APPENDIX K

LEVEL III ROSGEN WORKSHEETS

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

	Riparian Vegetation												
Stre	eam: Buffal	o River		Location: Buffalo River-1-1.19									
	servers: KD, JI		Reference reach	Disturbed (impacted reach)		9/27/2011							
spe	sting cies nposition:			Potential species composition:									
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species cor	Percent of total species composition								
ıry				Large trees		100%							
Overstory	Canopy layer	15%	2%										
1.													
						100%							
Understory	Shrub layer		2%	Shrubs Nettle/Burrs		40% 60%							
2. Und	Cinab layer		=/*										
						100%							
	Herbaceous		3%	Grass		100%							
evel	nerbaceous		376										
3. Ground level	Leaf or needle litter		0%	Remarks: Condition, vigor ar usage of existing r		100%							
	Bare ground		93%										
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%										

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

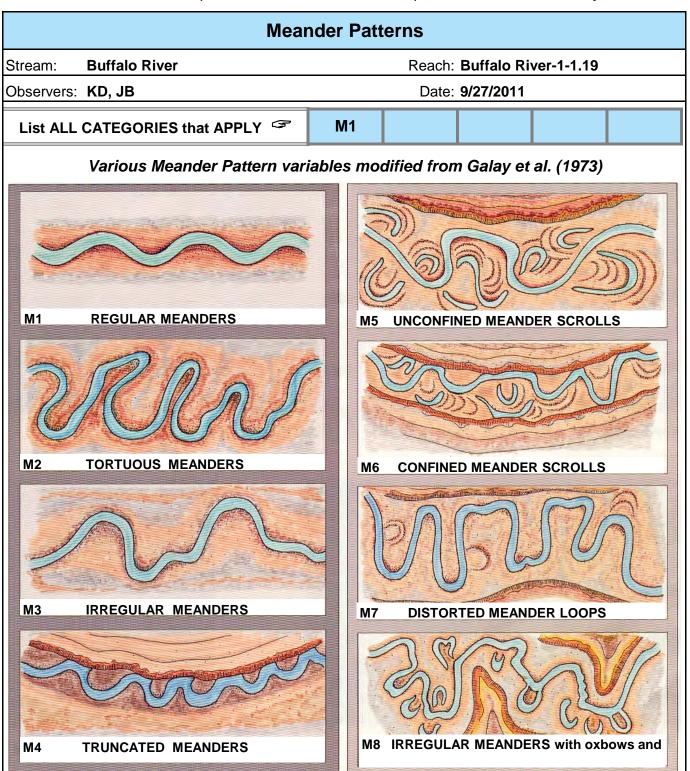
nological interpretations.											
		F	LOW I	REGIMI	E						
Stream:	Buffalo River		Location:	Buffalo l	River-1-1	.19					
Observers:	KD, JB						Date:	9/27/201	1		
List ALL	COMBINATIONS that	P1	P2	P9							
APF	APPLY										
General C	Category										
E	Ephemeral stream cha	nnels: Flo	ows only in	respons	e to precip	pitation					
S	Subterranean stream c surface flow that follow			llel to and	l near the	surface fo	or various	seasons	- a sub-		
ı	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology w	here		
Р	Perennial stream chan	nels: Surf	face water	persists y	yearlong.						
Specific (Category										
1	Seasonal variation in s	treamflow	dominated	d primarily	y by snow	melt runo	off.				
2	Seasonal variation in s	treamflow	dominated	d primarily	y by storn	nflow runc	off.				
3	Uniform stage and asso	ociated sti	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	, etc.			
4	Streamflow regulated b	y glacial r	melt.								
5	Ice flows/ice torrents fro	om ice da	m breache	es.							
6	Alternating flow/backwa	ater due to	o tidal influ	ence.							
7	Regulated streamflow	due to dive	ersions, da	am releas	e, dewate	ering, 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 generate	ed runoff.									

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

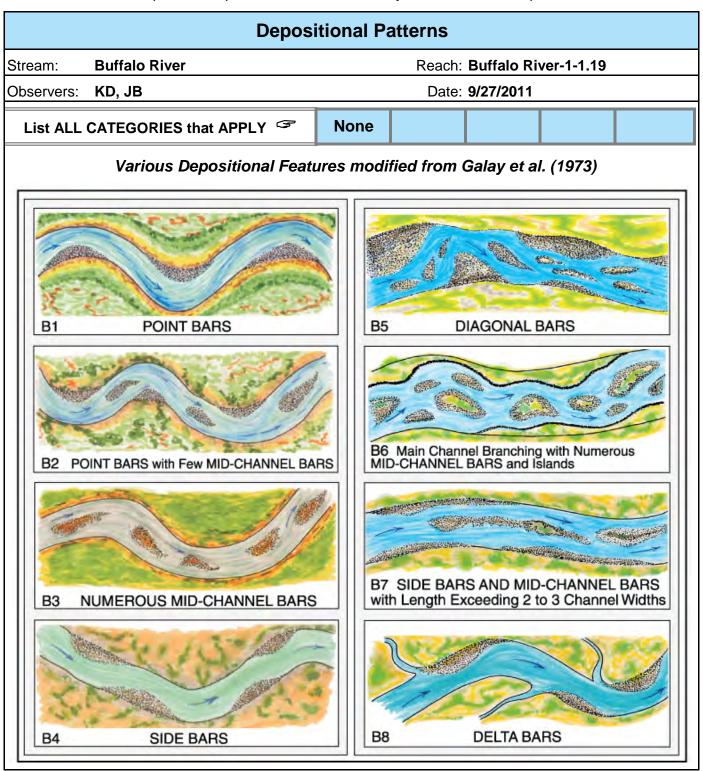
	Stream Size and Order											
Stream:	Buffalo River											
Location:	Buffalo River-	1-1.19										
Observers:	KD, JB											
Date:	9/27/2011											
Stream Size Category and Order 🤝 S-7												
STREAM SIZE: Bankfull Check (✓) Category width check (✓)												
	meters	feet	category									
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										
	Strear	n Order										
Add categoria	as in naranthasis	for enacific etras	m order of									

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

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



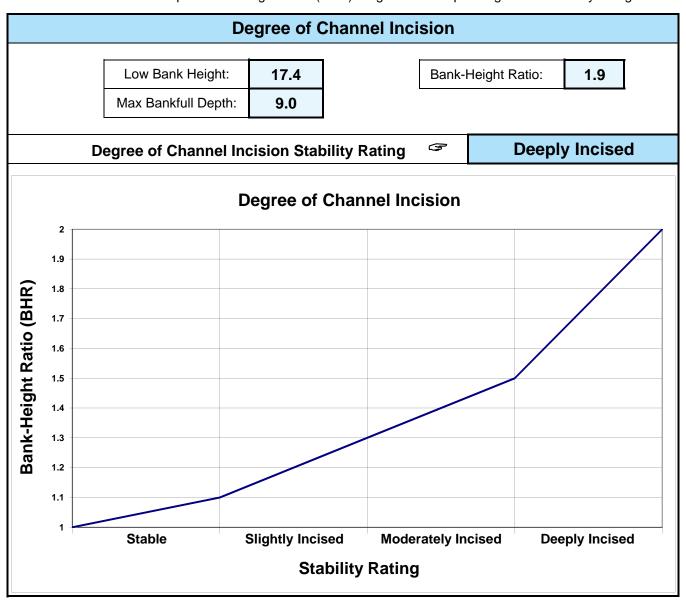
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



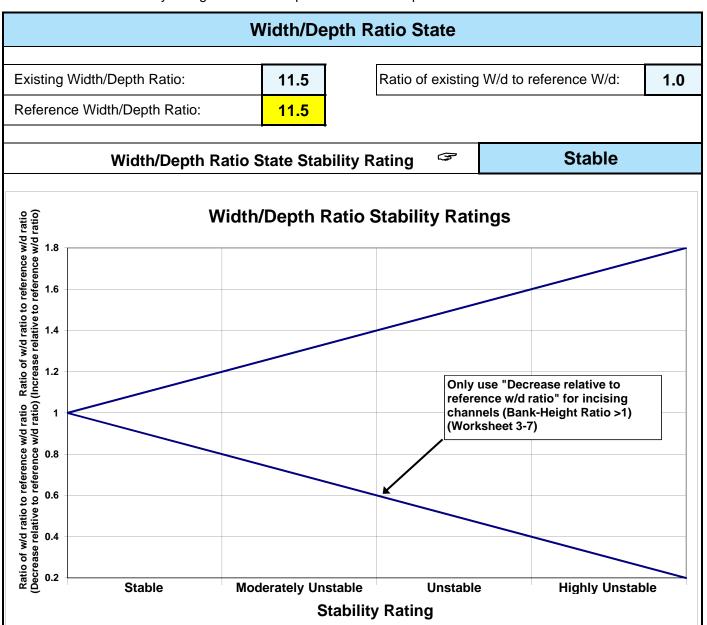
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages						
Strear	m: Buffalo Riv	er Location: Buffalo River-1-1.19						
Obser	rvers: KD, JB	Date: 9/27/2011						
Desc	ription/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.						
D1	None	Minor amounts of small, floatable material.	7					
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.	Y					
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	>					
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.						
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.						
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.						
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.						
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.						

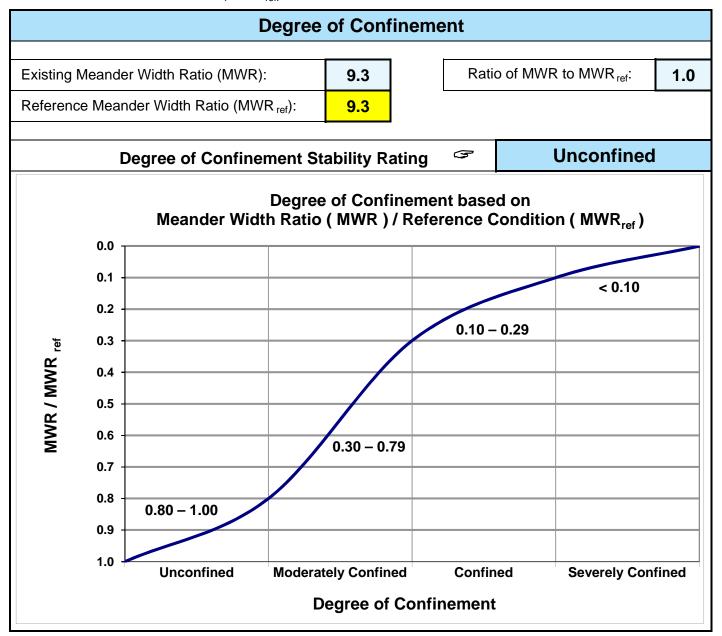
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



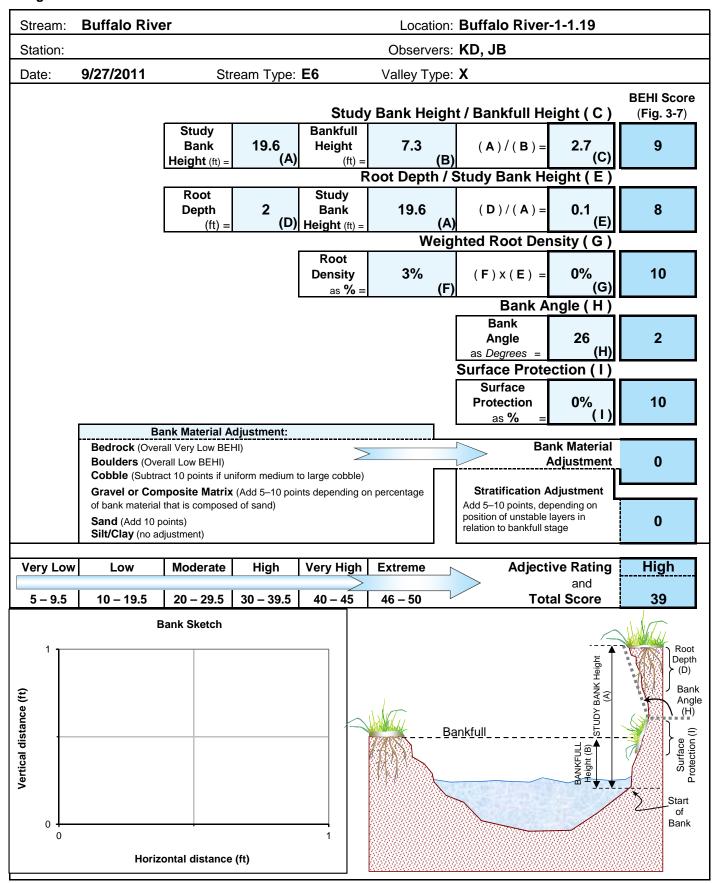
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Buffa	alo Riv	er				Loc	ation:	Buffa	lo Riv	er-1-1	1.19		Valley	Туре:	Х		Obs	ervers:	KD, J	JB				Date: 9/	27/201 <i>′</i>	1
Loca-	Key	Categ	ory			Exce	llent					Go	od					F	air						Poor		
tion	ive	Caleg	Ol y		D	Description	n		Rating			Description	n		Rating			Description	on		Rating			Desc	cription		Rating
υ	1	Landform slope	1	Bank slo	ope grad	dient <30	0%.		2	Bank slo	ope grad	dient 30-	-40%.		4	Bank sl	lope gra	dient 40	- 60%.		6	Bank sl	lope g	radient :	> 60%.		8
banks	2	Mass ero	SION I	No eviderosion.		past or t	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sedi	iment	9				using sediment of danger of s		12
Upper I	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	sizes.	•	ounts, m		6	predom	ninantl	y larger			8
D	4	Vegetativ bank protection			t a deep	nsity. Viç , dense					or sugge	y. Fewer est less			6	fewer s	6 density pecies f inuous r	rom a s		nd	9	vigor in	<50% density plus fewe vigor indicating poor, dis shallow root mass.				12
	5	Channel capacity		Bank heig stage. Wid	hts sufficie dth/depth r width/dep	ent to conta ratio depar th ratio = 1	ture from		1	Bankfull st Width/dep	age is cor th ratio de h ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/depth e width/depth ratio (BHR) = 1.1–1.3.		3	Bankfull s common ratio depa	stage is with flow arture fro	not contai	ined; over-bank f an bankfull. Widtl nce width/depth r > 1.3.	h/depth	4
nks	6	Bank rock content		12"+ co	mmon.	e angula			2	40–65% cobbles		y boulde	rs and s	small	d class.		6	or less.	.	Ū	s of gravel siz		8				
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in ing or de			2	currents fewer an	and mind d less fire		ing. Obs	tructions	4		th high flo		able obsti sing bank		6	cause b	bank e	rosion y	s and deflect /earlong. Sec gration occur	diment	8
Low	8	Cutting		Little or <6".	none. Ir	nfrequer	it raw ba	anks	4			ently at o aw bank			6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.		· 1.7					uts, some ove nangs frequer		16		
	9	Depositio	n I	Little or point ba		rgement	of char	nel or	4	Some n coarse (increase	, mostly	y from	8	and coa	arse san	d on old	new gra d and so	me	Extensive deposit of predominantly fine		Extensive deposit of predominantly fine particles. Accelerated bar development.		•	16	
	10	Rock angularity		Sharp e surfaces	U	nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well ro			urfaces	4	
	11	Brightnes	ss	General	lly not b					surfaces	3.	may hav		% bright	2	mixture	range.		i.e., 35-		3		Predominantly bright, > 6 scoured surfaces.		, > 65%, exp	osed or	4
E	12	Consolidat particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4	appare	nt overla	ар.	nt with n		6	easily n	No packing evident. Loose assortment, easily moved.			8	
Bottom	13	Bottom si distributio		No size material	_	evident 0%.	. Stable		1	50–80%).	it light. S		aterial	8	materia	ls 20–50	0%.	zes. Stat		12	Marked materia			hange. Stabl	e	16
_	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18				e bottom in a yearlong.	state of	24
	15	Aquatic vegetation			•	th moss- I. In swif						e forms i . Moss h			2	backwa	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. Perennial types so green, short-term					4					
			•			Exc	ellent	total =	15				Good	total =	20				Fair	total =	6				Poo	r total =	44
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6				
Good (Stable	-		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	67-9	_	Grand t	otal =	85
Fair (Mod. u	nstable	44-47			96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+							2 108-132 99-125 Exi		Existing		E 6	
Stream ty			DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6	G6 *Potentia		71	EG		
Good (Stabl	e)	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				stream		E6
Fair (Mod. u		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					ied char	
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stabi	lity ratin	g =
																	*Ra	ting is a	djusted	to poten	tial strea	ım type,	, not e	xisting.		Fair	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Stream: Buffalo River Estimating Near-Bank Stress (NBS) Location: Buffalo River											
Stream: Buffalo River Location: Buffalo River											
	-1-1.19										
Station: 0 Stream Type: E6	•	Valley Type:	Χ								
Observers: KD, JB		Date:	9/27/11								
Methods for Estimating Near-Bank Stress (N	BS)										
(1) Channel pattern, transverse bar or split channel/central bar creating NBS	_evel I	Recona	aissance								
(2) Ratio of radius of curvature to bankfull width (R _c / W _{bkf}) L	evel II	General	prediction								
(3) Ratio of pool slope to average water surface slope (S _p / S)	evel II	General	prediction								
(4) Ratio of pool slope to riffle slope (S_p/S_{rif})	evel II	General	prediction								
(5) Ratio of near-bank maximum depth to bankfull mean depth (d _{nb} / d _{bkf}) Le	evel III	Detailed	prediction								
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb}/τ_{bkf})	evel III	Detailed	prediction								
(7) Velocity profiles / Isovels / Velocity gradient	evel IV	Valid	dation								
Transverse and/or central bars-short and/or discontinuous											
(1) Extensive deposition (continuous, cross-channel)											
		INI	DO = EXHEIRE								
Curvature Width W. Ratio R. Stress											
(2) R_c (ft) R_c (ft) R_c (ft) R_c (NBS)											
Near-Bank			_								
Pool Slope Average Stress Slope S Ratio S _p / S (NBS)		ninant									
Sp Slope S Ratio Sp / S (NBS)		nk Stress									
	very	Low	<u>l</u>								
Pool Slope Riffle Slope Ratio S _p / Near-Bank Stress											
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$											
Near-Bank Near-Bank											
Max Depth Mean Depth Ratio d _{nb} / Stress											
GIID (17) GERT (17) GERT (1855)											
Near-Bank Shear	Bankfull		1								
Near-Bank Shear	Shear		Neer Deals								
	ess τ _{bkf} (Ratio τ _{nb} /	Near-Bank Stress								
	lb/ft ²)	$ au_{bkf}$	(NBS)								
> Near-Bank											
Velocity Gradient (ft / sec Stress											
(NBS)											
O.03 Very Low											
Converting Values to a Near-Bank Stress (NBS)	Rating										
Near-Bank Stress (NBS) Method number	(F)	(0)	(7)								
ratings (1) (2) (3) (4) Very Low N/A > 3.00 < 0.20 < 0.40	(5)	(6)	(7)								
	< 1.00	< 0.80 0.80 – 1.05	< 0.50 0.50 – 1.00								
	00 – 1.50 51 – 1.80	1.06 – 1.14	1.01 – 1.60								
2.07 2.20 0.17 0.00 0.01 0.00	31 – 1.60	1.15 – 1.19	1.61 – 2.00								
High See 1.81_2.00 0.61_0.80 0.81_1.00 1.8	J 1 - Z.JU										
	51 – 3.00	1 20 - 1 60									
Very High (1) 1.50 – 1.80 0.81 – 1.00 1.01 – 1.20 2.5	51 – 3.00 > 3.00	1.20 – 1.60 > 1.60	2.01 – 2.40 > 2.40								
Very High (1) 1.50 – 1.80 0.81 – 1.00 1.01 – 1.20 2.5	> 3.00	> 1.60	> 2.40 > Low								

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:											
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4552.5	Date: 9/27/2011						
Observers:	KD, JB		Valley Type:		Stream Type: E6						
(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)] (ft³/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}				
1.	High	Very Low	0.165	4552.5	19.6	14723	0.16				
2.						0	#DIV/0!				
3.						0	#DIV/0!				
4.						0	#DIV/0!				
5.						0	#DIV/0!				
6.						0	#DIV/0!				
7.						0	#DIV/0!				
8.						0	#DIV/0!				
9.						0	#DIV/0!				
10.						0	#DIV/0!				
11.						0	#DIV/0!				
12.						0	#DIV/0!				
13.						0	#DIV/0!				
14.						0	#DIV/0!				
15.						0	#DIV/0!				
Sum erosion	n subtotals in Colu	ımn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	14723					
Convert eros	sion in ft ³ /yr to yds	s ³ /yr {divide T	it ³ /yr) by 27}	Total Erosion (yds³/yr)	545						
Convert eros by 1.3}	sion in yds ³ /yr to t	ons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	709					
	osion per unit leno total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.16					

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

Stream:	Buffalo Ri	ver	St	ream Type:	E6					
Location:	Buffalo Ri	ver-1-1.19	١	/alley Type:	Х					
Observers:	KD, JB			Date:	9/27/2011					
Enter Rec	uired Infor	mation for Existing Condition								
	D ₅₀	Riffle bed material D ₅₀ (mm)								
-	D ₅₀	Bar sample D ₅₀ (mm)								
-	D _{max}	Largest particle from bar sample (ft)		-	(mm)	304.8 mm/ft				
	S	Existing bankfull water surface slope (ft/f	ft)							
	d	Existing bankfull mean depth (ft)								
1.65	γ_{s}	Submerged specific weight of sediment								
Select the	Appropria	te Equation and Calculate Critical D	imensio	nless She	ar Stress					
-	D ₅₀ /D ₅₀	Range: 3 – 7 Use EQUAT	ΓΙΟΝ 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
-	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use EQUAT	ΓΙΟΝ 2:	τ* = 0.038	4 (D _{max} /D ₅	₀) ^{-0.887}				
-	τ*	Bankfull Dimensionless Shear Stress		EQUATIO	ON USED:	2				
Calculate	Bankfull Me	an Depth Required for Entrainment of	f Largest	Particle in	Bar Sampl	е				
-	d	Required bankfull mean depth (ft)	$d = \frac{\mathcal{T}}{}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐ Degra	ding							
Calculate Sample	Bankfull W	ater Surface Slope Required for Ent	rainmen	t of Large	st Particle	in Bar				
-	S	Required bankfull water surface slope (ft	t/ft) S =	$= \frac{\tau * \gamma_s L}{d}$) max (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐ Degra	ding							
Sediment	Competen	ce Using Dimensional Shear Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (substitute hyd	draulic rac	lius, R, with	mean depth	d)				
	$\gamma = 62.4, c$	d = existing depth, S = existing slope								
	Predicted	largest moveable particle size (mm) at ban	kfull shea	r stress τ (F	igure 3-11)					
	Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)									
#DIV/0!		mean depth required to initiate movement		red D _{max} (mr		<u>t</u> 'S				
		ted shear stress, γ = 62.4, S = existing slope required to initiate movement of mea		(mm)	τ	' ວ				
#DIV/0!		ted shear stress, γ = 62.4, d = existing dep		ax \'''''/	$S = \frac{\iota}{\gamma d}$					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis Observers: KD, JB																			
u b	Strea	ım:	Buffal	o Rive	er				Loca	tion:	Buffa	lo Rive	er-1-1.1	19					Date: 9/2	7/2011	
		→ (⇒ (⇒ (→ (⇒ (⇒ (⇒ (⇒ (⇒(
a m		h Pan ICKET	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE			
p I	Tare	weight	Tare v	weight	Tare	weight	Tare	weight	Tare v	veight	Tare	weight	Tare	weight	Tare	weight	Tare	weight	SURFACE MATERIALS		
e s	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two la	DATA argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1																			No.	Dia.	WT.
3																			1 2		
4																			l		ı
5																			Bucket + materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials weight		0
11																			Materials less		
12																			than:		mm
13																				Be sure to separate n	
15																				weights to otal	grand
Net w	. total	0		0		0		0		0		0		0		0		0	0		
% Gr	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		~	
Accur	า. % =<	#####	\Longrightarrow	#####	\Longrightarrow	#####	>	#####		#####	\longrightarrow	#####		#####	>	#####	\longrightarrow	100%	GF	RAND TO	TAL
S	ample lo	cation no	otes				Sar	mple loca	location sketch												

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

Stream:	Buffalo River	Stream Type: E6
Location:	Buffalo River-1-1.19	Valley Type: X
Observers:	KD, JB	Date: 9/27/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	, $(B \rightarrow G)$, $(D \rightarrow G)$, $(C \rightarrow G)$, $(E \rightarrow G)$	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Buffalo River			Stream Ty	_{/pe:} E6	
Location: Buffalo River-1-1	.19		Valley Ty	_{/pe:} X	
Observers: KD, JB			Da	ate: 9/27/2011	
Lateral stability criteria		Selected			
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	9
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Buffalo River Stream Type: E6									
Loc	cation: Buffalo River-	1-1.19		Valley Type:	Х				
Ob:	servers: KD, JB			Date:	9/27/2011				
V	ertical stability criteria	Vertical Stabil	Selected						
Ca	hoose one stability ategory for each riterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
1	Sediment competence (Worksheet 3-14)	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)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
		(2)	(4)	(6)	(8)				
4	Stream succession states (Worksheet 3- 16)	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	B1	B2, B4	B3, B5	B6, B7, B8	1			
	3-5)	(1)	(2)	(3)	(4)				
6	Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	3			
		(1)	(2)	(3)	(4)				
			12						
		Vertical stat		int range for exces adation	s deposition /				
e: a; p:	ertical stability for xcess deposition / ggradation (use total bints and check stability ting)	No deposition 10 − 14 ✓	Moderate deposition 15 − 20	Excess deposition 21 – 30	Aggradation > 30				

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

Stream: Buffalo Rive	r		Stream Type:	E6	
Location: Buffalo Rive	r-1-1.19		Valley Type:	Χ	
Observers: KD, JB			Date:	9/27/2011	
Vertical stability	Vertical Stabi	ity Categories for	r Channel Incision	n / Degradation	Selected
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
	(2)	(4)	(6)	(8)	
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
	(2)	(4)	(6)	(8)	
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8
(WOIRSHEEL 3-1)	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4
ŕ	(2)	(4)	(6)	(8)	
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1
3-9)	(1)	(2)	(3)	(4)	
				Total points	17
	Vertical stak	oility category poi degra	nt range for chan dation	nnel incision /	
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 3-20. Channel enlargement prediction summary.

