement Prediction (use total points and check stability rating)	***No Increase*** **8 – 10** ☑	***Slight Increase*** **11 – 16** ☐	***Moderate Increase*** **17 – 24** ☐	***Extensive*** **> 24** ☐

Worksheet 5-29. Overall sediment supply.

Stream:	**Trail Creek, E4 Reference Reach**	Stream Type:	**E4**
Location:	**Pike National Forest, Colorado**	Valley Type:	**X**
Observers:	**K. Wright & B. Kasun**	Date:	**8/22/2010**

Overall Sediment Supply Prediction Criteria (choose corresponding points for each criterion 1–5)	**Stability Rating**	**Points**	**Selected Points**
1 **Lateral Stability (Worksheet 5-25)**	***Stable***	**[✓ 1]**	**1**
	Mod. Unstable	**2**	
	Unstable	**3**	
	Highly Unstable	**4**	
2 **Vertical Stability Excess Deposition or Aggradation (Worksheet 5-26)**	***No Deposition***	**[✓ 1]**	**1**
	Mod. Deposition	**2**	
	Excess Deposition	**3**	
	Aggradation	**4**	
3 **Vertical Stability Channel Incision or Degradation (Worksheet 5-27)**	***Not Incised***	**[✓ 1]**	**1**
	Slightly Incised	**2**	
	Mod. Incised	**3**	
	Degradation	**4**	
4 **Channel Enlargement Prediction (Worksheet 5-28)**	***No Increase***	**[✓ 1]**	**1**
	Slight Increase	**2**	
	Mod. Increase	**3**	
	Extensive	**4**	
5 **Pfankuch Channel Stability (Worksheet 5-15)**	***Good: Stable***	**[✓ 1]**	**1**
	Fair: Mod. Unstable	**2**	
	Poor: Unstable	**4**	
		Total Points	**5**

	Category Point Range			
Overall Sediment Supply Rating (use total points and check stability rating)	***Low*** **5** ☑	***Moderate*** **6 – 10** ☐	***High*** **11 – 15** ☐	***Very High*** **16 – 20** ☐

Worksheet 5-32. Summary of stability condition categories.

Stream:	**Trail Creek, E4 Reference Reach**			Location: **Pike National Forest, Colorado**					
Observers:	**K. Wright & B. Kasun**		Date: **8/22/2010**	Stream Type: **E4**	Valley Type: **X**				
Channel Dimension (Riffle XS 2+42.5)	Mean Bankfull Depth (ft): **0.73**	Bankfull Width (ft): **5.73**	Cross-Sectional Area (ft^2): **4.17**	Width of Flood-Prone Area (ft): **35.78**	Entrenchment Ratio: **6.24**				
Channel Pattern	Mean: Range:	λ/W_{bkf}: **5.4** **4.99-6.27**	L_m/W_{bkf}: **6.08** **5.09-7.27**	R_c/W_{bkf}: **3.09** **1.76-4.80**	MWR: **3.33** **2.76-3.80**	Sinuosity: **1.23**			
River Profile & Bed Features	Check: ☑ Riffle/Pool	☐ Step/Pool	☐ Plane Bed	☐ Convergence/Divergence	☐ Dunes/Antidunes/Smooth Bed				
	Max Bankfull Depth (ft):	Riffle **1.02** **0.95-1.19**	Pool **1.74** **1.44-2.94**	Depth Ratio (max to mean):	Riffle **1.52** **1.4-1.78**	Pool **2.6** **2.15-4.39**	Pool-to-Pool Spacing: Ratio **5.46**	Slope Valley: **0.0124**	Water Surface: **0.0101**
Level III Stream Stability Indices	Riparian Vegetation	Current Composition/Density: **Willow, Carex, Conifers**	Potential Composition/Density: **Same as existing**	Remarks: Condition, Vigor & Usage of Existing Reach: **Excellent coverage - some invasives need erad.**					
	Flow Regime: **P1, P2, P8**	Stream Size & Order: **S-3(3)**	Meander Patterns: **M3**	Depositional Patterns: **B2**	Debris/Channel Blockages: **D1**				
	Degree of Incision (Bank-Height Ratio): **1.0**	Degree of Incision Stability Rating: **Stable**	Modified Pfankuch Stability Rating (Numeric & Adjective Rating): **60 (Good)**						
	Width/depth Ratio (W/d): **7.85**	Reference W/d Ratio (W/d$_{ref}$): **7.85**	Width/Depth Ratio State (W/d) / (W/d$_{ref}$): **1.0**	W/d Ratio State Stability Rating: **Stable**					
	Meander Width Ratio (MWR): **3.33**	Reference MWR$_{ref}$: **3.33**	Degree of confinement (MWR / MWR$_{ref}$): **1.0**	MWR / MWR$_{ref}$ Stability Rating: **Unconfined**					
Bank Erosion Summary	Length of Reach Studied (ft): **250**	Annual Streambank Erosion Rate: **0.42** (tons/yr) **0.0017** (tons/yr/ft)	Curve Used: **Colorado**	Remarks: **Great Vegetation (used Yellowstone Curve for VL BEHI)**					
Sediment Capacity (POWERSED)	☑ Sufficient Capacity	☐ Insufficient Capacity	☐ Excess Capacity	Remarks: **Functioning as a stable, E4 Stream**					
Entrainment/ Competence	Largest Particle from Bar Sample (mm): **30**	$\tau =$ **0.461**	$\tau^* =$ **N/A**	Existing Depth: **0.73**	Required Depth: **0.7**	Existing Slope: **0.010**	Required Slope: **0.010**		
Successional Stage Shift	**E** →	**G** →	**F** →	**C** →	[✓ **E**] →	Existing Stream State (Type): **E4**	Potential Stream State (Type): **E4**		
Lateral Stability	☑ *Stable*	☐ *Mod. Unstable*	☐ *Unstable*	☐ *Highly Unstable*	Remarks/causes: **No Change**				
Vertical Stability (Aggradation)	☑ *No Deposition*	☐ *Mod. Deposition*	☐ *Ex. Deposition*	☐ *Aggradation*	Remarks/causes: **No Change**				
Vertical Stability (Degradation)	☑ *Not Incised*	☐ *Slightly Incised*	☐ *Mod. Incised*	☐ *Degradation*	Remarks/causes: **No Change**				
Channel Enlargement	☑ *No Increase*	☐ *Slight Increase*	☐ *Mod. Increase*	☐ *Extensive*	Remarks/causes: **Great Vegetation**				
Sediment Supply (Channel Source)	☑ *Low*	☐ *Moderate*	☐ *High*	☐ *Very High*	Remarks/causes: **Stable, Reference Reach with great Veg**				