Stream: Buffalo River			Stream Type:	E6	
Location: Buffalo River-1	-1.19		Valley Type:	X	
Observers: KD, JB			Date:	9/27/2011	
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2
	(2)	(4)	(6)	(8)	
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2
	(2)	(4)	(6)	(8)	
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2
(Worksheet 3-18)	(2)	(4)	(6)	(8)	
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4
(Worksheet 9-19)	(2)	(4)	(6)	(8)	
				Total points	10
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Buffalo River			Stream Type:	E6							
Lo	cation: Buffalo River-1-	1.19		Valley Type:	Х							
Ob	servers: KD, JB			Date:	9/27/2011							
p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points							
		Stable		1								
1	Lateral stability	Mod. unstab	ole	2	1							
'	(Worksheet 3-17)	Unstable		3	'							
		Highly unsta	able	4								
	Vertical stability	No deposition	on	1								
2	excess deposition/	Mod. deposi	ition	2	1							
-	aggradation	Excess depo	osition	3	•							
	(Worksheet 3-18)	Aggradation	1	4								
	Vertical stability	Not incised		1								
3	channel incision/	Slightly inci	sed	2	2							
ľ	degradation	Mod. Incised	d	3	2							
	(Worksheet 3-19)	Degradation	1	4								
	Channal anlargament	No increase		1								
4	Channel enlargement prediction (Worksheet	Slight increa	ight increase 2									
~	3-20)	Mod. increas	se	3	1							
	3-20)	Extensive		4								
	Pfankuch channel	Good: stable	e	1								
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2							
١	10)				2							
	10)	Poor: unsta	ble	4								
				Total Points	7							
	Category point range											
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □							

Worksheet 3-22. Summary of stability condition categories.

Stream:	Buffalo River			Location:	Buffalo River	-1-1.19		
Observers:	KD, JB	Date:	9/27/2011	Stream	n Type: E6	Valle	ey Type: X	
Channel Dimension	Mean bankfull depth (ft): 6.3	Mean bankfull width (ft):	3.1 Cross-section area (ft ²):	n 462.7	Width of flood- prone area (ft):	196.0	Entrenchment ratio:	2.7
Channel Pattern	Mean: Range: MWR:	9.3 Lm/W _b	9.3	Rc/	W _{bkf} :	1.3	Sinuosity:	2.2
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converge	nce/divergence	Dunes	/antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	io	Slope	
Features	bankfull 9.0 depth (ft):	(max/me	ean): 1.4		pool spacing:	Valley:	Average bankfull	3.7E-05
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	gor and/or usage of existir	ng reach:
	vegetation	<u> </u>					I=	
	Flow P-1, Strear regime: 2, 9 and or	rder:	Meander pattern(s):	M-1	Depositional pattern(s):	None	Debris/channel blockage(s):	D1-5
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.9 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective ratin	g):	Fair
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	11.5 Width/dep (W/d) / (W	th ratio sta /d _{ref}):	te 1.0	1	atio state by rating:	table
	Meander Width Ratio (MWR):	9.3 Reference MWR _{ref} :	9.3 Degree of (MWR / M	confineme WR _{ref}):	^{nt} 1.0)	/ MWR _{ref} ry rating:	onfined
Bank Erosion Summary	Length of reach studied (ft):) 3	mbank erosion rate s/yr) 0.16 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		isting Requestions Reputation	
Successional Stage Shift	→ -	→	→	→	Existing strestate (type)		Potential stream state (type):	n E6
Lateral Stability	▼ Stable □	Mod. unstable Г	Unstable	☐ High	ly unstable	Remarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	Remarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degr	adation	Remarks/cause	es:	
Channel Enlargement	✓ No increase	Slight increase	Mod. increase	☐ Exte	nsive	Remarks/cause	es:	
Sediment Supply (Channel Source)	□ Low □	Moderate	High 🔲 Very h	igh	ks/causes:			

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

			Riparian Ve	getation						
Stre	eam: Lowe i	r Rush River		Location: Lower Rush River-1-1.10						
Obs	servers: KP, A	L	Reference reach	Disturbed (impacted X reach) Date: 9/29/2011						
spe	sting cies nposition:			Potential species composition:						
R	iparian 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		20%							
				100%						
level	Herbaceous		48%							
3. Ground level	Leaf or needle litter		2%	Remarks: Condition, vigor and/or usage of existing reach:						
	Bare ground		30%							
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%							

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

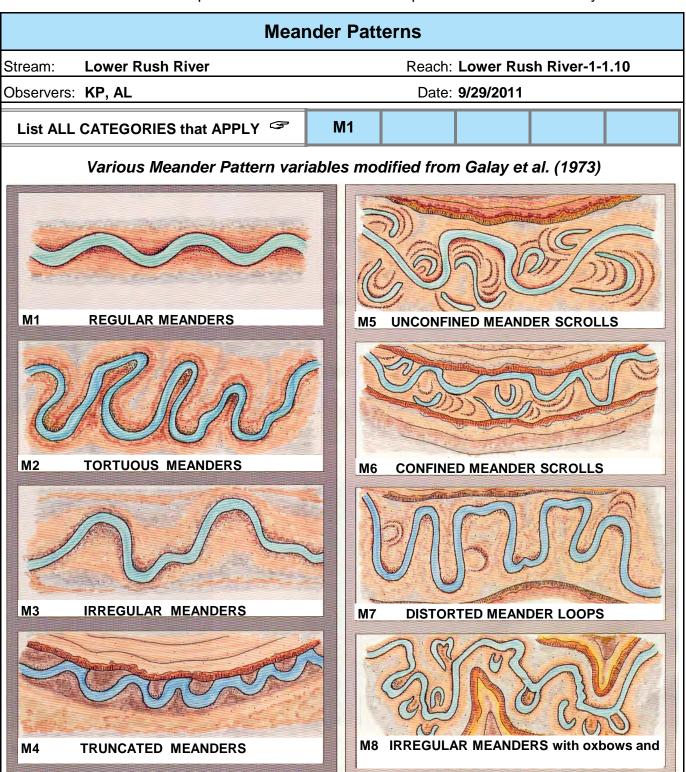
	F	LOW I	REGIM	E									
Lower Rush River		Location:	Lower R	ush Rive	r-1-1.10								
KP, AL						Date:	9/29/201	1					
List ALL COMBINATIONS that E1 E2 E9													
APPLY													
General Category													
E Ephemeral stream channels: Flows only in response to precipitation													
			llel to and	near the	surface fo	or various	seasons	- a sub-					
associated with sporad	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												
Perennial stream channels: Surface water persists yearlong.													
Category													
Seasonal variation in st	treamflow	dominate	d primarily	/ by snow	melt runo	ff.							
Seasonal variation in st	treamflow	dominate	d primarily	/ by storm	nflow runc	off.							
Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ndition, b	ackwater	, etc.						
Streamflow regulated b	y glacial ı	melt.											
Ice flows/ice torrents fro	om ice da	m breache	es.										
Alternating flow/backwa	ater due to	o tidal influ	ence.										
Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ring, etc.								
Rain-on-snow generate	ed runoff.												
	COMBINATIONS that COMBINATIONS that CLY	Lower Rush River KP, AL COMBINATIONS that LY	Lower Rush River KP, AL COMBINATIONS that PLY	Lower Rush River KP, AL COMBINATIONS that DLY	E1 E2 E9 Category Ephemeral stream channels: Flows only in response to precipe Subterranean stream channels: Flows parallel to and near the surface flow that follows the stream bed. Intermittent stream channel: Surface water flows discontinuou associated with sporadic and/or seasonal flows and also with losing/gaining reaches create flows that disappear then reapp Perennial stream channels: Surface water persists yearlong. Category Seasonal variation in streamflow dominated primarily by snow Seasonal variation in streamflow dominated primarily by storm Uniform stage and associated streamflow due to spring-fed constructions. Streamflow regulated by glacial melt. Ice flows/ice torrents from ice dam breaches. Alternating flow/backwater due to tidal influence. Regulated streamflow due to diversions, dam release, dewater Altered due to development, such as urban streams, cut-over conversions (forested to grassland) that change flow response	Lower Rush River KP, AL COMBINATIONS that DLY	Lower Rush River KP, AL COMBINATIONS that DLY	Lower Rush River KP, AL COMBINATIONS that Date: 9/29/201 Category Ephemeral stream channels: Flows only in response to precipitation Subterranean stream channel: Flows parallel to and near the surface for various seasons surface flow that follows the stream bed. Intermittent stream channel: Surface water flows discontinuously along its length. Often associated with sporadic and/or seasonal flows and also with Karst (limestone) geology willosing/gaining reaches create flows that disappear then reappear farther downstream. Perennial stream channels: Surface water persists yearlong. Category Seasonal variation in streamflow dominated primarily by snowmelt runoff. Seasonal variation in streamflow dominated primarily by stormflow runoff. Uniform stage and associated streamflow due to spring-fed condition, backwater, etc. Streamflow regulated by glacial melt. Ice flows/ice torrents from ice dam breaches. Alternating flow/backwater due to tidal influence. Regulated streamflow due to diversions, dam release, dewatering, etc. Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.					

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

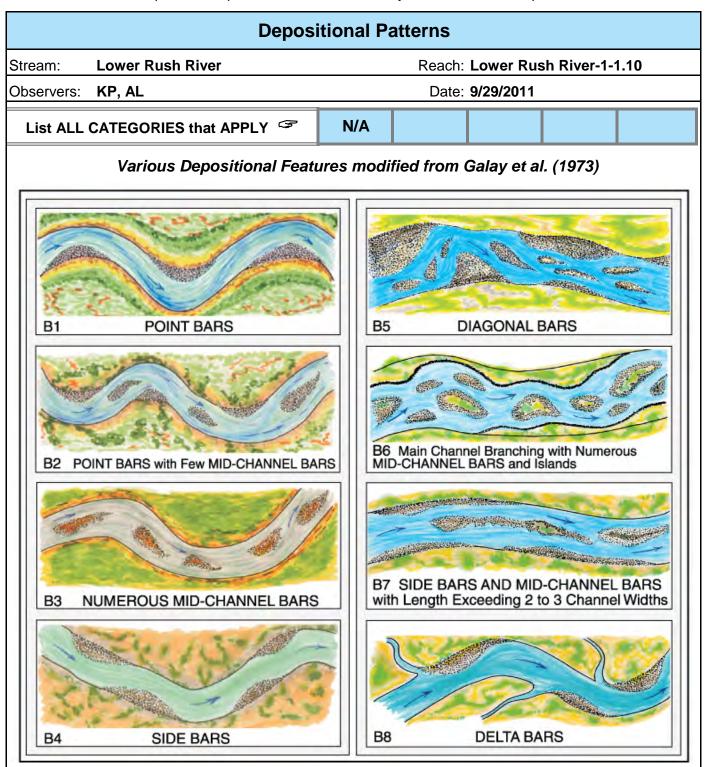
	Stream Size and Order											
Stream:	Lower Rush R	iver										
Location:	Lower Rush R	iver-1-1.10										
Observers: KP, AL												
Date: 9/29/2011												
Stream Size Category and Order S-5												
STREAM SIZE: Bankfull Check (✓) Category width check (✓)												
	meters	feet	category									
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										
	Strear	n Order										
A -1-1 4:												

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

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



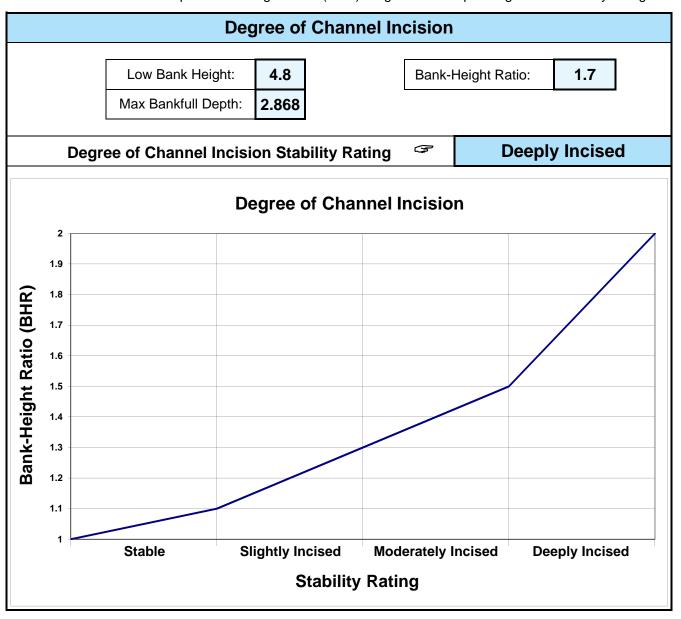
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



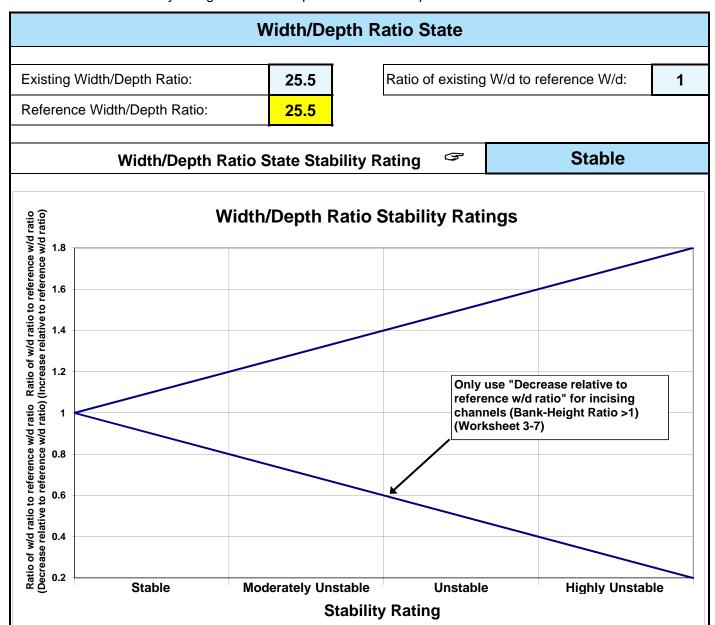
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages							
Strear	n: Lower Rus	h River Location: Lower Rush River-1-1.10							
Obser	vers: KP, AL	Date: 9/29/2011							
Desc	ription/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.							
D1	None	Minor amounts of small, floatable material.	▼						
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.							
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.							
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.							
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.							
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.							
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.							
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.							
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.							
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.							

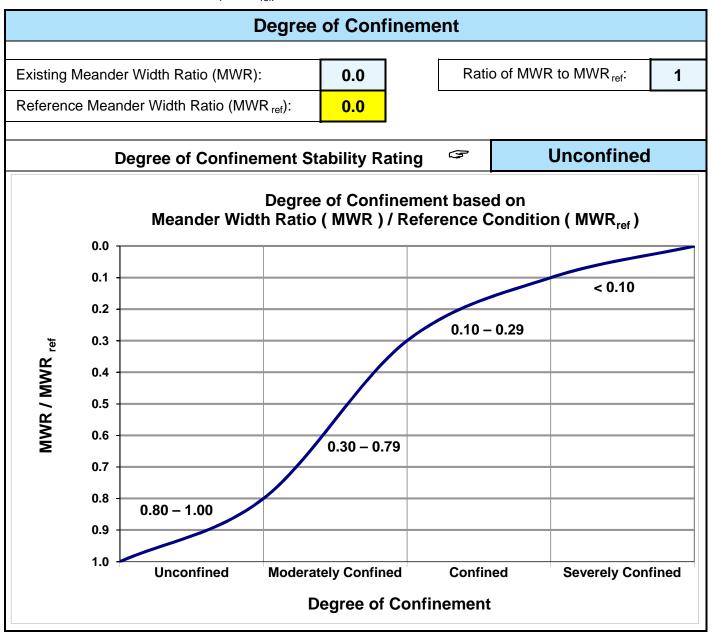
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



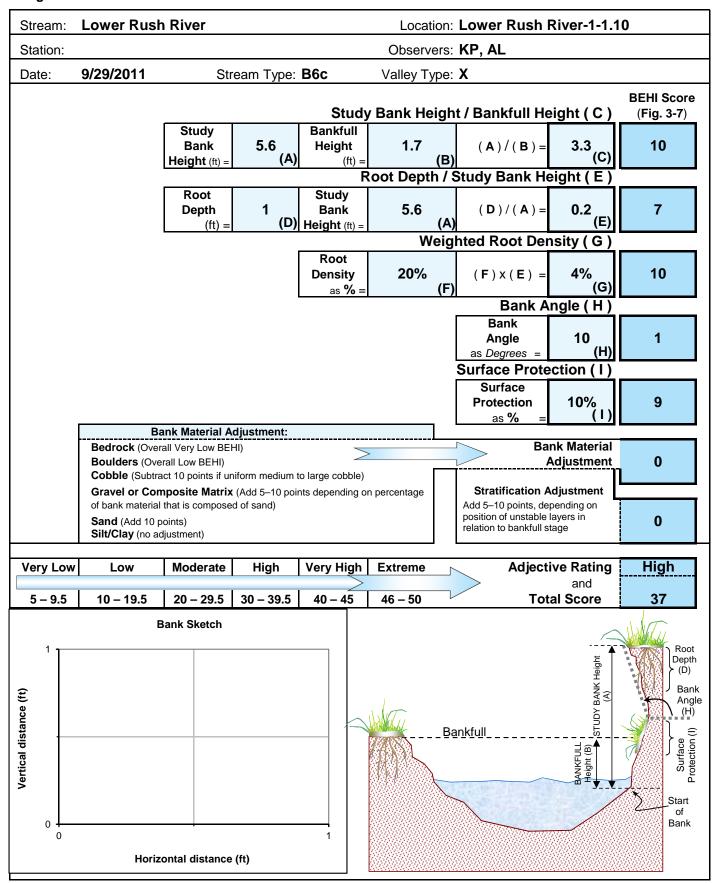
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream: Lower Rush River Locatio						ation:	Lowe	r Rus	h Rive	er-1-1.		Valley	Type:	Х		Obse	ervers:	KP, A	۸L				Date: 9/29/201	1			
Loca-	Key	Catoo	iorv			Exce	llent					Go	od					Fa	air						Poor		
tion	ney	Categ	JOIY			Descriptio	n		Rating		D	escriptio	n		Rating			Descriptio	n		Rating			Descri	ption	Rating	
(0	1	Landforn slope	n	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	ope grad	dient >	60%.	8	
Upper banks	2	Mass ero	osion	No evid erosion	ridence of past or future mass			3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.		12				
pper	3	Debris ja potential		Essentially absent from immediate channel area. Present, but mostly small twigs and limbs.				4	Moderate to heavy amounts, mostly larger sizes.			6	Moderat predomi	inantly la	arger s	izes.	8										
ס	4	Vegetative bank protection			t a deep	nsity. Vi , dense			3		or sugg	y. Fewer est less			6	fewer s		rom a sl		ınd	9		dicating	poor, c	er species and less discontinuous and	12	
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/d	oth ratio	3	Bankfull stage is not contained common with flows less than be ratio departure from reference Bank-Height Ratio (BHR) > 1.3			bankfull. Width/depth e width/depth ratio > 1.4.	4	
nks	6	Bank roc content	ck	12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3'	8	
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly in			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		th high flo		able obst sing bank		6	Frequent obstructions cause bank erosion ye traps full, channel migi			earlong. Sediment	8	
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6				l" high. I ughing (12	Almost continuous cuts, high. Failure of overhand			*	16	
	9	Deposition	on	Little or point ba		irgemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba	arse san		new gra		12				Extensive deposit of predominantly fine particles. Accelerated bar development.		16
	10	Rock angularit		Sharp e surface:		nd corne	rs. Plan	е	1			rs and e th and fla	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.		all dim	nensions, surfaces	4	
	11	Brightnes	ss	Surface Genera	,	lark or st right.	tained.		1	Mostly of surfaces		may hav	ve <35%	6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	3 Predominantly scoured surface			> 65%, exposed or	4	
E	12	Consolida particles		Assorte overlap		tightly pa	acked o	r	2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	10	6	No packing evident. Loose assort easily moved.		oose assortment,	8		
Bottom	13	Bottom s distribution		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable	16	
	14	Scouring deposition		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr		constri			18				bottom in a state of rearlong.	24	
	15	Aquatic vegetatio			•	th moss I. In swif			1			e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow- m may be present.	4	
						Exc	ellent	total =	31				Good	total =	12				Fair	total =	0				Poor total :	4	
Stream ty	ne	A1	A2	А3	Α4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6				
Good (Stabl	_		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	67-98		Grand total =	47	
Fair (Mod. u	,	44-47	44-47	91-129	96-132	96-142	81-110		46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110			108-132		99-125		Existing	D	
Poor (Unsta		48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+			stream type =	B6c		
Stream ty			DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6	Į.			*Potential	DC-	
Good (Stabl	_		40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107		90-112	85-107				stream type =	B6c	
Fair (Mod. u	ınstable	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				Modified cha	nnel	
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rati		
																	*Ra	ting is a	djusted	to poter	itial strea	ım type,	not exis	ting.	Good		
																								•			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)											
				ating Nea			•				
		Rush Rive	r		Location:	Lower Rus	sh River-1-	1.10			
Station	: 0			S	tream Type:	B6c	\	/alley Type:	X		
Observ	ers:	KP, AL						Date:	9/29/11		
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)				
(1) Chai	nnel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance		
(2) Ratio	o of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction		
(3) Ratio	o of pool slo	pe to average	water surface sl	ope (S _p / S)			Level II	General _I	prediction		
(4) Ratio	o of pool slo	pe to riffle slop	e (S _p / S _{rif})				Level II	General	prediction		
(5) Ratio	o of near-ba	ınk maximum d	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction		
(6) Ratio	o of near-ba	ink shear stress	to bankfull she	ear stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction		
(7) Velo	city profiles	/ Isovels / Velo					Level IV		lation		
								_			
Level	(1)										
				meander mig		ging flow		NE	35 = Extreme		
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress						
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)						
			` '								
_					Near-Bank						
= =	(2)	Pool Slope	Average		Stress			inant			
Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress			
_							Very	Low			
					Near-Bank						
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress						
	\	S _p	S _{rif}	S _{rif}	(NBS)						
		Near-Bank			Na an Danie						
		Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress						
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	•					
■											
Level III				Near-Bank			Bankfull				
تد	(0)	Near-Bank	Near-Bank	Shear Stress τ_{nb} (_	Shear	Ratio τ _{nb} /	Near-Bank		
	(6)	Max Depth d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	Mean Depth d _{bkf} (ft)	Average Slope S	Stress τ _{bkf} (Stress (NBS)		
		~IID (IT)	- FF - OID	ib/it)	∽DKI (¹¹)	Globe 9	ib/it)	$ au_{bkf}$	(IADO)		
				Near-Bank							
Level IV	(-)	Velocity Grad	dient (ft/sec	Stress							
eve	(7)	/ f	,	(NBS)	1						
_				Very Low							
		Col	verting V	alues to a N	Near-Bank	Stress (NF	SS) Rating				
Near-	Bank Str	ess (NBS)	70.111.9			ethod numb					
	rating	ıs	(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	Very L	ow	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		
	Modera	ate	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 H	-	(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		
	Extrer	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low		

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Lower Rush Ri	ver		Location:	Lower Rush	River-1-1.10	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4743.8		Date:	9/29/2011
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	B6c
(1)	(2)	(3)	(4) Bank	(5)	(6) Study bank	(7)	(8) Erosion
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	height (ft)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	High	Very Low	0.165	4743.8	5.6	4383	0.04
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosior	n subtotals in Col	combination	Total Erosion (ft³/yr)	4383			
Convert ero	sion in ft ³ /yr to yd	s ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	162		
Convert eros by 1.3}	sion in yds ³ /yr to	Total Erosion (tons/yr)	211				
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.04	

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

Stream:	Lower Rus	sh River	S	tream Type:	B6c				
Location:	Lower Rus	sh River-1-1.10	,	Valley Type:	Х				
Observers:	KP, AL			Date:	9/29/2011				
Enter Req	uired Infor	mation for Existing Cond	ition						
	D ₅₀	Riffle bed material D_{50} (mm)						
	D ₅₀	Bar sample D ₅₀ (mm)							
0	D _{max}	Largest particle from bar sa	imple (ft)		(mm)	304.8 mm/ft			
S Existing bankfull water surface slope (ft/ft)									
	d	Existing bankfull mean dep	th (ft)						
1.65	γ_s	Submerged specific weight	of sediment						
Select the	Appropria	te Equation and Calculate	e Critical Dimensio	nless She	ar Stress				
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^) ^{-0.872}			
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}			
#DIV/0!	τ*	Bankfull Dimensionless She	ear Stress	EQUATIO	ON USED:	#DIV/0!			
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample									
#DIV/0!	d	Required bankfull mean de	pth (ft) $d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading							
Calculate Sample	Bankfull W	ater Surface Slope Requi	ired for Entrainmer	nt of Large	st Particle	in Bar			
#DIV/0!	s	Required bankfull water sur	face slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading	□ Degrading						
Sediment	Competen	ce Using Dimensional Sh	ear Stress						
0	Bankfull sl	hear stress $\tau = \gamma dS$ (lbs/ft ²) (substitute hydraulic ra	dius, R, with	mean depth,	d)			
	$\gamma = 62.4$, c	d = existing depth, S = existing	g slope						
	Predicted	largest moveable particle size	(mm) at bankfull shea	ar stress τ (F	igure 3-11)				
	Predicted	shear stress required to initiat	e movement of measu	ıred D _{max} (m	m) (Figure 3	-11)			
#DIV/0!		mean depth required to initiate		red D _{max} (mı	$d = \frac{7}{1}$	<u>r</u> 'S			
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, S = slope required to initiate move	ement of measured D _m	_{ax} (mm)	$S = \frac{T}{vd}$	<u> </u>			
	τ = predic	ted shear stress, γ = 62.4, d =	existing depth		γd				

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis Observers: KP, AL								TA: S	ize Dis			•			KP, A	L		T		
u b	Strea	ım:	Lowe	r Rush	River		T		Loca	tion:	Lowe	r Rush	River	-1-1.1()		1		Date: 9/2	9/2011	
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒ (⇒ (
a a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm			
m p I	Tare v		Tare	weight	Tare	weight	Tare			veight	Tare		Tare	weight	Tare v		Tare v	veight		URFACE ATERIAL	
e s	Sample v	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two la	DATA argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1															-				No.	Dia.	WT.
3																			1 2		
4																			Bucket +		
5																			materials		
6																			weight		
7															1				Bucket tare		
8																			weight		
9 10																			Materials weight		0
11																			Materials less		
12																			than:		mm
13																				Be sure to separate n	
14 15																			// \	veights to	
Net wt	total	0		0		0		0		0		0		0		0		0	0	otal	
		#####		#####		#####		#####		#####		#####		#####		#####		#####		7	
Accum	n. % =<	#####		#####		#####	\Longrightarrow	#####		#####		#####		#####	1 1 1	#####		100%		RAND TO	TAL
			•		•				•												
s	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream: Lower Rush Ri	ver	Stream Type: B6c			
Location: Lower Rush Ri	ver-1-1.10	Valley Type: X			
Observers: KP, AL		Date: 9/29/2011			
Stream type chang successional stage shif		Stability rating (check appropriate rating)			
	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$				
(E→C), (C→High	W/d C)				
(G→F), (F→D), ((C→F)	☐ Unstable			
(C→D), (B→G), (D→G), ((C→G), (E→G)	☐ Highly unstable			

Worksheet 3-17. Lateral stability prediction summary.

Stream: Lower Rush Rive	er		Stream Ty	_{/pe:} B6c			
Location: Lower Rush Rive	er-1-1.10		Valley Ty	_{/pe:} X			
Observers: KP, AL			D	ate: 9/29/2011			
Lateral stability criteria		Lateral Stabili	ty Categories		Selected		
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)		
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2		
,	(2)	(4)	(6)	(8)			
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1		
	(1)	(2)	(3)	(4)			
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1		
	(1)		(3)				
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)			
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1		
(Worksheet 3-9)	(1)	(2)	(3)	(4)			
Total points							
Lateral stability category point range							
Overall lateral stability category (use total points and check stability rating) Stable 7-9 Moderately unstable Unstable 10-12 13-21 > 21							

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

Stream: Lower Rush F	River		Stream Type:	B6c			
Location: Lower Rush R	River-1-1.10		Valley Type:	Χ			
Observers: KP, AL			Date:	9/29/2011			
Vertical stability criteria	Vertical Stabi	ity Categories fo	r Excess Deposition	on / Aggradation	Selected		
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)		
Sediment 1 competence (Worksheet 3-14)	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)			
Sediment capacity (POWERSED)	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)			
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2		
	(2)	(4)	(6)	(8)			
Stream succession 4 states (Worksheet 3- 16)	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)			
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1		
3-3)	(1)	(2)	(3)	(4)			
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1		
	(1)	(2)	(3)	(4)			
Total points							
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Lower Rush	River		Stream Type:	B6c				
Location: Lower Rush	River-1-1.10		Valley Type:	X				
Observers: KP, AL			Date:	9/29/2011				
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected			
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2			
	(2)	(4)	(6)	(8)				
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2			
	(2)	(4)	(6)	(8)				
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8			
(WOIKSHEEL 3-1)	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4			
·	(2)	(4)	(6)	(8)				
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1			
3-9)	(1)	(2)	(3)	(4)				
	Total points							
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 3-20. Channel enlargement prediction summary.

Stream: Lower Rush River Stream Type: B6c								
Location: Lower Rush Ri	ver-1-1.10		Valley Type:	Х				
Observers: KP, AL			Date:	9/29/2011				
Channel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected			
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Worksheet o 15)	(2)	(4)	(6)	(8)				
Total points								
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Lower Rush Riv	er		Stream Type:	B6c			
Lo	cation: Lower Rush Riv	er-1-1.10		Valley Type:	Х			
Ob	servers: KP, AL			Date:	9/29/2011			
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points			
		Stable		1				
1	Lateral stability	Mod. unstab	ole	2	1			
l '	(Worksheet 3-17)	Unstable		3	•			
		Highly unsta	able	4				
	Vertical stability	No deposition	on	1				
2	excess deposition/	Mod. depos	ition	2	1			
-	aggradation	Excess depo	osition	3	•			
	(Worksheet 3-18)	Aggradation	1	4				
	Vertical stability	Not incised		1				
3	channel incision/	Slightly inci	sed	2	2			
l °	degradation	Mod. Incised	d	3	2			
	(Worksheet 3-19)	Degradation)	4				
	Channal anlargement	No increase		1				
4	Channel enlargement prediction (Worksheet	Slight increase 2		1				
"	3-20)	Mod. increas	se	3	•			
	3-20)	Extensive		4				
	Pfankuch channel	Good: stable	e	1				
5	stability (Worksheet 3-	Fair: mod u	nstable	2	1			
ľ	10)				•			
	10)	Poor: unsta	ble	4				
	Total Points 6							
	Category point range							
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □			

Worksheet 3-22. Summary of stability condition categories.

Stream:	Lower Rush River			Location:	Lower Rush	River-1-1.10)	
Observers:	KP, AL	Date:	9/29/2011	Strean	n Type: B6c	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 1.77	Mean bankfull width (ft):	.32 Cross-section area (ft ²):	n 80.5	Width of flood- prone area (ft):	72.2	Entrenchment ratio:	1.6
Channel Pattern	Mean: MWR:	0.0 Lm/W _b	kf: 0.0	Rc/	/W _{bkf} :	0.0	Sinuosity:	0
	Check: Riffle/pool	☐ Step/pool ☐		Converge	nce/divergence	✓ Dunes/	antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool Depth r	Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull depth (ft): 2.9	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull:	0.00034
	Nipanan	nt composition/density:	Potential composi	tion/density:	Remark	s: Condition, vig	or and/or usage of existing	reach:
	vegetation							
	Flow E1, 2, Strear regime: 9 and or	3-3	Meander pattern(s):	M1	Depositional pattern(s):	N/A	Debris/channel blockage(s):	D1
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.7 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective rating	g):	ood
	Width/depth ratio (W/d): 25.5	Reference W/d ratio (W/d _{ref}):	25.5 Width/dept (W/d) / (W/		te 1.0		tio state / rating:	able
	Meander Width Ratio (MWR):	0.0 Reference MWR _{ref} :	0.0 Degree of (MWR / MV		ent 1.0		MWR _{ref} / unco	nfined
Bank Erosion Summary	Length of reach studied (ft):	44	mbank erosion rate	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Require depth _{bkf} :		sting Requi	
Successional Stage Shift	→ -	→	→	→	Existing stre state (type)		Potential stream state (type):	B6c
Lateral Stability	▼ Stable □	Mod. unstable Г	Unstable	☐ High	ly unstable	emarks/cause	s:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	radation	emarks/cause	S:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degr	radation	emarks/cause	S:	
Channel Enlargement	✓ No increase	Slight increase	Mod. increase	☐ Exte	nsive	emarks/cause	S:	
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High 🔲 Very hi	gh	rks/causes:			

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

	Riparian Vegetation									
Stre	eam: Lowe i	r Rush River		Location: Lower Rush River-2-6.03						
Obs	servers: KP, A	L	Reference reach	Disturbed (impacted reach) X Date: 11/18/2010						
spe	sting cies nposition:			Potential species composition:						
R	Riparian cover categories Percent aerial cover* Coverage**			Species composition Percent of total species composition						
1. Overstory	Canopy layer	1%	1%							
	ı			100%						
2. Understory	Shrub layer		14%							
				100%						
level	Herbaceous		84%							
3. Ground level	Leaf or needle litter		0%	Remarks: Condition, vigor and/or usage of existing reach:						
	Bare ground		1%	None						
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%							

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

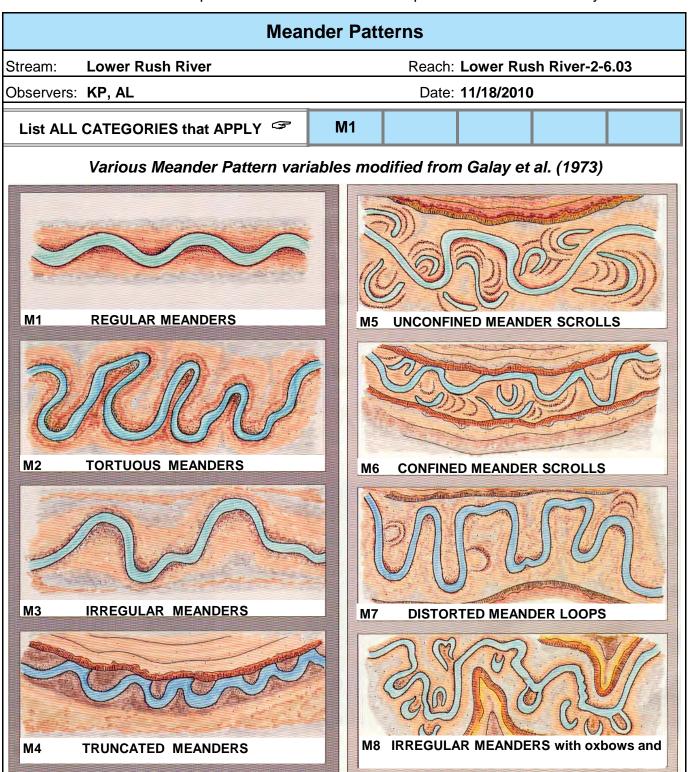
	erpretations.								
FLOW REGIME									
Stream:	Lower Rush River		Location:	Lower R	ush Rive	r-2-6.03			
Observers:	KP, AL						Date:	11/18/20	10
List ALL	COMBINATIONS that	E1	E2	E 9					
APF	PLY			E9					
General Category									
E	Ephemeral stream char	nnels: Flo	ows only in	respons	e to precij	pitation			
s		Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.							
I	associated with sporad	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.							
Р	Perennial stream chanr	nels: Surf	face water	persists	yearlong.				
Specific (Category								
1	Seasonal variation in st	reamflow	dominated	d primaril	y by snow	melt runo	ff.		
2	Seasonal variation in st	reamflow	dominated	d primaril	y by storn	nflow runc	off.		
3	Uniform stage and asso	ciated st	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.	
4	Streamflow regulated b	y glacial r	melt.						
5	Ice flows/ice torrents fro	om ice da	m breache	s.					
6	Alternating flow/backwa	ater due to	o tidal influ	ence.					
7	Regulated streamflow of	lue to dive	ersions, da	ım releas	e, dewate	ering, etc.			
8	Altered due to develope conversions (forested to								
9	Rain-on-snow generate	d runoff.							

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

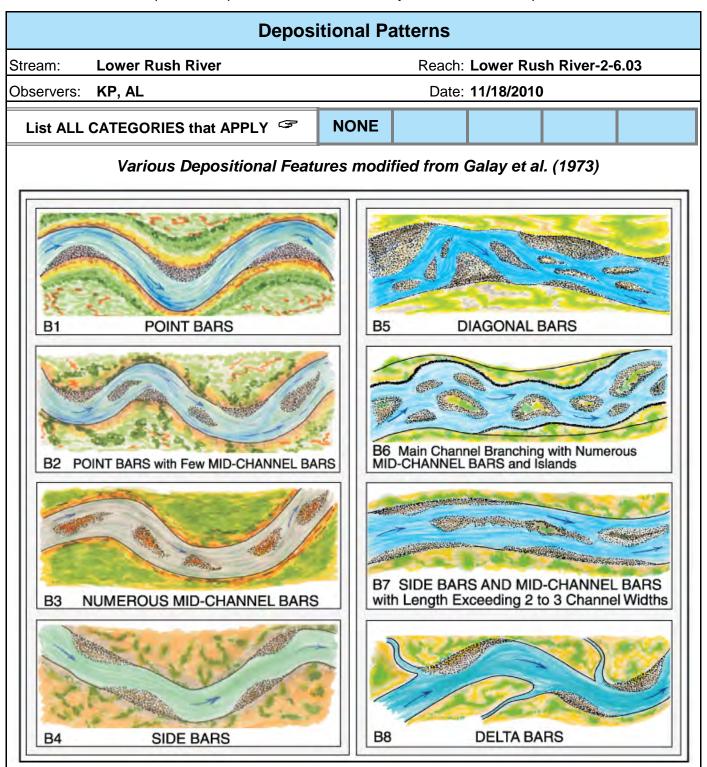
Stream Size and Order								
Stream:	Lower Rush R	iver						
Location:	Lower Rush R	iver-2-6.03						
Observers:	KP, AL							
Date:	11/18/2010							
Stream Siz	Stream Size Category and Order S-7							
Category		ZE: Bankfull dth	Check (✓) appropriate					
	meters	feet	category					
S-1	0.305	<1						
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						
	Strear	n Order						
Add categoria	as in naranthasis	for enacific etras	m order of					

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

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



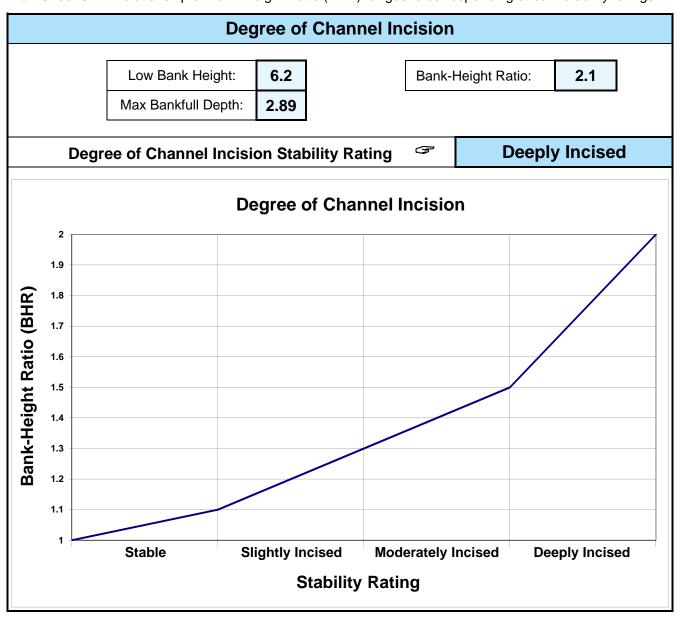
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



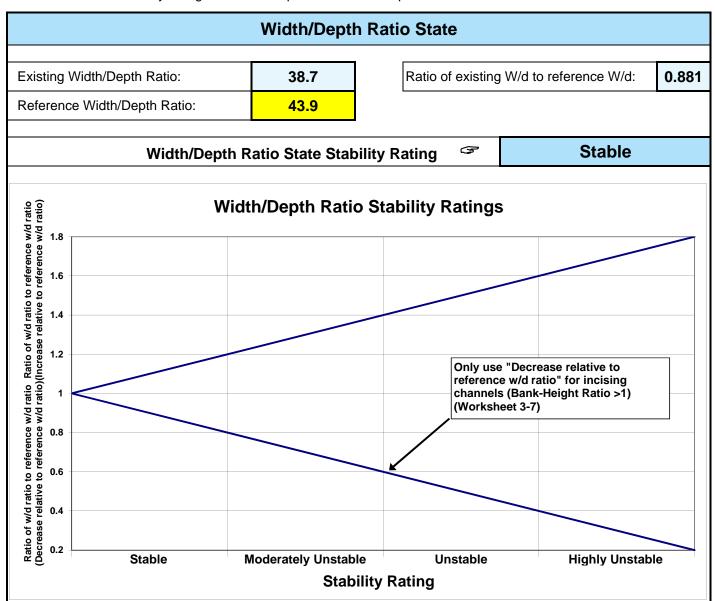
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages								
Strear	m: Lower Rusi	h River Location: Lower Rush River-2-6.03							
Obser	vers: KP, AL	Date: 11/18/2010							
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply						
D1	None	Minor amounts of small, floatable material.	▼						
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.							
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.							
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.							
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.							
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.							
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.							
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.							
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.							
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.							

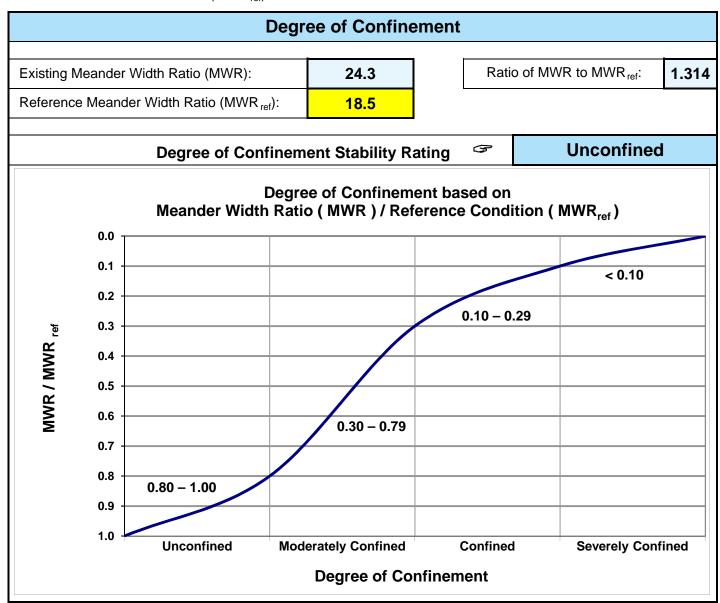
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



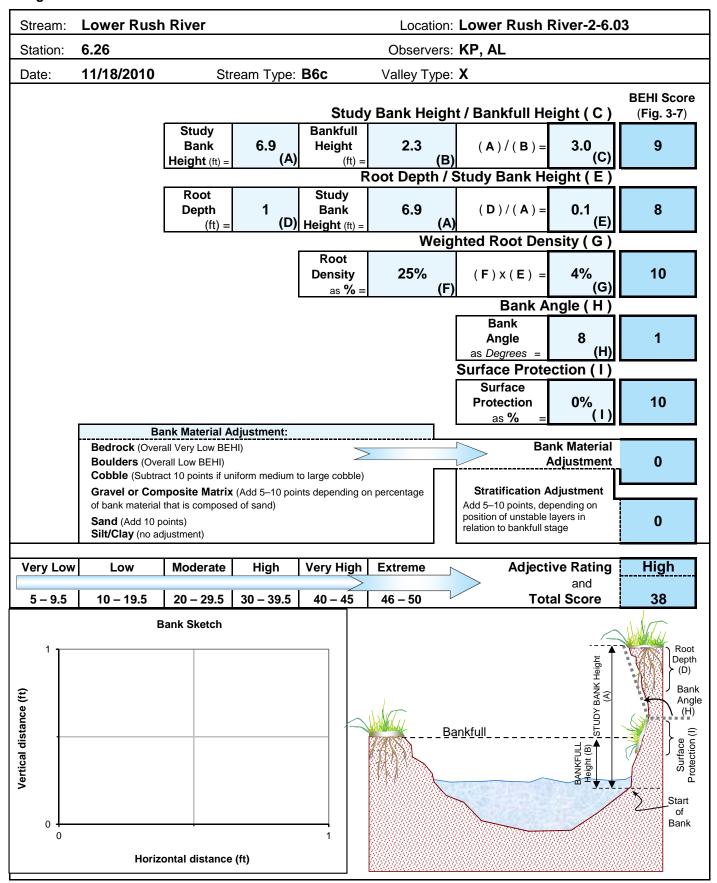
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Low	er Rus	h Riv	er			Loc	ation:	Lowe	r Rus	h Rive	er-2-6.		Valley	Type:	Χ		Obse	ervers:	KP, A	۸L				Date: 11/18/20)10
Loca-	Key	Categ	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	ney	Caley	ΙΟΙ У			Descriptio	n		Rating		D	escriptio	n		Rating			Descriptio	n		Rating			Descri	iption	Rating
(0	1	Landform slope	า	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slope gradient >		dient >	60%.	8
Upper banks	2	Mass ero	sion	No evid erosion		past or	future m	nass	3	Infreque future p		stly heale	ed over.	Low	6		uent or large, causing sediment ly yearlong.		9				sing sediment nearl t danger of same.	12		
pper	3 Debris jam potential Essentially absent from immediate channel area. Vegetative > 90% plant density. Vigor and varie				2	limbs.		ostly sma			4	larger s					6	Moderat predomi	inantly la	arger s	sizes.	8				
ס	4	Vegetative bank protection			t a deep	nsity. Vi , dense	_		3		or sugge	y. Fewer est less			6	fewer s	6 densit pecies f inuous r	rom a sl	hallow,	ınd	9		dicating	poor, c	ver species and less discontinuous and	12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	tage is no	t containe reference	d. Width/dep	oth ratio	3	common w	vith flows I rture from	ess than reference	ed; over-bank flows are a bankfull. Width/depth be width/depth ratio > 1.4. 1.3.	4
nks	6	Bank roc content	k	12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3	8
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly in			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		ely freque th high flo I filling.				6	cause b	ank eros	sion ye	and deflectors earlong. Sediment ration occurring.	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6		ant. Cut erhangs		-		12				s, some over 24" angs frequent.	16
	9	Deposition	on	Little or point ba		irgement	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba					12		Extensive deposit of predominantly fine particles. Accelerated bar development.		16	
	10	Rock angularit		surface	s rough.			е	1			rs and e th and fla	•		2	Corners dimens	s and ed ions.	lges we	ll rounde	ed in 2	3	smooth.			nensions, surfaces	4
	11	Brightnes		Genera	lly not b				1	surface	S	may hav		6 bright	2	Mixture mixture	dull and range.	d bright,	i.e., 35-	-65%	3	Predom scoured	,	0 ,	> 65%, exposed or	4
Æ	12	Consolida particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4		loose as nt overla		nt with n	10	6	No packing evident. Loo easily moved.		oose assortment,	8	
Bottom	13	Bottom s distribution		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ite chan	0%.			12	Marked material			ange. Stable	16
	14	Scouring deposition		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr	6 affecte ructions, Some fi	constri	ctions a		18				bottom in a state of yearlong.	24
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow- m may be present.	4
						Exc	ellent	total =	37				Good	total =	0				Fair	total =	0				Poor total	= 4
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stabl	_		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	67-98		Grand total =	41
Fair (Mod. u	,	44-47	44-47	91-129	96-132	96-142	81-110		46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110			108-132		99-125		Existing	
Poor (Unsta		48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+		stream type =	B6c
Stream ty	ре	DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential	DC-
Good (Stabl	le)	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				stream type =	B6c
Fair (Mod. u	ınstable	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				Modified cha	nnel
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rati	
_																	*Ra	ting is a	djusted	to poter	itial strea	ım type,	not exis	ting.	Good	
L																										

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

CIUSIUI	erosion rate.											
				ating Nea	r-Bank St		-					
		Rush Rive	r		Location:	Lower Ru	sh River-2-	6.03				
Station:	6.26			S	tream Type:	B6c		/alley Type:	Χ			
Observe	ers:	KP, AL						Date:	11/18/10			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chan	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	nissance			
(2) Ratio	of radius of	of curvature to b	ankfull width (F	R _c / W _{bkf})		Level II	General prediction					
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General _l	prediction			
(4) Ratio	of pool slo	pe to riffle slop	e (S _p / S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum d	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ_{nb}	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Veloc	city profiles						Level IV		lation			
								_				
Level	(1)											
				meander mig		ging flow		NE	35 = Extreme			
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)							
			, ,									
_					Near-Bank	l						
= =	(2)	Pool Slope	Average		Stress			inant				
Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)	I	Near-Bank Stress					
_							Very	Low				
					Near-Bank							
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress							
	` ,	S _p	S _{rif}	S _{rif}	(NBS)							
		Near-Bank			Neer Deal	l						
	/= \	Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress							
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d_{bkf}	(NBS)	Ī						
■												
Level III				Near-Bank		•	Bankfull					
Ľ	(0)	Near-Bank Max Depth	Near-Bank	Shear Stress τ_{nb} (Maan Danth		Shear Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank			
	(6)	d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	Mean Depth d _{bkf} (ft)	Average Slope S	Ib/ft ²)		Stress (NBS)			
		IID (**)	i IID	ib/it)	~0KI (11)	Giopo G	ib/it)	$ au_{ m bkf}$	(1400)			
				Near-Bank								
2	(7)	Velocity Grad	dient (ft/sec	Stress								
Level IV	(7)	/ f	t)	(NBS)	1							
_				Very Low								
		Cor	verting Va	lues to a N	Near-Bank	Stress (NE	SS) Rating					
Near-E	Bank Str	ess (NBS)				ethod numk						
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)			
	Very L		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			
	Modera		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 H	-	(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			
<u> </u>	Extren	ne	Above < 1.50 > 1.0			> 1.20	> 3.00	> 1.60	> 2.40			
			Overall Near-Bank Stress (NBS) rating Very Low									

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Stream: Lower Rush River Location: Lower Rush River-2-6.03									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4828.7	Date: 11/18/2010					
Observers:	KP, AL		Valley Type:			Stream Type:				
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	4828.7	6.9	5497	0.05			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Col	umn (7) for ead	combination	Total Erosion (ft ³ /yr)	5497					
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	204					
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	265				
	osion per unit len total length of stre	Erosion	Total Erosion (tons/yr/ft)	0.05						

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

Stream:	Lower Rus	sh River	Str	eam Type:	B6c				
Location:	Lower Rus	sh River-2-6.03	V	alley Type:	Х				
Observers:	KP, AL			Date:	11/18/2010)			
Enter Req	uired Infor	mation for Existing Condition							
	D ₅₀	Riffle bed material D ₅₀ (mm)							
	D ₅₀	Bar sample D ₅₀ (mm)							
0	D_{max}	Largest particle from bar sample	(ft)		(mm)	304.8 mm/ft			
0.00038	S	Existing bankfull water surface s	lope (ft/ft)						
0	d	Existing bankfull mean depth (ft)							
1.65	γ_{s}	Submerged specific weight of se	diment						
Select the	Appropria	te Equation and Calculate Cri	tical Dimensior	less She	ar Stress				
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7 Use	EQUATION 1: 1	t* = 0.083	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}			
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use	EQUATION 2: 1	t* = 0.038	34 (D _{max} /D ₅	₀) ^{-0.887}			
#DIV/0!	τ*	Bankfull Dimensionless Shear St	tress	EQUATIO	ON USED:	#DIV/0!			
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample									
#DIV/0!	d	Required bankfull mean depth (for	$d = \frac{\tau}{\tau}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading ☐							
Calculate Sample	Bankfull W	ater Surface Slope Required	for Entrainmen	t of Large	st Particle	in Bar			
#DIV/0!	s	Required bankfull water surface	slope (ft/ft) S =	$=\frac{\tau * \gamma_s D}{d}$	D _{max} (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading ☐	Degrading						
Sediment	Competen	ce Using Dimensional Shear S	Stress						
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (subst	itute hydraulic rad	ius, R, with	mean depth,	d)			
	$\gamma = 62.4, c$	d = existing depth, S = existing slop	е						
	Predicted	largest moveable particle size (mm) at bankfull shear	stress τ (F	igure 3-11)				
	Predicted	shear stress required to initiate mo	vement of measur	ed D _{max} (m	m) (Figure 3	-11)			
0	Predicted	mean depth required to initiate mov	vement of measure	ed D _{max} (mr	$\mathbf{d} = \frac{1}{2}$	<u></u>			
		ted shear stress, γ = 62.4, S = existing slope required to initiate movement		(mm)	<u>σ</u> -γ	<i>'</i> S			
#DIV/0!		slope required to initiate movement ted shear stress, γ = 62.4, d = exis		x (111111)	$S = \frac{\tau}{\gamma d}$				

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S																					
u b	Strea	ım:	Lowe	r Rush	River		T		Loca	tion:	Lowe	r Rush	River	-2-6.0	3		1		Date: 11/18/2010)
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒ (⇒ (
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm			
m p l	Tare v		Tare	weight	Tare weight		Tare weight		Tare weight		Tare weight		Tare weight		Tare v		Tare v	veight		URFACE ATERIAL	
e s	Sample v	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two la	DATA argest pa	rticles)
3	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	(1,00,0	argoot pu	1110100)
1																			No.	Dia.	WT.
2																			1		
3																			2		
5																			Bucket + materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials		
10																			weight		0
11																			Materials less		
12															1				than:		mm
13																				Be sure to separate n	
14																			// \	veights to	
15 Net wt	total	0		0		0		0		_		0		0		_		0	0	otal	
		#####		0 #####		#####		#####		0 #####		0 #####		#####		0 #####		#####		7	
	. % =<	#####		#####		#####		#####		#####		#####		#####	1 1 1	#####		100%		AND TO	
71000	, , ,	***************************************						***************************************						***************************************		***************************************		10070	g GR	RAND TO	IAL
S	ample lo	cation no	otes				Sar	nple loca	ation ske	etch											
								<u>'</u>													

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

Stream:	Lower Rush River	Stream Type: B6c
Location:	Lower Rush River-2-6.03	Valley Type: X
Observers:	KP, AL	Date: 11/18/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Lower Rush River Stream Type: B6c											
Location: Lower Rush Rive	er-2-6.03		Valley Ty	_{/pe:} X							
Observers: KP, AL			Da	ate: 11/18/2010							
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected						
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)						
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2						
	(2)	(4)	(6)	(8)							
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1						
	(1)	(2)	(3)	(4)							
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1						
	(1)		(3)								
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)							
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1						
(Worksheet 3-9)	(1)	(2)	(3)	(4)							
Total points											
	La	teral stability c	ategory point ra	inge							
Overall lateral stability category (use total points and check stability rating)	Stable 7 − 9 <mark>▽</mark>	Moderately unstable 10 − 12	Unstable 13 – 21 □	Highly unstable > 21 □							

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

Stream: Lower Rush River Stream Type: B6c									
Location: Lower Rush F	River-2-6.03		Valley Type:	X					
Observers: KP, AL			Date:	11/18/2010					
Vertical stability criteria	Vertical Stabi	Selected							
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	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)					
Sediment capacity (POWERSED)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheet 3- 16)	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)					
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1				
3-5)	(1)	(2)	(3)	(4)					
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1				
	(1)	(2)	(3)	(4)					
				Total points	10				
	Vertical stat		int range for exces adation	s deposition /					
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Lower Rush River Stream Type: B6c										
Location: Lower Rush	River-2-6.03		Valley Type:	X						
Observers: KP, AL			Date:	11/18/2010						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected					
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
	(2)	(4)	(6)	(8)						
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
	(2)	(4)	(6)	(8)						
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8					
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
	(2)	(4)	(6)	(8)						
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1					
3-9)	(1)	(2)	(3)	(4)						
				Total points	17					
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 3-20. Channel enlargement prediction summary.

Stream: Lower Rush River Stream Type: B6c										
Location: Lower Rush Ri	ver-2-6.03		Valley Type:	Х						
Observers: KP, AL			Date:	11/18/2010						
Channel enlargement	Char	Selected								
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)					
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2					
	(2)	(4)	(6)	(8)						
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2					
	(2)	(4)	(6)	(8)						
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2					
(Worksheet 3-18)	(2)	(4)	(6)	(8)						
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4					
(Workonoot o 10)	(2)	(4)	(6)	(8)						
				Total points	10					
_		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	B6c					
Lo	cation: Lower Rush Rive	er-2-6.03		Valley Type:	X	
Ob	servers: KP, AL			Date:	11/18/2010	
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points	
		Stable		1		
1	Lateral stability	Mod. unstab	ole	2	1	
•	(Worksheet 3-17)	Unstable		3	1	
		Highly unsta	able	4		
	Vertical stability	No deposition	on	1		
2	excess deposition/	Mod. depos	ition	2	1	
~	aggradation	Excess dep	osition	3	1	
	(Worksheet 3-18)	Aggradation	1	4		
	Vertical stability	Not incised		1		
3	channel incision/	Slightly inci	sed	2	2	
J	degradation	Mod. Incised	d	3	2	
	(Worksheet 3-19)	Degradation)	4		
	Channal anlargement	No increase		1		
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1	
~	3-20)	Mod. increa	se	3	•	
	<i>3 23</i> ,	Extensive		4		
	Pfankuch channel	Good: stable	e	1		
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	1	
ľ	10)				•	
	10)	Poor: unsta	ble	4		
				Total Points	6	
			Category p	oint range		
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □	

Worksheet 3-22. Summary of stability condition categories.

Stream:	Lower Rush River			Location:	Lower Rush	River-2-6.03	3
Observers:	KP, AL	Date:	11/18/2010	Stream	n Type: B6c	Valle	y Type: X
Channel Dimension	Mean bankfull depth (ft): 1.63	Mean bankfull 63 width (ft):	.11 Cross-section area (ft ²):	108.6	Width of flood- prone area (ft):	90.5	Entrenchment ratio:
Channel Pattern	Mean: MWR:	24.3 Lm/W _b		Rc/	/W _{bkf} :	3.6	Sinuosity: 1.28
	Check: Riffle/pool	☐ Step/pool ☑		Converge	nce/divergence	<u></u> Dunes/	/antidunes/smooth bed
River Profile and Bed Features	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rati	0	Slope
	bankfull 2.9 depth (ft):	(max/me	ean): 1.8		pool spacing:	Valley:	Average bankfull: 6.6E-05
	Nipanan	nt composition/density:	Potential composit	tion/density:	Remarks	s: Condition, vig	or and/or usage of existing reach:
	vegetation						
	Flow E1, 2, Stream regime: 9 and or	3-/	Meander pattem(s):	M1	Depositional pattern(s):	NONE	Debris/channel blockage(s):
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.1 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective rating	g): G00d
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	43.9 Width/dept (W/d) / (W/		te 0.9		tio state y rating: Stable
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of one (MWR / MV		nt 1.3		MWR _{ref} y rating: Unconfined
Bank Erosion	Length of reach	74	mbank erosion rate		Curve used:	Remarks:	
Summary	studied (ft):	265 (ton	s/yr) 0.05 (ton	ns/yr/ft)	Fig 3-9		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	capacity	Remark	s: 	
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :		sting Required slope _{bkf} :
Successional Stage Shift	→ -	→	→		Existing stre state (type)		6c Potential stream state (type):
Lateral Stability	▼ Stable □	Mod. unstable	Unstable	□ High	ly unstable	emarks/cause	es: None
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	emarks/cause	es: None
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degr	adation	emarks/cause	es: None
Channel Enlargement	✓ No increase □	Slight increase	Mod. increase	☐ Exte	nsive	emarks/cause	S: None
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High 🔲 Very hi	gh	ks/causes:	lone	

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

Riparian Vegetation								
Stre	eam: Maple	River		Location: Maple River-1-0.78				
Observers: KP, AL			Reference reach	Disturbed (impacted reach) Date: 11/16/2010				
spe	sting cies nposition:			Potential species composition:				
Riparian cover categories Cover*		Percent of site coverage**	Species composition Percent of total species composition					
1. Overstory	Canopy layer	5%	1%					
	ı			100%				
2. Understory	Shrub layer		58%					
				100%				
level	Herbaceous		36%					
3. Ground level	Leaf or needle litter			Remarks: Condition, vigor and/or usage of existing reach:				
	Bare ground		5%					
	ed on crown closure. sed on basal area to	surface area.	Column total = 100%					

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

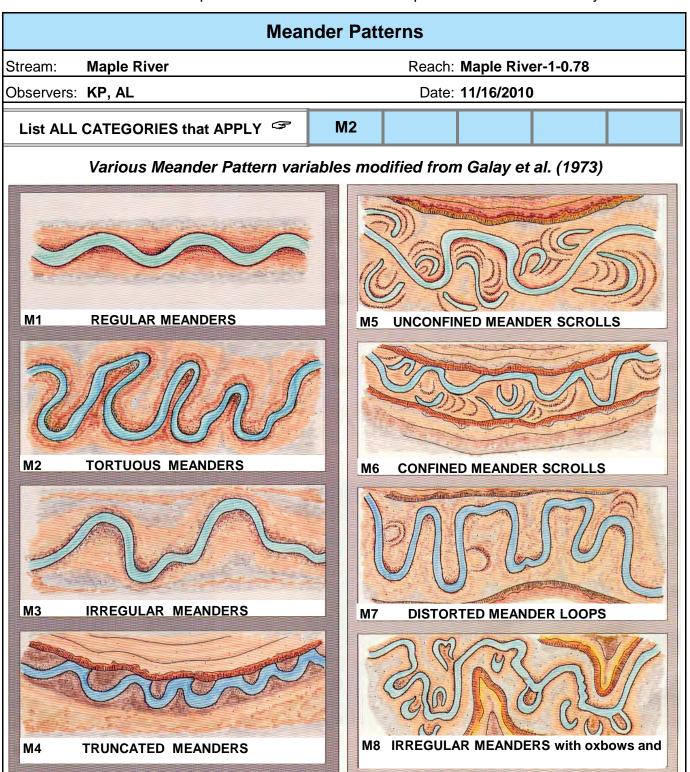
	FLOW DECIME								
FLOW REGIME									
Stream:	Maple River Location: Maple River-1-0.78								
	Observers: KP, AL Date: 11/16/2010								10
	List ALL COMBINATIONS that P1 P2 P7 P9								
APF	APPLY								
General C	General Category								
E	Ephemeral stream channels: Flows only in response to precipitation								
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.								
ı	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.								
Р	Perennial stream channels: Surface water persists yearlong.								
Specific Category									
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.								
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.								
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.								
4	Streamflow regulated by glacial melt.								
5	Ice flows/ice torrents from ice dam breaches.								
6	Alternating flow/backwater due to tidal influence.								
7	Regulated streamflow due to diversions, dam release, dewatering, etc.								
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.								
9	Rain-on-snow generated runoff.								

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

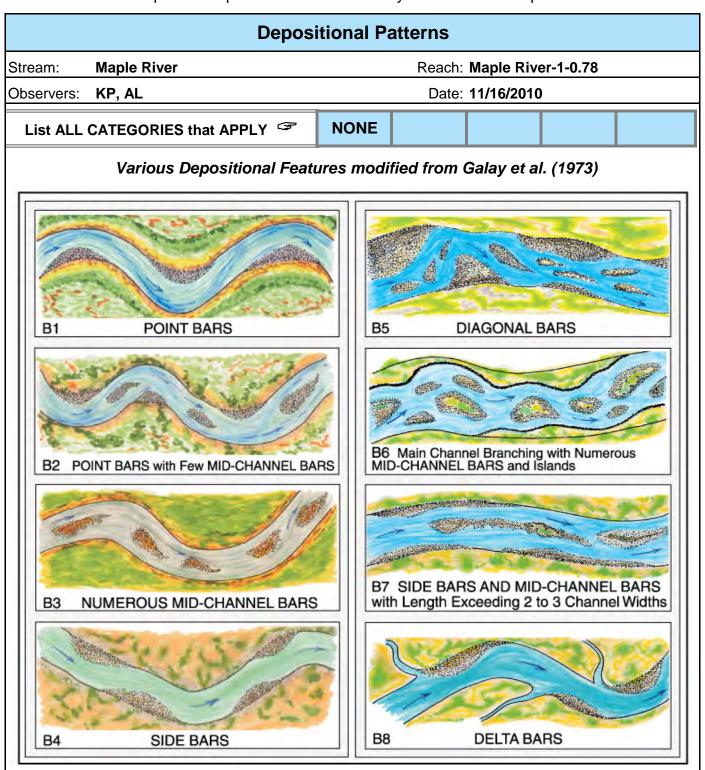
Stream Size and Order						
Stream: Maple River						
Location:	Location: Maple River-1-0.78					
Observers: KP, AL						
Date: 11/16/2010						
Stream Size Category and Order 🤝 S-6						
Category	STREAM SIZ	Check (✓) appropriate				
	meters	feet	category			
S-1	0.305	<1				
S-2	0.3 – 1.5	1 – 5				
S-3	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						

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

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



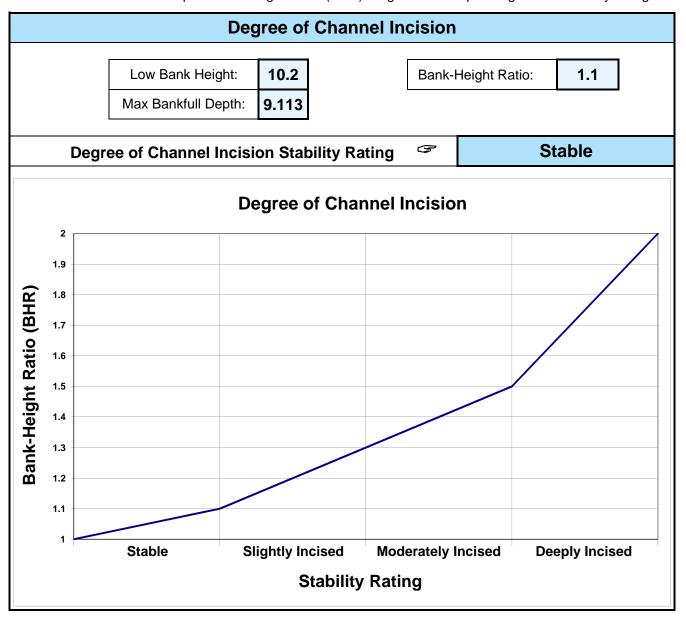
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



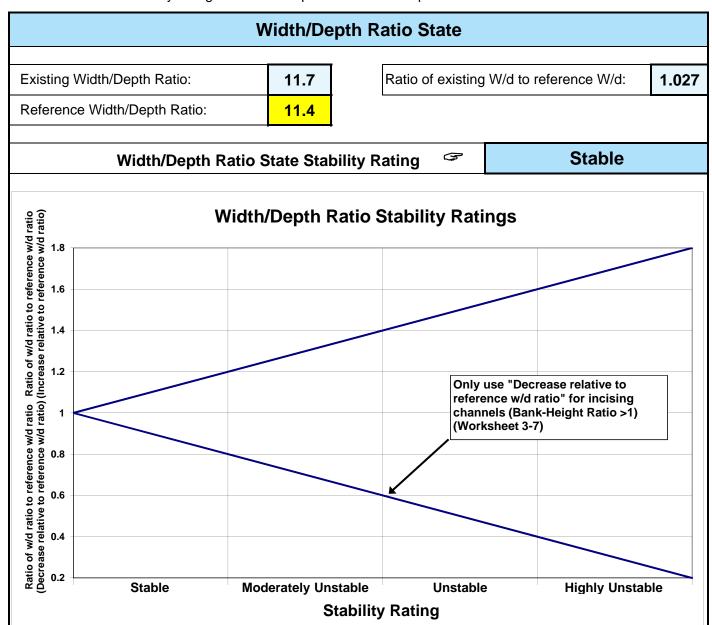
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages										
Strear	m: Maple Rive	Location: Maple River-1-0.78								
Obser	rvers: KP, AL	Date: 11/16/2010								
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply							
D1	None	Minor amounts of small, floatable material.	₹							
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.								
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.								
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.								
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	>							
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.								
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.								
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.								
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.								
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.								

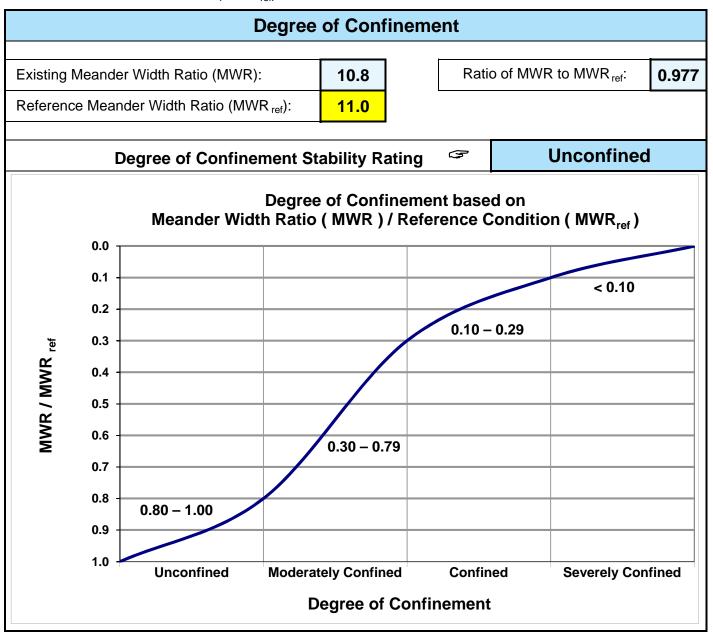
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



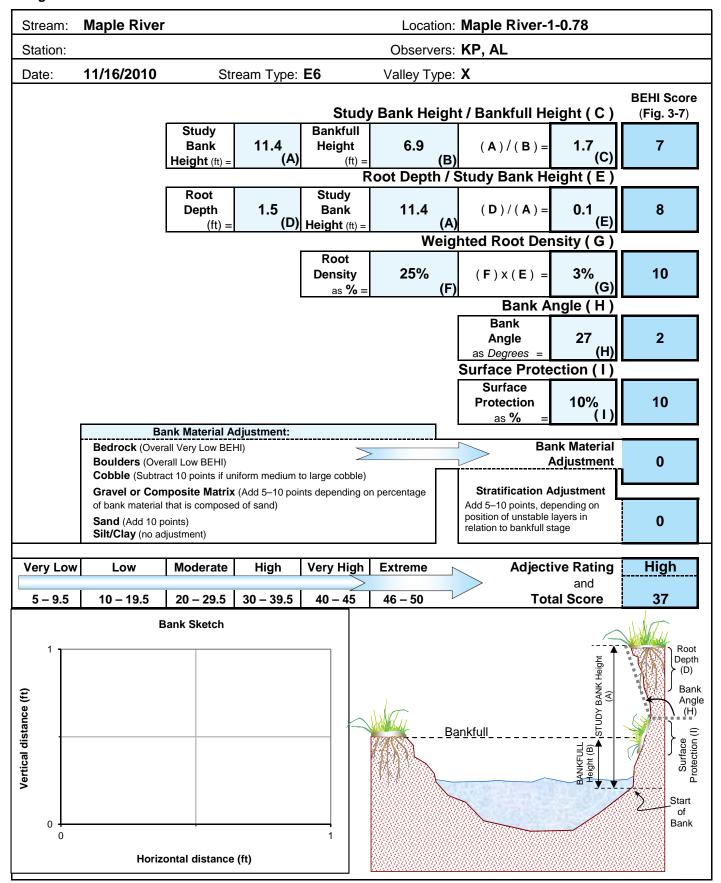
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Mapl	le Rive	r				Loc	ation:	Maple	e Rive	r-1-0.	78		Valley	Type:			Obse	ervers:	KP, A	\L				Date: ='WS	3-1'	!N6														
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor																
tion	Ney	Calego	OI y			Descriptio	n		Rating			Description	n		Rating		[Description	n		Rating		[Descri	otion		Rating														
(0	1	Landform slope		Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradie	ent >	60%.		8														
banks	2	Mass eros	SION	No eviderosion.		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or lar		ing sedi	ment	9				sing sediment r danger of sam		12														
Upper	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma	_		4	larger s	sizes.	-	ounts, m	-	6	Moderate predomin	nantly lar	ger si	zes.		8														
D	4	Vegetative bank protection		> 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass.		3		or sugg	y. Fewer est less			6	fewer s	6 densit pecies f inuous r	rom a sl		nd	9	<50% density plus few vigor indicating poor, of shallow root mass.		oor, d			12																	
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from			Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/dep width/dep (BHR) = 1	th ratio	3	common w	th flows les ure from re	ss than eference	d; over-bank flows bankfull. Width/dep e width/depth ratio .3.	:h	4														
nks	6	Bank rock content	nt 12"+ common. 2 cobbles 6–12". 4 class. 6 or less.				1–3"	8																																	
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	Frequent obstructions cause bank erosion ye traps full, channel migr		cause bank erosion y		on ye	arlong. Sedime		8												
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	_			" high. F ughing e		12															Almost continuous cuts, high. Failure of overhand				"	16
	9	Depositio	n	Little or point ba		irgement	t of char	nnel or	4	Some r coarse		increase	, mostly	y from	8		arse sar		new gra I and so		12		extensive deposit of predominantly fine articles. Accelerated bar development.			16															
	10	Rock angularity		Sharp edges and corners. Plane surfaces rough.			е	1			rs and e	•		2	Corners dimens		lges we	l rounde	ed in 2	3	Well roui smooth.	nded in a	all dim	ensions, surfac	es	4															
	11	Brightnes	s	General	lly not b					surface	S.	may hav		% bright	2	mixture	range.		i.e., 35-		3	Predominantly bright scoured surfaces.			> 65%, exposed	or	4														
Ē	12	Consolidati particles		overlap	ping.	tightly pa			2	overlap	ping.	ked with			4	appare	nt overla	ар.	nt with n		6	easily mo	packing evident. Loose assortment, ily moved.		i,	8															
Bottom	13	Bottom siz		No size material	_	e evident 0%.	. Stable		4	50–80%	, o.	t light. S		aterial	8	materia	ls 20–5	0%.	es. Stat		12	Marked of materials			ange. Stable		16														
	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions ar	d. Scour nd where depositi	grades		12	at obstr		constri			18	More tha flux or ch			oottom in a stat earlong.	e of	24														
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo ater. Sea rocks sl	sonal a	stly in Igae gro	wth	3				or absent. Yel m may be pres		4														
						Exc	ellent	total =	21				Good	total =	14				Fair	total =	27				Poor to	tal =	4														
Stream typ	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	ĺ		Ī															
Good (Stable			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		67-98		Grand tota	=	66														
Fair (Mod. ur	nstable	44-47	14-47	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	108-132 108-132 99-125 Existing			E6																
Poor (Unstat			48+ DA4	130+ DA5	133+ DA6	143+ E3	111+ E4	59+ E5	59+ E6	79+ F1	85+ F2	89+ F3	79+ F4	62+ F5	62+ F6	106+ G1	111+ G2	111+ G3	106+ G4	133+ G5	133+ G6	133+	126+		stream typ *Potential	# =															
Stream typ Good (Stable			40-63	40-63	40-63	40-63	E4 50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107	90-112					stream typ	e =_	E 6														
Fair (Mod. ur	nstable	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				Modified	chan	nel														
Poor (Unstat	ble)		87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability		g =														
																	*Ra	ting is a	djusted t	to poten	tial strea	m type, r	ot existi	ng.	Fa	ir															

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

CIUSIUII	erosion rate.												
			Estim	ating Nea	r-Bank St	ress (NB	S)						
Stream:	•	River				Maple Riv	er-1-0.78						
Station:	0			S	tream Type:	E6	\	/alley Type:	X				
Observe	rs:	KP, AL	Date: 11/16/10 Methods for Estimating Near-Bank Stress (NBS)										
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)						
(1) Chanr	nel pattern	transverse ba	or split channe	el/central bar cr	eating NBS		Level I	Recona	issance				
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})		Level II	General prediction						
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction				
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction				
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction				
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction				
(7) Veloci	ty profiles						Level IV		lation				
11													
Levell	(1)												
				meanuer mig		girig now		INE	S = EXHEIRE				
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress								
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)								
_					Near-Bank				_				
e I	(3)	Pool Slope	Average		Stress			inant	Ī				
Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress					
_							Very	Low					
		D 101	D:(() O)	Datia C /	Near-Bank								
	(4)	Pool Slope S _p	Riffle Slope S _{rif}	Ratio S _p / S _{rif}	Stress (NBS)								
		Фр	Onr	o _{lii}	(NBC)								
		Near-Bank			Near-Bank								
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress								
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d_{bkf}	(NBS)								
≡													
Level III				Near-Bank			Bankfull						
Ľ	(6)	Near-Bank Max Depth	Near-Bank	Shear Stress τ_{nb} (Maan Danth	A	Shear Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank				
	(6)	d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	Mean Depth d _{bkf} (ft)	Average Slope S	Ib/ft ²)	$\tau_{\rm bkf}$	Stress (NBS)				
		- 110 (7	. 110	10/10	DNI (**)	C.0p0 C	15/11	- DKI	(11,50)				
				Near-Bank									
Level IV	(7 \	Velocity Grad	lient (ft / sec	Stress									
eve	(7)	/ f	t)	(NBS)	1								
7				Very Low									
		Cor	verting Va	lues to a N	Near-Bank	Stress (NF	SS) Rating						
Near-B	ank Str	ess (NBS)				ethod numb							
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)				
	Very Lo	ow	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				
	Modera		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						
	Very Hi	-	(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				
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40				
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low				

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	tream: Maple River Location: Maple River-1-0.78									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	5624.5		Date:	11/16/2010			
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E6			
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	5624.5	11.4	10580	0.09			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosion	n subtotals in Col	umn (7) for ead	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	10580				
Convert eros	sion in ft ³ /yr to yd	Total Erosion (yds³/yr)	392							
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	509				
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.09				

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

Stream:	Maple Rive	er	S	Stream Type:	E6					
Location:	Maple Rive	er-1-0.78		Valley Type:	Х					
Observers:	KP, AL			Date:	11/16/2010)				
Enter Req	uired Infor	mation for Existing Co	ondition							
	D ₅₀	Riffle bed material D_{50} ((mm)							
	D ₅₀	Bar sample D ₅₀ (mm)								
	D _{max}	Largest particle from ba	ar sample (ft)		(mm)	304.8 mm/ft				
	S	Existing bankfull water	surface slope (ft/ft)							
	d	Existing bankfull mean	depth (ft)							
1.65	γ_s	Submerged specific we	ight of sediment							
Select the	Appropria	te Equation and Calcu	ılate Critical Dimensio	nless She	ar Stress					
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless	Shear Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate	Bankfull Me	an Depth Required for	Entrainment of Larges	t Particle ir	Bar Sampl	е				
#DIV/0!	d	Required bankfull mean	n depth (ft) $d = \frac{7}{2}$	$S^* \gamma_s D_{max}$	(use	D _{max} in ft)				
	Check:	□ Stable □ Aggrad								
Calculate Sample	Bankfull W	ater Surface Slope Re	equired for Entrainme	nt of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water	r surface slope (ft/ft) \$	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrad	ling □ Degrading							
Sediment	Competen	ce Using Dimensional	Shear Stress							
0	Bankfull sl	near stress τ = γdS (lbs/f	t ²) (substitute hydraulic ra	idius, R, with	mean depth,	d)				
<u> </u>	$\gamma = 62.4, c$	d = existing depth, S = exis	sting slope							
	Predicted	largest moveable particle	size (mm) at bankfull she	ar stress τ (F	igure 3-11)					
	Predicted	shear stress required to in	nitiate movement of meas	ured D _{max} (m	m) (Figure 3	-11)				
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{\sqrt{s}}$									
#DIV/0!	Predicted	τ = predicted shear stress, γ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D _{max} (mm) $\mathbf{S} = \frac{\tau}{m}$								
	τ = predic	ted shear stress, $\gamma = 62.4$, d = existing depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Side	e BAR	-BULK	MATE	RIALS	Point / Side BAR-BULK MATERIALS SAMPLE [
u b	Strea	ım:	Maple	River					Loca	tion:	Maple	River	-1-0.78	3			_		Date: 1	1/1	6/2010				
		→		→		⇒ (→		⇒ (⇒(→		→		⇒(
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve	SIZE	Sieve	SIZE							
m p	Tare		Tare	mm weight	Tare	mm veight	Tare \	mm veight	Tare v	mm veight	Tare	mm weight	Tare	mm weight	Tare	mm weight	Tare	mm weight		SURFACE					
1	10101	volgili		oigint	Taio	ioigin.	1010	oigin		voigin.	Taro	roigin	laio	roigin	1410	giit	1410	oigin			ERIAL: DATA	S			
e s	Sample v		Sample		Sample		Sample		Sample		Sample	_	Sample		Sample		Sample		(Tw		gest par	ticles)			
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.			
2																			-	1	Dia.	VV I .			
3																				2					
4																			Bucket -	+					
5																			material weight						
6																									
7																			Bucket ta weight						
9																			Material	s					
10																			weight		0				
11																			Materials I	ess					
12																			than:			mm			
14																				se	sure to a	aterial			
15																			<i>[</i>]	we	eights to g al	grand			
Net wt	. total	0		0		0		0		0		0		0		0		0	0						
		#####		#####		#####		#####		#####		#####		#####		#####		#####		~					
Accum	1. % =<	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	100%	<u> </u>	GRA	ND TO	ΓAL			
<u> </u>	amnle lo	cation no	ntes				Sar	nple loca	ation ske	etch															
	umpio io	oation no	, , , , , , , , , , , , , , , , , , ,	l			- Gai	npio ioo	ation on	31011															

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

Stream:	Maple River	Stream Type: E6
Location:	Maple River-1-0.78	Valley Type: X
Observers:	KP, AL	Date: 11/16/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Maple River Stream Type: E6											
Location: Maple River-1-0.7	78		Valley Ty	_{rpe:} X							
Observers: KP, AL			Da	ate: 11/16/2010							
Lateral stability criteria		Selected									
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)						
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2						
,	(2)	(4)	(6)	(8)							
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1						
,	(1)	(2)	(3)	(4)							
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3						
,	(1)		(3)								
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)							
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1						
(Worksheet 3-9)	(1)	(2)	(3)	(4)							
Total points											
	La	teral stability c	ategory point ra	nge	-						
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream	n: Maple River			Stream Type:	E6				
Location	on: Maple River-1-	-0.78		Valley Type:	X				
Observ	vers: KP, AL			Date:	11/16/2010				
	ical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	n / Aggradation	Selected			
categ	ose one stability gory for each rion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
1 co	ediment ompetence /orksheet 3-14)	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)				
	ediment capacity OWERSED)	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	/d ratio state /orksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
		(2)	(4)	(6)	(8)				
	ream succession ates (Worksheet 3-	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 pa	epositional atterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1			
3-	5)	(1)	(2)	(3)	(4)				
ı n	ebris / blockages /orksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	3			
		(1)	(2)	(3)	(4)				
	Total points								
		Vertical stat		int range for exces	s deposition /				
exce aggr	ical stability for ess deposition / adation (use total ts and check stability g)	No deposition 10 − 14 ✓	Moderate deposition 15 – 20 □	Excess deposition 21 – 30	Aggradation > 30				

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

Stream: Maple River Stream Type: E6											
Lo	cation: Maple River-1	-0.78		Valley Type:	X						
Ob	oservers: KP, AL			Date:	11/16/2010						
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected					
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
		(2)	(4)	(6)	(8)						
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
		(2)	(4)	(6)	(8)						
3	Degree of channel incision (BHR)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	2					
	(Worksheet 3-7)	(2)	(4)	(6)	(8)						
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2					
	·	(2)	(4)	(6)	(8)						
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
	3-9)	(1)	(2)	(3)	(4)						
					Total points	9					
Vertical stability category point range for channel incision / degradation											
d p	Pertical stability for channel incision/legradation (use total points and check stability rating)	Not incised 9 – 11 ✓	Slightly incised 12 – 18	Moderately incised 19 – 27 □	Degradation > 27 □						

Worksheet 3-20. Channel enlargement prediction summary.

Str	Stream: Maple River Stream Type: E6											
Loc	cation: Maple River-1-0).78		Valley Type:	Х							
Ob	servers: KP, AL			Date:	11/16/2010							
	channel enlargement	Char	Channel Enlargement Prediction Categories									
(c	rediction criteria choose one stability ategory for each criterion –4)	No increase	Slight increase	Moderate increase	Extensive	Selected points (from each row)						
1	Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2						
		(2)	(4)	(6)	(8)							
2	Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4						
		(2) (4)		(6)	(8)							
3	Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2						
	(Worksheet 3-18)	(2)	(4)	(6)	(8)							
4	Vertical stability incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2						
	(Workendot o 10)	(2)	(4)	(6)	(8)							
	Total points											
			Category p	ooint range								
p p	Channel enlargement rediction (use total oints and check stability ating)	No increase 8 – 10 ✓	Slight increase 11 – 16	Moderate increase 17 – 24	Extensive > 24							

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

Str	eam: Maple River			Stream Type:	E6					
Lo	cation: Maple River-1-0.	78		Valley Type:	X					
Ob	servers: KP, AL			Date:	11/16/2010					
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	/ Rating	Points	Selected Points					
		Stable		1						
1	Lateral stability	Mod. unstab	ole	2	3					
! '	(Worksheet 3-17)	Unstable		3	3					
		Highly unsta	able	4						
	Vertical stability	No deposition	on	1						
2	excess deposition/	Mod. deposi	ition	2	1					
	aggradation	Excess depo	osition	3	•					
	(Worksheet 3-18)	Aggradation	1	4						
	Vertical stability	Not incised		1						
3	channel incision/	Slightly inci	sed	2	1					
ľ	degradation	Mod. Incised	d	3	•					
	(Worksheet 3-19)	Degradation	1	4						
	Channel enlargement	No increase		1						
4	prediction (Worksheet	Slight increa	ase	2	1					
~	3-20)	Mod. increas	se	3	•					
	0 20)	Extensive		4						
	Pfankuch channel	Good: stable	е	1						
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2					
ľ	10)				_					
	. • /	Poor: unsta	ble	4						
				Total Points	8					
	Category point range									
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □					

Worksheet 3-22. Summary of stability condition categories.

Stream:	Maple River			Location: I	Maple River-1	-0.78		
Observers:	KP, AL	Date:	11/16/2010	Stream	Туре: Е6	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 5.84	Mean bankfull 68 width (ft):	.49 Cross-section area (ft ²):	399.1	Width of flood- prone area (ft):	377.25	Entrenchment ratio:	5.5
Channel Pattern	Mean: Range: MWR:	10.8 Lm/W _b	kf: 10.8	Rc/\	W _{bkf} :	2.2		2.15
	Check: Riffle/pool	 			ce/divergence	<u></u> Dunes/	antidunes/smooth bed	l
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rati	0	Slope	
Features	bankfull depth (ft): 9.1	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull:	0.00011
	Nipanan	nt composition/density:	Potential composi	tion/density:	Remarks	: Condition, vig	or and/or usage of existing	reach:
	vegetation	<u> </u>		1.			I	
	Flow P1, 2, Strear regime: 7, 9 and or	der:	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D1, 5
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	0.8 Degree of stability rat	31	anie	Modified Pfankı (numeric and a	•	· · · · · · · · · · · · · · · · · · ·	ir
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	11.4 Width/dept (W/d) / (W/		e 1.0		tio state y rating:	ble
	Meander Width Ratio (MWR):	10.8 Reference MWR _{ref} :	Degree of (MWR / MV		^{nt} 1.0		MWR _{ref} Uncory rating:	fined
Bank Erosion Summary	Length of reach studied (ft):	25	mbank erosion rate s/yr) 0.09 (tor	i: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :		sting Require slope _{bk} f: slope _{bk}	
Successional Stage Shift	→ -	→ →	→	→	Existing stre	eam E	Potential stream state (type):	E6
Lateral Stability	☐ Stable 🔽	Mod. unstable Г	Unstable	☐ Highly	y unstable	emarks/cause	S: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	emarks/cause	s: None	
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	Mod. incised	☐ Degra	adation	emarks/cause	None	
Channel Enlargement	▼ No increase □	Slight increase	Mod. increase	☐ Exten	nsive	emarks/cause	S: None	
Sediment Supply (Channel Source)	□ Low ▼	Moderate	High 🔲 Very hi	gh	ks/causes: N	one		

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

	Riparian Vegetation											
Stre	eam: Maple	River		Location: M	aple River - 2	- 11.39						
Obs	servers: KP, A		Reference reach	Disturbed (impacted reach)		11/20/2010						
spe	sting cies nposition:			Potential species composition:								
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species cor	mposition	Percent of total species composition						
1. Overstory	Canopy layer											
		<u> </u>				100%						
2. Understory	Shrub layer											
-						100%						
level	Herbaceous											
3. Ground level	Leaf or needle litter			Remarks: Condition, vigor ar usage of existing r		100%						
	Bare ground			None								
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%									

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

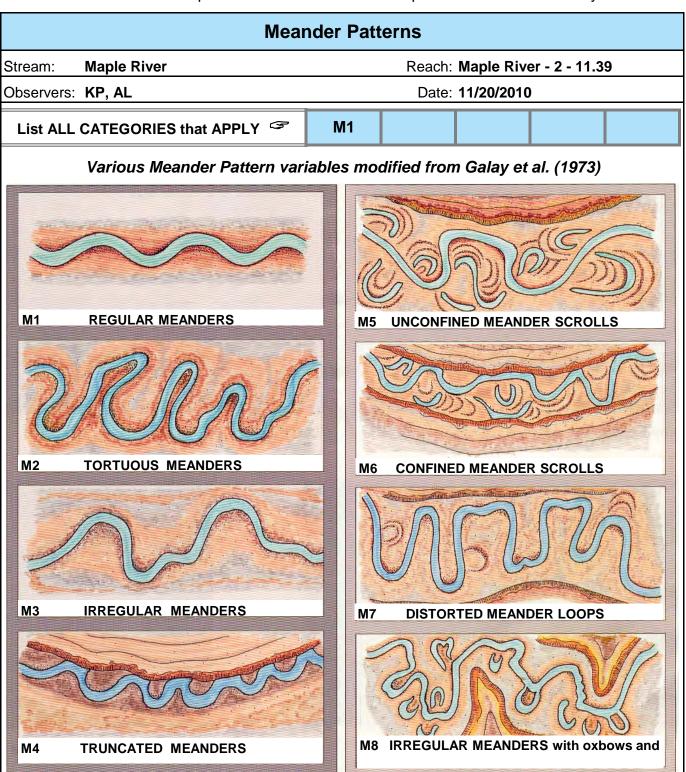
	FLOW REGIME													
Stream:	Maple River		Location:	Maple Ri	iver - 2 -	11.39								
Observers:	<u> </u>						Date:	11/20/20	10					
	COMBINATIONS that	P1	P2	P7	P9									
API	PLY													
General (General Category													
E	, , , , ,													
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.													
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology wl	here					
Р	Perennial stream channels: Surface water persists yearlong.													
Specific (Category													
1	Seasonal variation in st	treamflow	dominate	d primarily	/ by snow	melt runc	ff.							
2	Seasonal variation in st	treamflow	dominate	d primarily	/ by storn	nflow runc	off.							
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	r, etc.						
4	Streamflow regulated b	y glacial ı	melt.											
5	Ice flows/ice torrents fro	om ice da	m breache	es.										
6	Alternating flow/backwa	ater due to	o tidal influ	ence.										
7	Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ering, 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 generate	Rain-on-snow generated runoff.												

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

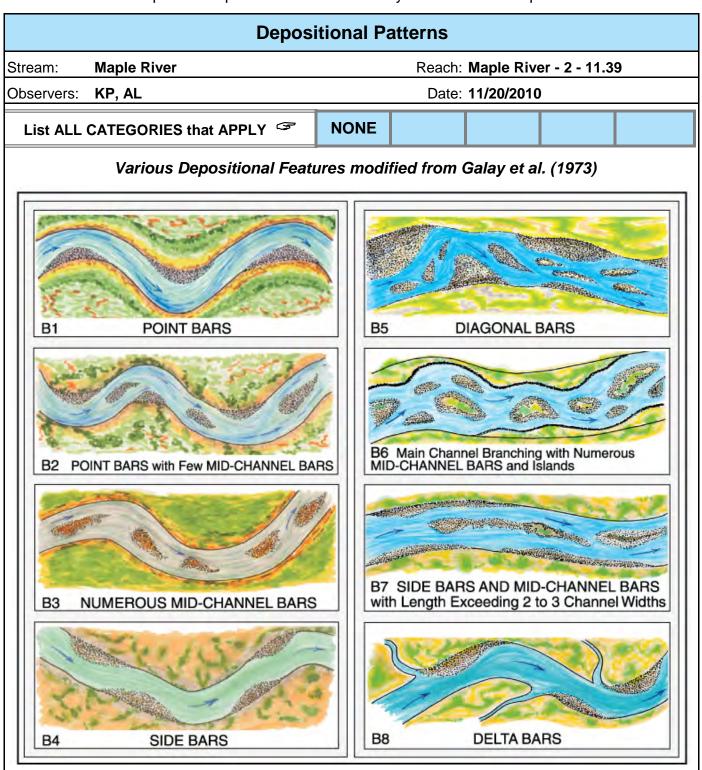
Stream Size and Order										
Stream:	Maple River									
Location:	Maple River - 2	2 - 11.39								
Observers:	KP, AL									
Date:	11/20/2010									
Stream Siz	e Category and	l Order 🍜	S-6							
Category		ZE: Bankfull dth	Check (✓) appropriate							
meters feet category										
S-1	0.305	<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								
	Strear	n Order								
Add categori	ac in naranthacic	for enacific etras	m order of							

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

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



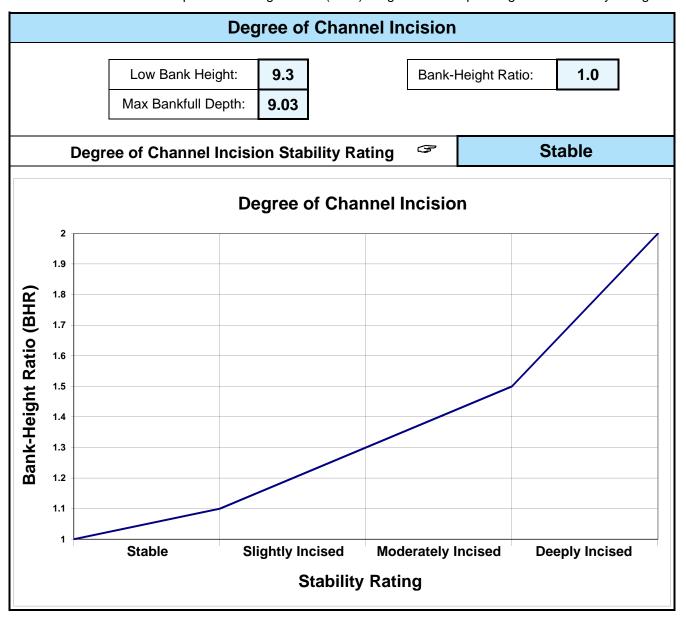
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



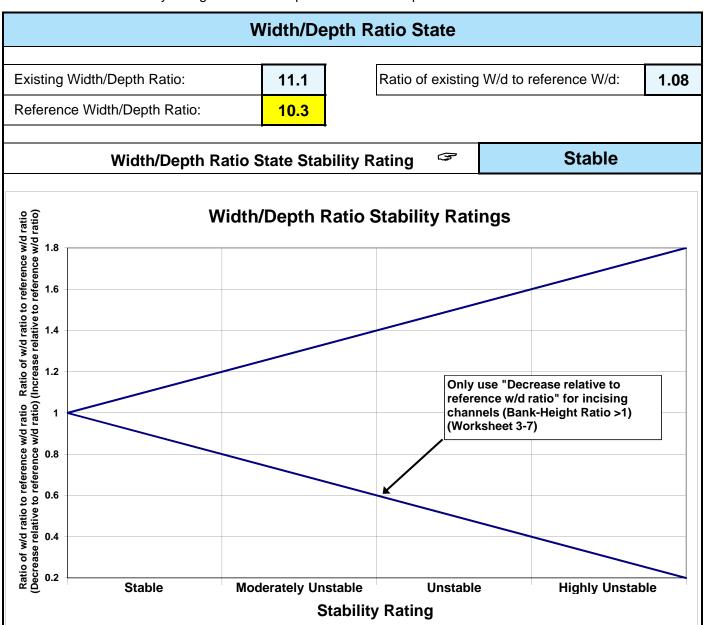
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Maple Rive	r Location: Maple River - 2 - 11.39	
Obser	rvers: KP, AL	Date: 11/20/2010	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	~
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

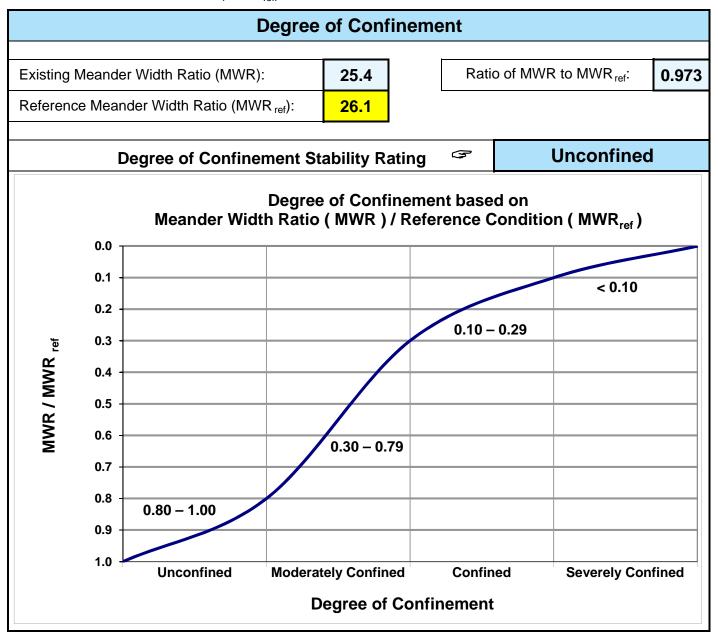
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



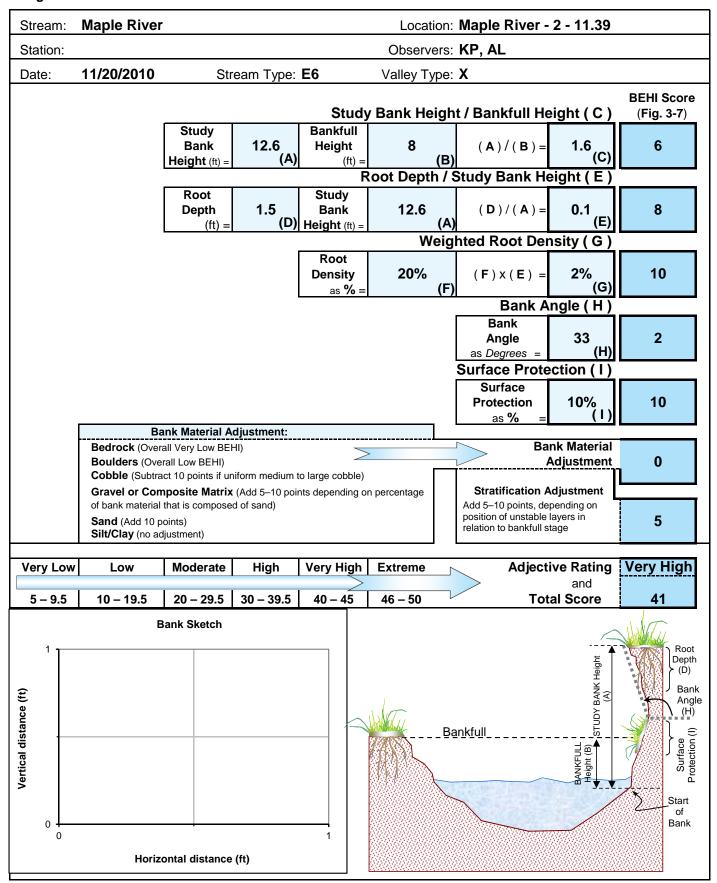
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream: Maple River Location: Maple River - 2 - 11.39 Valley Type: X Observers: KP, AL								Date: 11/20/2	010																	
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Ney	Calego	Ory			Descriptio	n		Rating			Description	n		Rating		[Description	n		Rating			Descri	ption	Rating
(0	1	Landform slope	1	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	⊢ 60%.		6	Bank slo	pe gradi	ent >	60%.	8
banks	2	Mass ero	sion	No eviderosion.		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sedi	ment	9	Frequent or large, causi yearlong OR imminent o				rly 12
Upper	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma	_		4	Moderate to heavy amounts, mostly larger sizes. 50–70% density. Lower vigor and					6	Moderate predomin	nantly la	rger s	izes.	8
)	4	Vegetativ bank protection			t a deep	nsity. Vi , dense	_		3		or sugg	y. Fewer est less			6	fewer s		rom a sl	hallow,	nd	9		icating p	oor, d	er species and les liscontinuous and	s 12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/de width/dep (BHR) = 1	th ratio	3	common w	th flows le ure from re	ss than eferenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1. .3.	. 4
nks	6	Bank rock content	k	12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	eter	6	or less.			of gravel sizes, 1–	8 8
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		th high flo		able obsti ing bank		6	cause ba	nk eros	ion ye	and deflectors arlong. Sediment ation occurring.	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	U			l" high. F ughing e		12				s, some over 24" ngs frequent.	16
	9	Depositio	n	Little or point ba		irgement	t of char	nnel or	4	Some n		increase	, mostly	y from	8		arse san		new gra d and so		12				redominantly fine bar development.	16
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rounded in all dime smooth.		smooth.		4
	11	Brightnes	ss	General	lly not b					surface	3.	may hav		% bright	2	mixture	range.		i.e., 35-	3		Predomi scoured			> 65%, exposed o	4
E	12	Consolidat particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4	appare	nt overla	ар.	nt with n		6	No packing evident. Loos easily moved.			8	
Bottom	13	Bottom si distributio		No size material	_	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable	16
	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions ar	d. Scour nd where depositi	grades		12	at obstr		constri			18	More tha flux or ch			bottom in a state ovearlong.	f 24
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				e or absent. Yellow m may be present	
						Exc	ellent	total =	21				Good	total =	14				Fair	total =	18				Poor tota	= 4
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	В5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stable			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		67-98		Grand total =	57
Fair (Mod. u	nstable	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		Existing	E6
Poor (Unstal			48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+		stream type :	
Stream tyl Good (Stable	-		DA4 40-63	DA5 40-63	DA6 40-63	E3 40-63	E4 50-75	E5 50-75	E6 40-63	F1 60-85	F2 60-85	F3 85-110	F4 85-110	F5 90-115	F6 80-95	G1 40-60	G2 40-60	G3 85-107	G4 85-107	G5 90-112	G6 85-107			-	*Potential stream type :	E6
Fair (Mod. u	nstable	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				Modified ch	annel
Poor (Unstal	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability ra	_
																	*Ra	ting is a	djusted	to poten	tial strea	m type, r	not exist	ing.	Good	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)												
			Estim	ating Nea	r-Bank St	ress (NB	S)					
Stream:	Maple	River					er - 2 - 11.3	39				
Station:	0			S	tream Type:	E6	'	Valley Type:	Х			
Observe	rs:	KP, AL						Date:	11/20/10			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chann	nel pattern	, transverse ba	r or split channe	el/central bar cr	Level I	Recona	aissance					
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum de	epth 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_{bkt}) Level III Detailed prediction												
(7) Veloci	ty profiles						Level IV		dation			
					or discontinuo							
(1) Extensive deposition (continuous, cross-channel)												
				meanuer mig		girig now		INE	S = EXHEILIG			
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)							
_					Near-Bank							
e e	(2)	Pool Slope	Average		Stress			inant				
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)			nk Stress				
_							Very	Low				
					Near-Bank							
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress							
	()	S _p	S _{rif}	S _{rif}	(NBS)							
		Near-Bank			N D 1							
		Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress							
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	•						
=												
Level III				Near-Bank			Bankfull					
Le		Near-Bank	Near-Bank	Shear			Shear	Dotio = /	Near-Bank			
	(6)	Max Depth	Slope S _{nb}	Stress τ _{nb} (Mean Depth	Average	Stress τ_{bkf} (lb/ft^2)	Ratio τ _{nb} /	Stress			
		d _{nb} (ft)	Globe Gub	ID/IT)	d _{bkf} (ft)	Slope S	ID/IT)	$ au_{bkf}$	(NBS)			
				N 5 :								
≥		Velocity Grad	dient (ft/sec	Near-Bank Stress								
Level IV	(7)	/ f		(NBS)								
Ľ				Very Low								
		Co	worting V	duec to a h	loar Donla	Stroce /NF	2C) Poting					
Near-R	ank Str	ess (NBS)	iverting va	แนะร เบ ส โ	Near-Bank M	ethod numk						
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)			
	Very Lo		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			
	Modera	ate	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 Hi	gh	(1) 1.50 – 1.80 0.81 – 1.00				2.51 – 3.00	1.20 – 1.60	2.01 – 2.40			
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40			
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Maple River			Location:	Maple River	- 2 - 11.39	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	9295		Date:	11/20/2010
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E6
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	Very High	Very Low	0.165	9295	12.6	19324	0.10
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosion	n subtotals in Col	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr) Total	19324	
Convert eros	sion in ft³/yr to yd	716					
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	930	
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.10	

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

Stream:	Maple Rive	er	S	tream Type:	E6						
Location:		er - 2 - 11.39		Valley Type:							
Observers:	KP, AL			Date:	11/20/2010)					
Enter Req	uired Infor	mation for Existing Cond	dition								
	D ₅₀	Riffle bed material D ₅₀ (mn	n)								
	D ₅₀	Bar sample D ₅₀ (mm)									
	D _{max}	Largest particle from bar s	ample (ft)		(mm)	304.8 mm/ft					
	S	Existing bankfull water sur	face slope (ft/ft)								
	d	Existing bankfull mean dep	oth (ft)								
1.65	γ_s	Submerged specific weigh	t of sediment								
Select the	Appropria	te Equation and Calcula	te Critical Dimensio	nless She	ar Stress						
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless Sh	near Stress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean de	epth (ft) $d = \frac{\tau}{2}$	' * γ _s D _{max} S	use (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading									
Calculate Sample	Bankfull W	ater Surface Slope Requ	ired for Entrainmer	nt of Large	st Particle	in Bar					
#DIV/0!	s	Required bankfull water su	urface slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading	g Degrading								
Sediment	Competen	ce Using Dimensional St	near Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²)	(substitute hydraulic ra	dius, R, with	mean depth,	d)					
	$\gamma = 62.4, c$	d = existing depth, S = existing	ig slope								
	Predicted	largest moveable particle size	e (mm) at bankfull shea	ar stress τ (F	igure 3-11)						
	Predicted	shear stress required to initia	ate movement of measu	ıred D _{max} (m	m) (Figure 3	-11)					
#DIV/0!	#DIV/0! Predicted mean depth required to initiate movement of measured D_{max} (mm) $\tau = \text{predicted shear stress}, \gamma = 62.4, S = \text{existing slope}$										
#DIV/0!	Predicted	slope required to initiate mov	rement of measured D _m	_{lax} (mm)	$S = \frac{T}{2d}$.					
	τ = predic	ted shear stress, γ = 62.4, d	= existing depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S u	Strea			River		T (I/ (LO	SAMP		Loca				- 2 - 1		ervers:	ΛP, A	<u> </u>		Date: 1	1/20/201	10
b	Olice		Mapie						2000		Mapie								Date: 1	1720720	
s a		h Pan	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	I		
m		CKET	-	mm		mm		mm		mm		mm		mm		mm		mm		SURFAC	Έ
p I	l are v	weight	rare	weight	Tare	weight	rare v	weight	Tare v	veignt	Tare v	veight	Tare v	veignt	Tare v	weight	rare v	weight		IATERIA DATA	
e s	Sample	weights	Sample	weights	Sample	weights	Sample		Sample	weights	Sample		Sample	weights	Sample	weights	Sample	weights	(Two	largest pa	articles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
2																			N	o. Dia.	WT.
3																			Ⅱ	2	
4																			Bucket +		1
5																			materials		
6																			weight		
7 8																			Bucket tar weight	е	
9																			Materials		
10																			weight		0
11 12																			Materials le than:	SS	mm
13																				Be sure to	mm o add
14																				separate weights to	material
15																				total	o grana
Net wt		0		0		0		0		0		0		0		0		0	0	7	
	and total	##### #####		##### #####		##### #####		##### #####		##### #####	_	##### #####		##### #####		##### #####	_	##### 100%		DAND T	0741
7100011	1. 70 = <	ппппп		пппппп		ппппп		пппппп		ппппп		ппппп		ппппп		ппппп		100 /6		SRAND TO	JIAL
S	ample lo	cation n	otes				Sar	nple loc	ation ske	etch											

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

Stream:	Maple River	Stream Type: E6
Location:	Maple River - 2 - 11.39	Valley Type: X
Observers:	KP, AL	Date: 11/20/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Maple River			Stream Ty	_{/pe:} E6					
Location: Maple River - 2 -	11.39		Valley Ty	_{/pe:} X					
Observers: KP, AL			Da	ate: 11/20/2010					
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected				
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)				
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2				
,	(2)	(4)	(6)	(8)					
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	В3	B5, B6, B7	1				
,	(1)	(2)	(3)	(4)					
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1				
,	(1)		(3)						
Dominant BEHI / NBS (Worksheet 3-13)	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)	(6)	(8)					
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1				
(Worksheet 3-9)	(1)	(2)	(3)	(4)					
				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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Maple River Stream Type: E6								
Location: Maple River - 2 - 11.39 Valley Type: X								
Observers: KP, AL	Date: 11/20/2010							
Vertical stability criteria	Vertical Stabi	Selected						
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	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)				
Sediment capacity (POWERSED)	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)				
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheet 3- 16)	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)				
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1			
3-5)	(1)	(2)	(3)	(4)				
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1			
·	(1)	(2)	(3)	(4)				
Total points								
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 Г	Moderate deposition 15 – 20 □	Excess deposition 21 – 30	Aggradation > 30				

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

Stream: Maple River Stream Type: E6								
Location: Maple River - 2 - 11.39 Valley Type: X								
Observers: KP, AL Date: 11/20/2010								
Vertical stability criteria (choose one stability category for each criterion 1–5)	Vertical Stabil	Selected						
	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2			
	(2)	(4)	(6)	(8)				
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2			
	(2)	(4)	(6)	(8)				
Degree of channel 3 incision (BHR)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	2			
(Worksheet 3-7)	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2			
,	(2)	(4)	(6)	(8)				
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1			
3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-20. Channel enlargement prediction summary.

Stream: Maple River Stream Type: E6												
Location: Maple River - 2	- 11.39		Valley Type:	Х								
Observers: KP, AL			Date:	11/20/2010								
Channel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected							
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)							
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2							
	(2)	(4)	(6)	(8)								
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4							
	(2)	(4)	(6)	(8)								
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2							
(Worksheet 3-18)	(2)	(4)	(6)	(8)								
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2							
(Workonoot o 10)	(2)	(4)	(6)	(8)								
				Total points	10							
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Maple River			Stream Type:	E6							
Lo	cation: Maple River - 2 -	11.39		Valley Type:	X							
Ob	servers: KP, AL			Date:	11/20/2010							
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points							
		Stable		1								
1	Lateral stability	Mod. unstab	ole	2	2							
•	(Worksheet 3-17)	Unstable		3	2							
		Highly unsta	able	4								
	Vertical stability	No deposition	on	1								
2	excess deposition/	Mod. deposi	ition	2	1							
~	aggradation	Excess depo	osition	3	'							
	(Worksheet 3-18)	Aggradation	1	4								
	Vertical stability	Not incised		1								
3	channel incision/	Slightly inci	sed	2	1							
J	degradation	Mod. Incised	d	3	1							
	(Worksheet 3-19)	Degradation	1	4								
	Channal anlargement	No increase		1								
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1							
~	3-20)	Mod. increas	se	3	•							
	<i>3 23)</i>	Extensive		4								
	Pfankuch channel	Good: stable	e	1								
5	stability (Worksheet 3-	Fair: mod ur	nstable	2	1							
ľ	10)				•							
	10)	Poor: unsta	ble	4								
				Total Points	6							
	Category point range											
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □							

Worksheet 3-22. Summary of stability condition categories.

Stream:	Maple River			L	ocation:	Maple River	· - 2 - 11.39		
Observers:	KP, AL	Dat	te: 11/20	/2010	Strean	n Type: E6	Vall	ey Type: X	
Channel Dimension	Mean bankfull depth (ft): 6.5	Mean bankfull width (ft):	72.07	Cross-section area (ft ²):	4h 4	Width of flood prone area (ff	6/7	Entrenchme ratio:	ent 9.3
Channel Pattern	Mean: Range: MWR:	25.4 Lm/\				/W _{bkf} :	3.6	Sinuosity:	1.67
	Check: Riffle/pool		Plane		onverge	nce/divergenc	e 🔽 Dune:	s/antidunes/s	
River Profile and Bed	Max Riffle	Pool Dent	h ratio	Riffle	Pool	. 55. 15	atio	Slop	
Features	bankfull 9.0 depth (ft):	·	mean):	1.4		pool spacing:	Valley:		Average bankfull: 6.9E-05
	I raparian	nt composition/density:	Po	tential composition	n/density:	Rema	rks: Condition, v	igor and/or usag	e of existing reach:
	vegetation								
	Flow P1, 2, Strear regime: 7, 9 and or	h	Meand pattern		M1	Depositional pattern(s):	NONE	Debris/char blockage(s)	117
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	stability	of incisior rating:	Stat		· · · · · · · · · · · · · · · · · · ·	adjective ratir	ng):	Good
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	10.3	10.3 Width/depth ra (W/d) / (W/d _{ref})		ate 1	1	atio state ty rating:	Stable
	Meander Width Ratio (MWR):	25.4 Reference MWR _{ref} :	26.1	Degree of co (MWR / MW		ent 1	0	/ MWR _{ref} ty rating:	Unconfined
Bank Erosion Summary	Length of reach studied (ft):	295	eambank tons/yr)	erosion rate: 0.10 (tons/	/yr/ft)	Curve used: Fig 3-9	Remarks	:	
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient c	apacity	□ Excess c	apacity	Rema	rks:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ =	1		xisting epth _{bkf} :	Requir depth _b		kisting ope _{bkf} :	Required slope _{bkf} :
Successional Stage Shift	→ -	→	_	-	→	Existing s state (type		E6 Potentia	al stream /pe):
Lateral Stability	☐ Stable 🔽	Mod. unstable	☐ Uns	table 「	High	ıly unstable	Remarks/caus	es: None	
Vertical Stability (Aggradation)	✓ No deposition	Mod. deposition	☐ Ex.	deposition [Aggr	radation	Remarks/caus	es: None	
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	☐ Mod	. incised	Degr	radation	Remarks/caus	es: None	
Channel Enlargement	▼ No increase □	Slight increase	□ Mod	. increase	□ Exte	ensive	Remarks/caus	es: None	
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High	Very high	Remar	rks/causes:	None		

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

			Riparian Ve	getation	
Stre	eam: Red R	iver		Location: Red River-1-41	0.65
	servers: KD, JI		Reference reach	Disturbed (impacted X	9/28/2011
spe	sting cies nposition: Trees	, Brush		Potential species composition:	
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
<u>~</u>				Trees	100%
1. Overstory	Canopy layer	15%	1%		
					100%
2. Understory	Shrub layer		20%	Small Shrubs	100%
_		X			100%
level	Herbaceous		10%	Grass/Weeds	100%
3. Ground level	Leaf or needle litter		0%	Remarks: Condition, vigor and/or usage of existing reach:	100%
	Bare ground		69%		
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%		

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

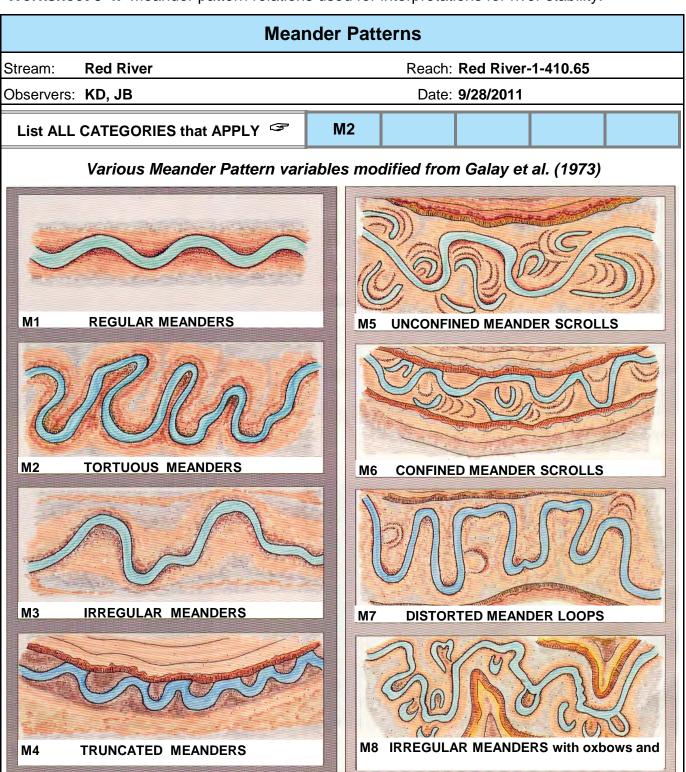
FLOW REGIME														
O.														
Stream: Observers:	Red River Location: Red River-1-410.65 KD, JB Date: 9/28/2011													
	COMBINATIONS that													
APF	PLY P1													
General Category														
E	Ephemeral stream channels: Flows only in response to precipitation													
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.													
ı	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.													
Р	Perennial stream channels: Surface water persists yearlong.													
Specific (Category													
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.													
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.													
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.													
4	Streamflow regulated by glacial melt.													
5	Ice flows/ice torrents from ice dam breaches.													
6	Alternating flow/backwater due to tidal influence.													
7	Regulated streamflow due to diversions, dam release, dewatering, etc.													
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.													
9	Rain-on-snow generated runoff.													

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

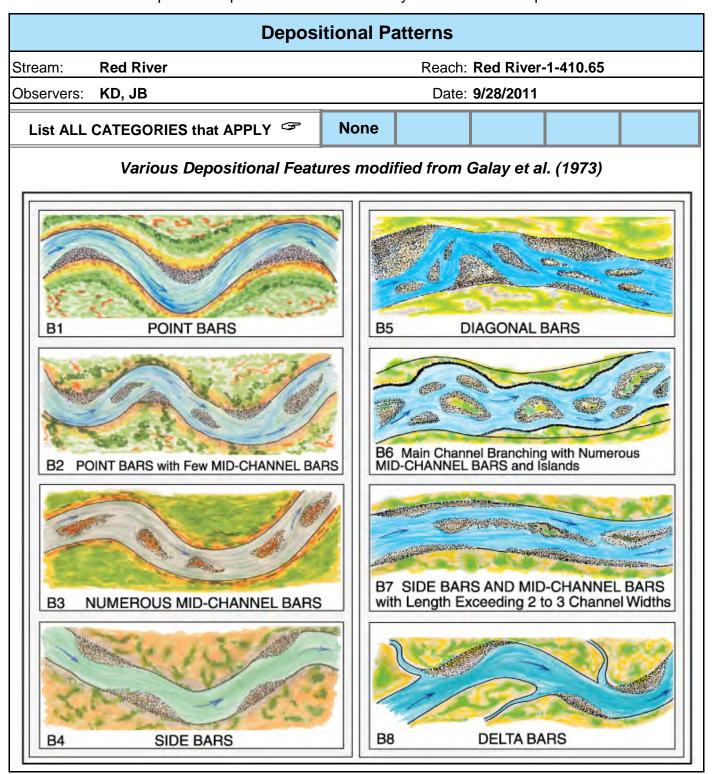
	Stream Siz	Stream Size and Order												
Stream:	Red River													
Location: Red River-1-410.65														
Observers: KD, JB														
Date: 9/28/2011														
Stream Size Category and Order S-9														
Category STREAM SIZE: Bankfull Check (width appropriate category														
	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	S-13 >305 >1000 \square													
	Stream	n Order												

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

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



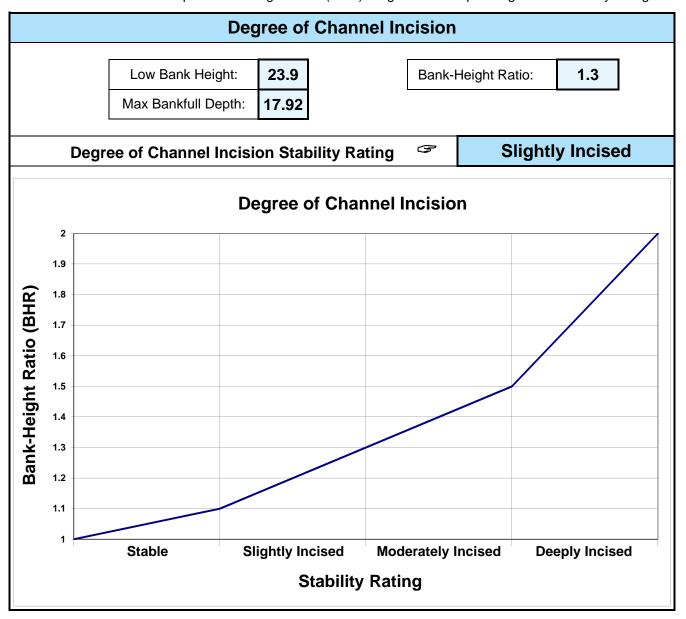
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



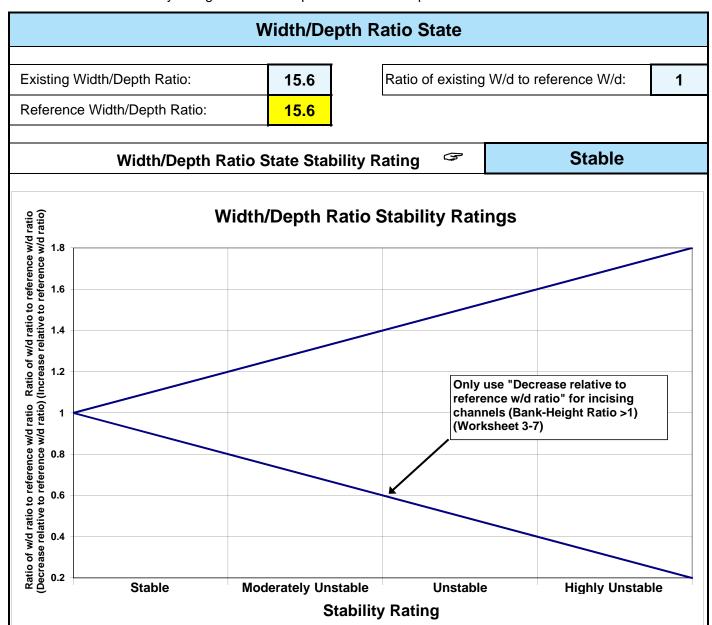
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages						
Strear	m: Red River	Location: Red River-1-410.65						
Obser	rvers: KD, JB	Date: 9/28/2011						
Desc	ription/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.						
D1	None	Minor amounts of small, floatable material.						
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	•					
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	~					
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.						
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.						
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.						
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.						
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.						
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.						
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.						

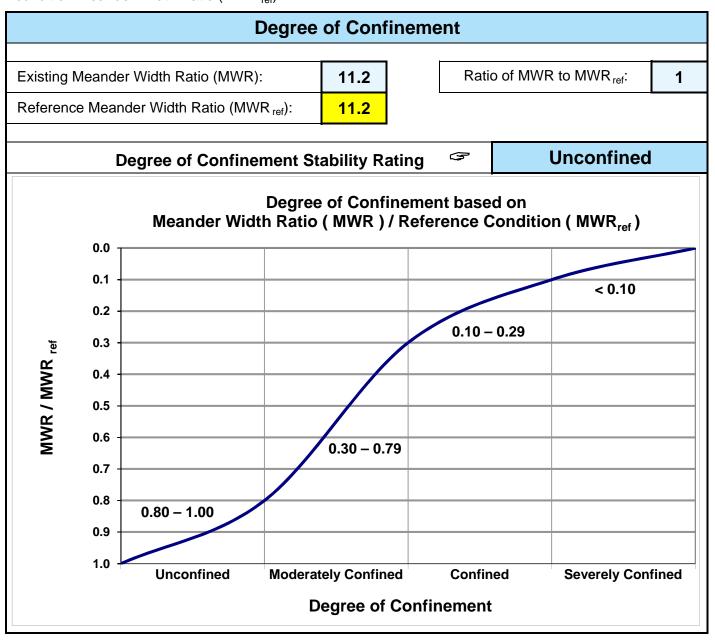
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



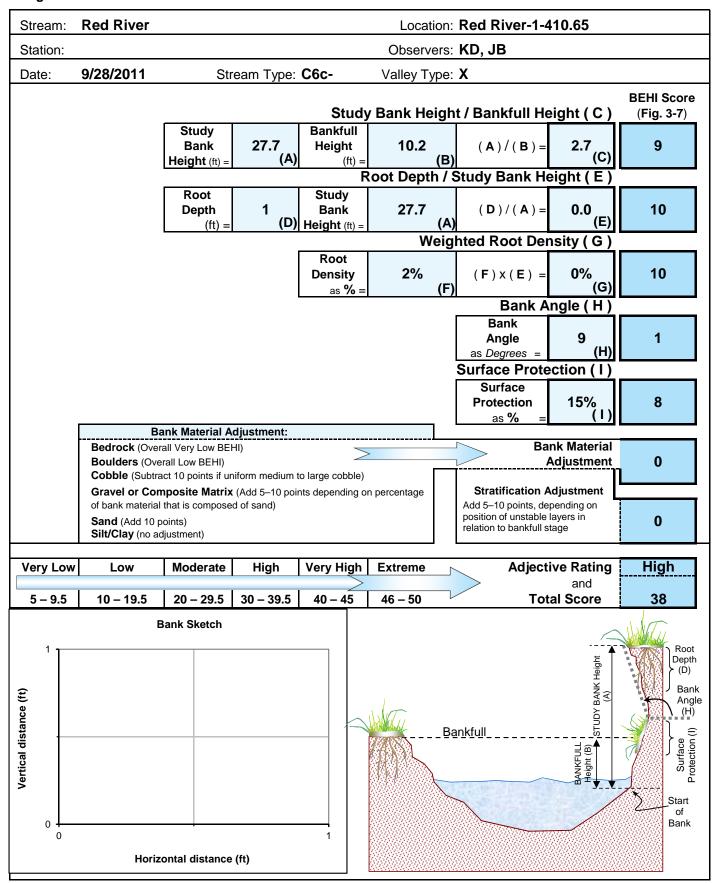
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River					Loc	ation:	Red F	River-	1-410.	.65		Valley	Type:	Χ		Obse	ervers:	KD,	JB			Date: 9/28/2011						
Loca-	Kov	Cotoo	10 m/			Exce	llent					Go	od					F	air						Poor					
tion	Key	Categ	JOI y		[Descriptio	n		Rating		D	Descriptio	n		Rating			Descriptio	n		Rating			Descri	ption	Rating				
(0	1	Landform slope	n	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe grad	lient >	60%.	8				
Upper banks	2	Mass ero	osion	No evid erosion		past or	future m	nass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9	Frequent or large, causing sec yearlong OR imminent danger				12				
pper	3	Debris ja potential		channel	l area.	ent from			2	Present, but mostly small twigs and limbs.			4	Moderate to heavy amounts, mostly larger sizes.			6	Moderat predomi	nantly la	arger s	izes.	8								
ס	4	Vegetative > 90% plant density. Vigor and variety bank suggest a deep, dense soil-binding protection root mass. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. 50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.							ınd	9		dicating p	poor, c	er species and less discontinuous and	12															
	Bank heights sufficient to contain the bankfull stage is contained within banks. Channel capacity Bank heights sufficient to contain the bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. 1.0. 1.2. Bank-Height Ratio (BHR) = 1.2. 1.4. Bank-Height Ratio (BH						oth ratio	3	common w	vith flows le	ess than referenc	ed; over-bank flows are bankfull. Width/depth ee width/depth ratio > 1.4. 1.3.	4																	
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula			2	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3"	8				
Lower banks	7	7 Obstructions to flow Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Moderately frequent, unstable obstruction move with high flows causing bank cutting and pool filling.						6	cause b	ank eros	sion ye	and deflectors earlong. Sediment ration occurring.	8																	
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6				l" high. F ughing e		12				s, some over 24" ings frequent.	16				
	9	Depositio	on	Little or point ba		argement of channel or Some new bar increase, mostly from Moderate deposition of new gravel and coarse sand on old and some						Extensive deposit of predominantly fine particles. Accelerated bar development.				16														
	10	Rock angularit		Sharp e surface:		nd corne	rs. Plan	е	1	Rounded corners and edges. Surfaces smooth and flat.				2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.		all dim	nensions, surfaces	4					
	11	Brightnes	ss	Surface Genera	,	dark or s right.	tained.		1	Mostly of surface		may hav	ve <35%	6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predominantly bright, a scoured surfaces.			> 65%, exposed or	4				
E	12	Consolida particles		Assorte overlap		tightly p	acked o	r	2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	10	6		No packing evident. Loose assortment, easily moved.		8					
Bottom	13	Bottom s distribution		No size materia	•	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable	16				
_	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18				bottom in a state of rearlong.	24				
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		tly in gae growth					3				e or absent. Yellow- m may be present.	4
						Exc	ellent	total =	21				Good	total =	12				Fair	total =	0				Poor total :	44				
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6							
Good (Stab	•		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	67-98		Grand total =	77				
Fair (Mod. u		44-47	44-47	91-129	96-132	96-142	81-110		46-58	61-78	65-84	69-88	61-78	51-61	51-61			91-110			108-132		99-125		Existing	00				
Poor (Unsta		48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+			133+	133+	126+		stream type =	C6c-							
Stream ty	ре	DA3	DA4	DA5	DA6	E3	E4	E5	E 6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential	CC-				
Good (Stab	-		40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107		90-112	85-107				stream type =	C6c-				
Fair (Mod. u	Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 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 61-78 108-120 108-120 113-125 108-120 108				nnel																									
Poor (Unsta	able)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability ration	ng =				
		_															*Ra	ting is a	djusted	to poter	itial strea	ım type,	not exis	ting.	Good					

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	rate.										
			Estim	ating Nea	r-Bank St	ress (NB	S)				
Stream:	Red Ri	ver			Location:	Red River	-1-410.65				
Station:	0			S	tream Type:	C6c-	1	/alley Type:	Χ		
Observe	rs:	KD, JB						Date:	9/28/11		
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)				
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Reconaissance			
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})	General prediction						
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction		
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction		
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction		
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction		
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation		
Levell	(1)										
د				meander mig		ging flow		NI	SO = Extreme		
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress						
	(2)	R _c (ft)	(ft)								
		<u> </u>	()	W _{bkf}	(NBS)						
					Near-Bank						
Level II	(2)	Pool Slope	Average	D # 0 /0	Stress		Dom	inant			
-ev	(3)	S_p	Slope S	Ratio S _p / S	(NBS)	Ī	Near-Bai	nk Stress			
_							Very	Low			
					Near-Bank	•			_		
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress	ess					
	(.,	S _p	S _{rif}	S _{rif}	(NBS)						
		N D 1									
		Near-Bank Max Depth	Mean Depth	<i>Ratio</i> d _{nb} /	Near-Bank Stress						
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)						
=											
Level III				Near-Bank			Bankfull				
Le		Near-Bank	Na an Danie	Shear			Shear		Near-Bank		
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Stress		
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)		
≥		Velocity Cros	dient (ft / sec	Near-Bank Stress							
Level IV	(7)	/ f		(NBS)							
Le			03	Very Low							
			Į.		J	04	10) D. (
Noar-P	ank Ct	Cor ess (NBS)	iverting Va	liues to a l	Near-Bank	Stress (NE ethod numb					
iveai-E	rating		(1)	(2)	(3)	etnoa numi (4)	(5)	(6)	(7)		
	Very Lo		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		
	Modera		N/A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80				
	High		See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.01 – 1.60 1.61 – 2.00		
	Very Hi		(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		
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
					ear-Bank S				Low		

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	Red River-1	-410.65				
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	10739.3	Date: 9/28/2011					
Observers:	KD, JB		Valley Type:		Stream Type: C6c-					
(1)	(2)	(3)	(4) Bank	(5)	(6) Study bank	(7)	(8) Erosion			
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	height (ft)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	10739.3	27.7	49084	0.22			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Colu	ımn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	49084				
Convert eros	sion in ft ³ /yr to yd:	s ³ /yr {divide T	otal Erosion (t	it ³ /yr) by 27}	Total Erosion (yds³/yr)	1818				
Convert eros by 1.3}	sion in yds ³ /yr to t	Total Erosion (tons/yr)	2363							
	osion per unit leng total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.22				

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

Stream:	Red River			Stream Type:	: C6c-						
Location:	Red River-	-1-410.65		Valley Type:							
Observers:	KD, JB			Date	9/28/2011						
Enter Req	uired Infor	mation for Existing Co	ondition								
	D ₅₀	Riffle bed material D ₅₀	(mm)								
	D ₅₀	Bar sample D ₅₀ (mm)									
0	D _{max}	Largest particle from ba	ar sample (ft)		(mm)	304.8 mm/ft					
	S	Existing bankfull water	surface slope (ft/ft)								
	d	Existing bankfull mean	depth (ft)								
1.65	γ_s	Submerged specific we	eight of sediment								
Select the	Appropria	te Equation and Calc	ulate Critical Dimens	ionless She	ar Stress						
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7	Use EQUATION 1	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	$ au^*$	Bankfull Dimensionless	s Shear Stress	EQUATION	ON USED:	#DIV/0!					
Calculate	Bankfull Me	an Depth Required for	Entrainment of Large	est Particle i	n Bar Sampl	e					
#DIV/0!	d	Required bankfull mear	n depth (ft) $d =$	$\frac{\tau * \gamma_s D_{max}}{s}$	(use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrad									
Calculate Sample	Bankfull W	ater Surface Slope Ro	equired for Entrainm	ent of Large	est Particle	in Bar					
#DIV/0!	s	Required bankfull wate	er surface slope (ft/ft)	$S = \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrad	ding □ Degrading								
Sediment	Competen	ce Using Dimensiona	I Shear Stress								
0	Bankfull sl	near stress τ = γdS (lbs/	(ft ²) (substitute hydraulic	radius, R, with	n mean depth	, d)					
	$\gamma = 62.4$, c	d = existing depth, S = exi	isting slope								
	Predicted	largest moveable particle	size (mm) at bankfull sh	ear stress τ (I	Figure 3-11)						
	Predicted	shear stress required to in	nitiate movement of mea	sured D _{max} (m	nm) (Figure 3	-11)					
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\tau = \text{predicted shear stress}, \ \gamma = 62.4, \ S = \text{existing slope}$										
#DIV/0!	Predicted	slope required to initiate r	movement of measured I	O _{max} (mm)	$S = \frac{\tau}{vd}$						
	τ = predic	ted shear stress, $\gamma = 62.4$	i, a = existing depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	TA: Size Distribution Analysis Observers: KD, JB													
u b	Strea	ım:	Red R	liver					Loca	tion:	Red R	liver-1	-410.6	5					Date: \$	9/28	/2011		
		⇒ (→ (⇒ (⇒(⇒ (⇒ (⇒ (→ (⇒ (
s a		h Pan	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve	SIZE	Sieve	SIZE		<i></i>			
m p	Tare	CKET	Tare	mm weight	Tare	mm veight	Tare \	mm	Tare v	mm	Tare	mm weight	Tare v	mm weight	Tare	mm weight	Tare	mm weight		SURFACE			
	Tare	voigni	Taic	Weight	Tare	voigni	Taro	voigili	raicv	veignt	Tare	Weight	Tare	weight	Tare	Weight	Tare	Weight			TERIAL DATA	S	
e s	Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		Sample		Sample		(Tw		rgest par	ticles)	
4	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Di-	\A/T	
2																			 	1 1	Dia.	WT.	
3																				2			
4																			Bucket	+			
5																			materia				
6																			weight				
7																			Bucket tare weight				
9																			Materia	ls			
10																			weight		()	
11																			Materials	less			
12																			than:			mm	
13																					e sure to a eparate m		
15																			1	W	eights to g tal	grand	
Net wt	. total	0		0		0		0		0		0		0		0		0	0		7		
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		<u></u>			
Accum	1. % =<	#####	\Longrightarrow	#####	\Rightarrow	#####		#####	$\qquad \qquad \longrightarrow$	#####	\longrightarrow	#####	\Longrightarrow	#####	$\qquad \qquad $	#####		100%]	GRA	AND TO	TAL	
	ample lo	action no	****				Cor	nnla laa	ation ske	atob													
	ample io	cation no	nes				Sai	ripie ioca	ation ske	elcn													

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

Stream:	Red River	Stream Type: C6c-					
Location:	Red River-1-410.65	Valley Type: X					
Observers:	KD, JB	Date: 9/28/2011					
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)					
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	☑ Stable					
	(E→C), (C→High W/d C)						
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable					
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable					

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-		
Location: Red River-1-410.	65		Valley Ty	_{/pe:} X		
Observers: KD, JB			Da	ate: 9/28/2011		
Lateral stability criteria		Lateral Stabilit	y Categories		Selected	
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)	
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2	
	(2)	(4)	(6)	(8)		
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1	
	(1)	(2)	(3)	(4)		
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3	
	(1)		(3)			
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)		
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1	
(Worksheet 3-9)	(1)	(2)	(3)	(4)		
				Total points	11	
	La	teral stability c	ategory point ra	inge		
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-		
Location: Red River-1-4	10.65		Valley Type:	X		
Observers: KD, JB			Date:	9/28/2011		
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	n / Aggradation	Selected	
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)	
Sediment 1 competence (Worksheet 3-14)	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)		
Sediment capacity (POWERSED)	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)		
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2	
	(2)	(4)	(6)	(8)		
Stream succession 4 states (Worksheet 3- 16)	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)		
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1	
3-5)	(1)	(2)	(3)	(4)		
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1	
	(1)	(2)	(3)	(4)		
				Total points	10	
	Vertical stat		int range for exces adation	s deposition /		
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River			Stream Type:	C6c-		
Location: Red River-1-4	410.65		Valley Type:	X		
Observers: KD, JB			Date:	9/28/2011		
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected	
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)	
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
	(2)	(4)	(6)	(8)		
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
	(2)	(4)	(6)	(8)		
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4	
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)		
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4	
	(2)	(4)	(6)	(8)		
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1	
3-9)	(1)	(2)	(3)	(4)		
				Total points	13	
	Vertical stab	ility category poi degra	nt range for chan dation	nel incision /		
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 3-20. Channel enlargement prediction summary.

Stream: Red River			Stream Type:	C6c-	
Location: Red River-1-41	0.65		Valley Type:	X	
Observers: KD, JB			Date:	9/28/2011	
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2
	(2)	(4)	(6)	(8)	
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4
	(2)	(4)	(6)	(8)	
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2
(Worksheet 3-18)	(2)	(4)	(6)	(8)	
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4
(Workshoot o 15)	(2)	(4)	(6)	(8)	
				Total points	12
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Red River			Stream Type:	C6c-		
Lo	cation: Red River-1-410.	.65		Valley Type:	X		
Ob	servers: KD, JB			Date:	9/28/2011		
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points		
		Stable		1			
1	Lateral stability	Mod. unstab	ole	2	3		
'	(Worksheet 3-17)	Unstable		3	3		
		Highly unsta	able	4			
	Vertical stability	No deposition	on	1			
2	excess deposition/	Mod. deposi	ition	2	1		
	aggradation	Excess depo	osition	3	1		
	(Worksheet 3-18)	Aggradation	1	4			
	Vertical stability	Not incised		1			
3	channel incision/	Slightly inci	sed	2	2		
٦	degradation	Mod. Incised	d	3	2		
	(Worksheet 3-19)	Degradation	1	4			
	Channal anlargement	No increase		1			
4	Channel enlargement prediction (Worksheet	Slight increa	2				
"	3-20)	Mod. increas	se	3	2		
	3-20)	Extensive		4			
	Pfankuch channel	Good: stable	e	1			
5	stability (Worksheet 3-	Fair: mod ur	nstable	2	1		
ľ	10)				•		
	10)	Poor: unsta	ble	4			
				Total Points	9		
			Category p	oint range			
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □		

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River			Location:	Red River-1-4	10.65			
Observers:	KD, JB	Date:	9/28/2011	Stream	n Type: C6c-	Valley Type: X			
Channel Dimension	Mean bankfull depth (ft): 11.9	Mean bankfull width (ft):	5.2 Cross-section area (ft ²):	n 2157	Width of flood- prone area (ft):	683.3333	Entrenchment ratio: 3	.7	
Channel Pattern	Mean: Range: MWR:	11.2 Lm/W _b	kf: 11.2	Rc/	W _{bkf} :	2.3	Sinuosity: 1.96	5	
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converger	nce/divergence	<u></u> Dunes/	antidunes/smooth bed		
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rati	0	Slope		
Features	bankfull depth (ft): 17.9	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull: 6.	3E-05	
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remarks	: Condition, vig	or and/or usage of existing read	:h:	
	vegetation								
	Flow P1, 2, Stream regime: 7, 9 and o	rder:	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	biockage(s):	2, 3	
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.3 Degree of stability rat	ing:	ly iliciseu	Modified Pfankı (numeric and a	djective rating	g):		
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	th ratio stat //d _{ref}):	te 1.0		tio state Stable y rating:	ting:		
	Meander Width Ratio (MWR):	11.2 Reference MWR _{ref} :	Degree of (MWR / M	confineme WR _{ref}):	nt 1.0	I	MWR _{ref} Unconfin vating:	ed	
Bank Erosion	Length of reach	11111	mbank erosion rate	- I					
Summary	studied (ft):	2363 (ton	s/yr) 0.22 (to	ns/yr/ft)	Fig 3-9				
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Exces	s capacity	Remark	S: 			
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Required depth _{bkf} :		sting Required pe _{bkf} : slope _{bkf} :		
Successional Stage Shift	→ -	→	→	→	Existing stre	eam Co	Potential stream state (type):	C6c-	
Lateral Stability	☐ Stable 	∙ Mod. unstable Γ	Unstable	☐ Highl	ly unstable	emarks/cause	S:		
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	emarks/cause	s:		
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degr	adation	emarks/cause	S:		
Channel Enlargement	☐ No increase №	Slight increase	Mod. increase	☐ Exter	nsive	emarks/cause	S:		
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very h	igh	ks/causes:				

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

			Riparian Ve	getation							
Stre	eam: Red R	iver		Location: Red River-2-419.14							
	servers: KD, JI		Reference reach	I I (impacted X II							
spe	sting cies nposition: Trees	, Shrubs		Potential species composition:							
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species	oosition	Percent of total species composition					
Z.				Trees			100%				
Overstory	Canopy layer	40%	2%								
ŏ.		1070	= 73								
_											
							100%				
ory				Nettles Small shrub	S		10% 90%				
Understory	Shrub layer		15%								
			10,0								
2.											
_							100%				
				Grass, weed	ls		100%				
	Llorbossous		400/								
	Herbaceous		10%								
evel											
nd i							100%				
Ground leve	Leaf or needle litter		0%	Remarks:							
3.				Condition, vigo usage of existing							
	Bare ground		73%								
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%								

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

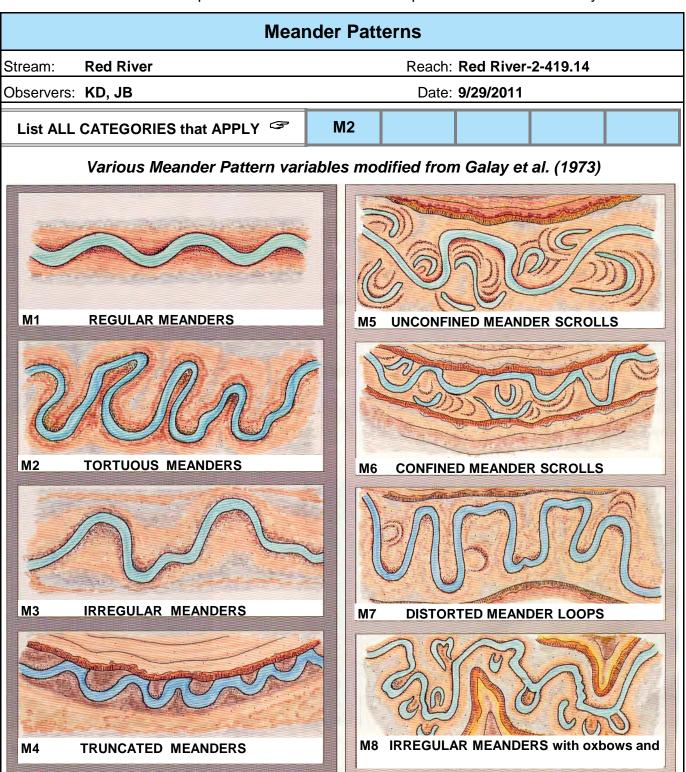
	FLOW REGIME									
Stream:	Red River Location: Red River-2-419.14									
Observers:	KD, JB Date: 9/29/2011									
List ALL	COMBINATIONS that P1 P2 P7 P9									
APPLY										
General Category										
E	Ephemeral stream channels: Flows only in response to precipitation									
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.									
ı	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.									
Р	Perennial stream channels: Surface water persists yearlong.									
Specific (Category									
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.									
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.									
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.									
4	Streamflow regulated by glacial melt.									
5	Ice flows/ice torrents from ice dam breaches.									
6	Alternating flow/backwater due to tidal influence.									
7	Regulated streamflow due to diversions, dam release, dewatering, etc.									
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.									
9	Rain-on-snow generated runoff.									

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

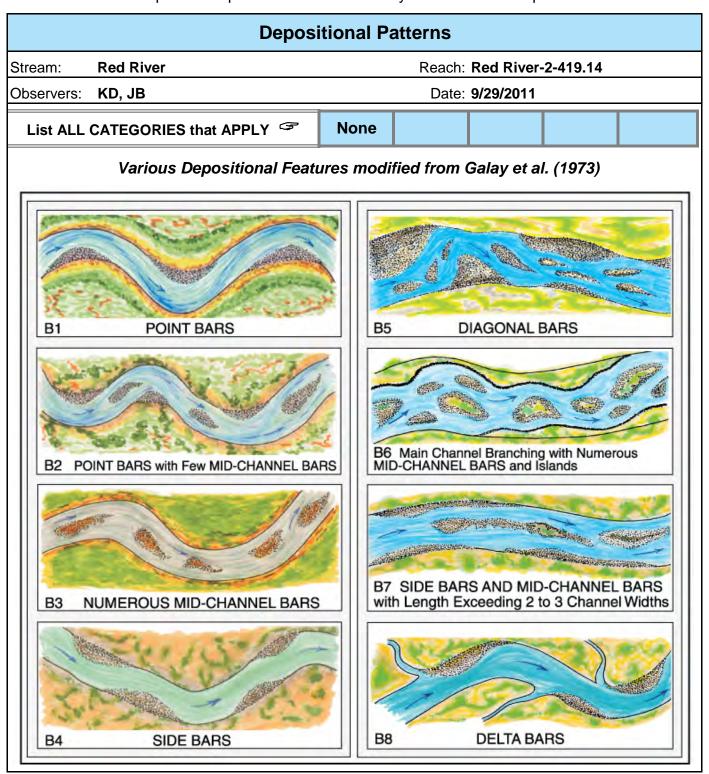
	Stream Size and Order									
Stream: Red River										
Location: Red River-2-419.14										
Observers:	KD, JB									
Date:	9/29/2011									
Stream Size Category and Order S-9										
Category	Category STREAM SIZE: Bankfull width									
	meters	feet	category							
S-1	0.305	<1								
S-2	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								
	Strear	n Order								
A d d										

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

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



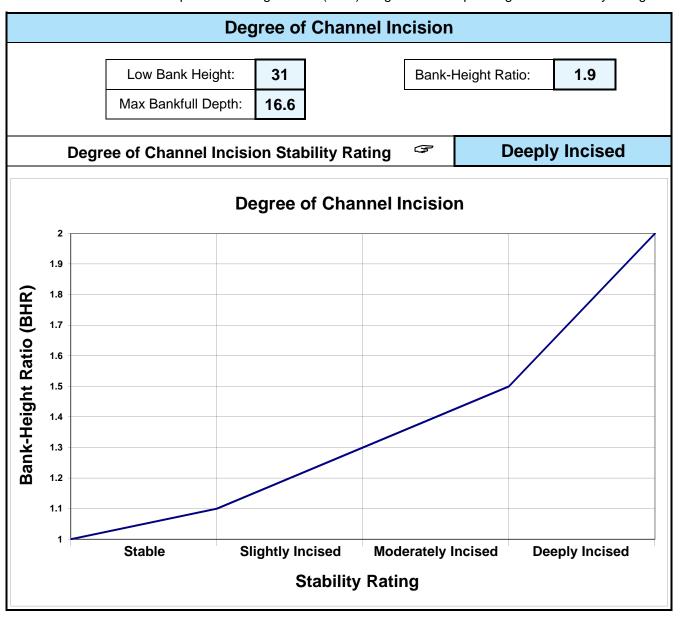
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



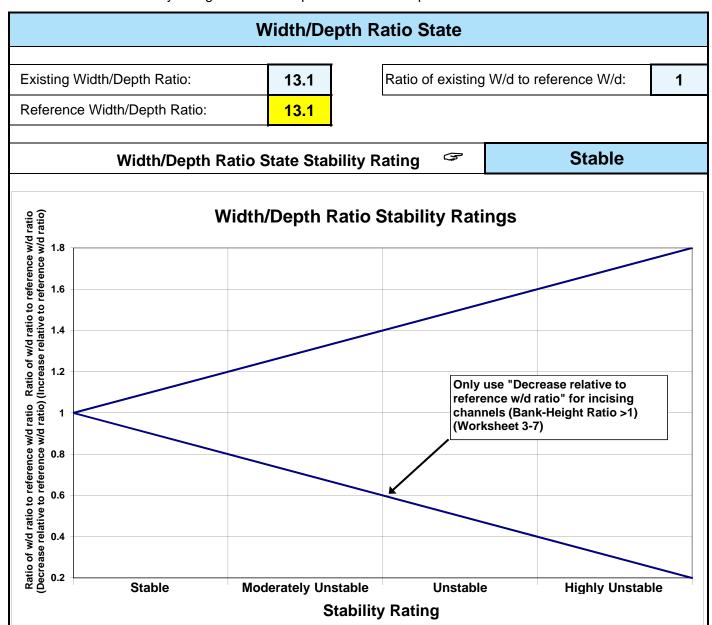
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages								
Stream	m: Red River	Location: Red River-2-419.14								
Obsei	rvers: KD, JB	Date: 9/29/2011								
Desc	ription/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.	7							
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	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.									
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.								
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.								
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.								
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.								
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.								
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.								

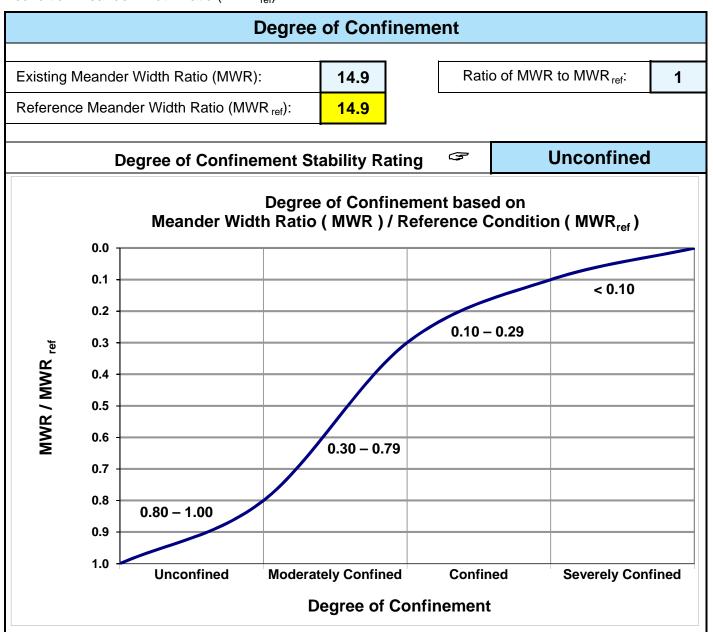
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



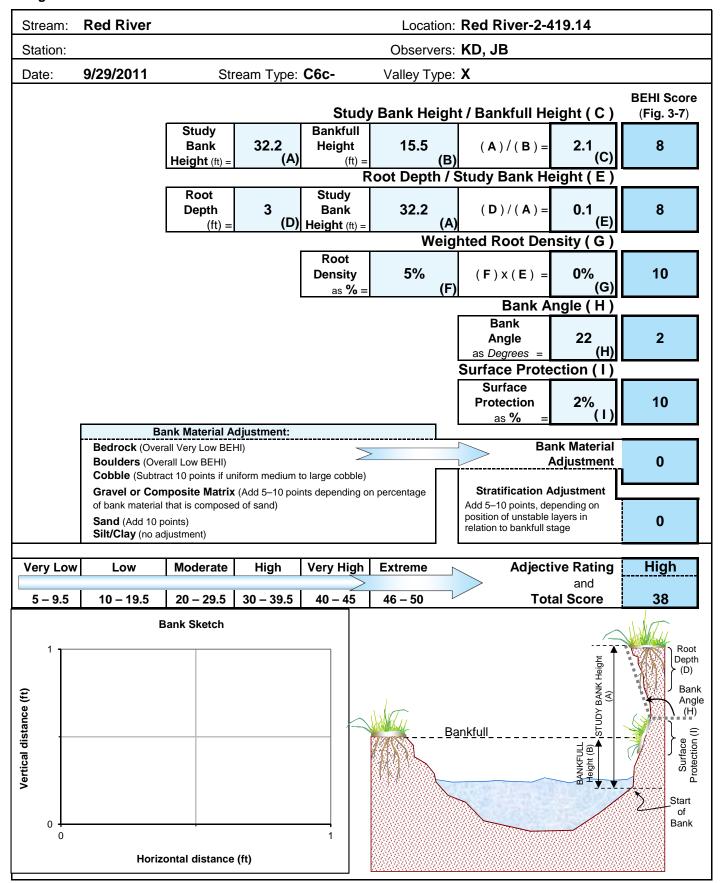
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River			Location: Red River-2-419.14 Valley Type: X Observers: KD, JB															Date: 9/29/20	11					
Loca-	Kov	Cotoo	10 m/			Exce	llent					Go	od					F	air						Poor	
tion	Key	Categ	JOI y			Descriptio	n		Rating		D	escriptio	n		Rating			escriptio	n		Rating			Descri	ption	Rating
(0	1	Landform slope	n	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe grad	dient >	60%.	8
Upper banks	2	Mass ero	osion	No evid erosion		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6	Frequent or large, causing sediment nearly yearlong.			9	Frequent or large, causing sediment near yearlong OR imminent danger of same.				12		
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.	resent, but mostly small twigs and mbs. 0–90% density. Fewer species or					Moderate to heavy amounts, mostly larger sizes.			6	Moderat predomi	nantly la	arger s	izes.	8		
ם	4	Vegetative bank protection			t a deep	nsity. Vi			3		or sugge	y. Fewer est less			6	50–70% fewer sp disconti		rom a sl	nallow,	nd	9		dicating	poor, c	er species and les discontinuous and	s 12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	tage is no rture from	t containe reference	d. Width/d	th ratio	3	common w	rith flows I	ess than reference	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.1.3.	ı. 4
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula			٠,	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	6. Most	in the 3-	-6" diam	eter	6	or less.			of gravel sizes, 1–	8 8
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly ir ting or d			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4	Moderate move wit and pool	th high flo		able obsti ing bank		6	cause b	ank eros	sion ye	and deflectors earlong. Sediment ration occurring.	8
Low	8	Cutting		Little or <6".	none. I	ne. Infrequent raw banks 4 Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". Significant. Cu mat overhangs									12				s, some over 24" ings frequent.	16						
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some new bar increase, mostly from coarse gravel.				8	Moderate depostion of new gravel and coarse sand on old and some new bars. Corners and edges well rounded in 2			12	Extensive deposit of predominantly fin particles. Accelerated bar developmen				16			
	10	Rock angularit		surface	s rough.			е	1	Rounded corners and edges. Surfaces smooth and flat.				2	Corners dimensi		ges we	l rounde	ed in 2	3	Well rounded in all dimer smooth.			•	4	
	11	Brightnes	ss	Surface Genera	,	dark or s right.	tained.		1	Mostly of surfaces		may hav	ve <35%	6 bright	2	Mixture dull and bright, i.e., 35–65% mixture range.			3	Predominantly bright, > scoured surfaces.			> 65%, exposed o	4		
E	12	Consolida particles		Assorte overlap		tightly p	acked o	r	2	Modera overlap		ked with	some		4	Mostly loose assortment with no apparent overlap.			6	No packing evident. Lo easily moved.			oose assortment,	8		
Bottom	13	Bottom s distribution		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked material			ange. Stable	16
_	14	Scouring deposition		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	30–50% at obstr bends.		constri	ctions ar		18				bottom in a state o	f 24
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i Moss h			2	backwa	t but spo ter. Sea rocks sli	sonal a		wth	3				e or absent. Yellow m may be present	4
						Exc	ellent	total =	19				Good	total =	4				Fair	total =	12				Poor tota	= 52
Stream ty	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stabl	_		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		Grand total =	87
Fair (Mod. u Poor (Unsta		44-47 48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110 111+	91-110 111+	86-105 106+	108-132 133+	108-132 133+	108-132 133+	99-125 126+		Existing stream type :	C6c-
Stream ty	-		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1 G2 G3 G4 G5		G6		_		*Potential	C6c-			
				80-95	40-60	40-60	85-107	85-107	90-112					stream type :												
Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 76-96 76-96 64-86 86-105 86-105 111-125 116-130 96-110 61-78 108-120 108-1																										
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Rat	121+	121+ diusted	126+ to poten	121+ tial strea	ım type,	not exis	sting	stability ra Fair	ing =
																	ila	y 15 a	ajuotou	o poten	51160	type,	I OL ONIO	ıg.	i-ali	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion	Tale.										
	Estimating Near-Bank Stress (NBS) Stream: Red River Location: Red River-2-419.14										
Stream:	Red Ri	ver			Location:	Red River	-2-419.14				
Station:	0			S	tream Type:	C6c-	\	/alley Type:	X		
Observe	ers:	KD, JB						Date:	9/29/11		
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)				
(1) Chanı	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance		
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction		
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction		
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction		
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction		
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction		
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation		
_					or discontinuo						
Levell	(1)				-channel)						
				meander mig	ration, conver	ging flow		INE	55 = Extreme		
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress						
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)						
_					Near-Bank	1			_		
l le	(3)	Pool Slope	Average		Stress			inant			
Level II	(0)	Sp	Slope S	Ratio S _p / S	(NBS)	1		nk Stress			
							Very	Low			
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank						
	(4)	S _p	S _{rif}	S _{rif}	Stress (NBS)						
		P									
		Near-Bank			Near-Bank						
	<i>(</i> 5)	Max Depth	Mean Depth	<i>Ratio</i> d _{nb} /	Stress						
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	1					
Level III		16.6	11.5	1.45	Low		DL4-II		1		
eve		Near Book		Near-Bank Shear			Bankfull Shear		l., .		
	(6)	Near-Bank Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Near-Bank Stress		
	(0)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)		
				·			,				
>				Near-Bank							
Level IV	(7)	-	dient (ft/sec	Stress							
Lev	(')	/ f		(NBS)]						
		0.	04	Very Low	<u> </u>						
			nverting Va	lues to a l	Near-Bank	Stress (NE	3S) Rating				
Near-B		ess (NBS)				ethod numb			1		
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	Very Lo		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		
	Modera		N/A See	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 Very High			See (1)	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00		
	Extren	_	Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40		
	-Au ell	IU	, 10016	< 1.50	<u>> 1.00</u> lear-Bank \$	> 1.20	> 3.00	> 1.60	> 2.40		
									Low		

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	Red River-2	-419.14	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	13635.2		Date:	9/29/2011
Observers:	KD, JB		Valley Type:	X			C6c-
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	High	Very Low	0.165	13635.2	32.2	72444	0.26
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosion subtotals in Column (7) for each BEHI/NBS combination Total Erosion (ft³/yr) 72444							
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (ft ³ /yr) by 27}	Total Erosion (yds³/yr)	2683	
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds³/yr)	Total Erosion (tons/yr)	3488	
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.26							

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

Stream:	Red River		S	tream Type:	C6c-					
Location:	Red River-	2-419.14	,	Valley Type:	Х					
Observers:	KD, JB			Date:	9/29/2011					
Enter Req	uired Infor	mation for Existing Condition								
	D ₅₀	Riffle bed material D ₅₀ (mm)								
	D ₅₀	Bar sample D ₅₀ (mm)								
0	D _{max}	Largest particle from bar sample	(ft)		(mm)	304.8 mm/ft				
S Existing bankfull water surface slope (ft/ft)										
d Existing bankfull mean depth (ft)										
1.65 γ_s Submerged specific weight of sediment										
Select the	Appropria	e Equation and Calculate Crit	ical Dimensio	nless She	ar Stress					
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 Use	EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use	EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless Shear St	ress	EQUATIO	ON USED:	#DIV/0!				
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample										
#DIV/0!	d	Required bankfull mean depth (ft)	$d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐								
Calculate Sample	Bankfull W	ater Surface Slope Required f	or Entrainmer	nt of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water surface s	slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐	Degrading							
Sediment	Competen	ce Using Dimensional Shear S	itress							
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (substi	tute hydraulic ra	dius, R, with	mean depth,	d)				
<u> </u>	$\gamma = 62.4, c$	I = existing depth, S = existing slope	Э							
Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)										
	Predicted	shear stress required to initiate mov	rement of measu	ıred D _{max} (m	m) (Figure 3	-11)				
#DIV/0! Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{vs}$										
#DIV/0!	τ = predicted shear stress, γ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D _{max} (mm) $\mathbf{S} = \frac{\tau}{\tau}$									
	τ = predic	ted shear stress, γ = 62.4, d = exist	ing depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR-	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, J	В				
u b	Strea	ım:	Red R	iver					Loca	tion:	Red R	liver-2	-419.1	4					Date: 9/2	Date: 9/29/2011	
		→		⇒ (⇒ (⇒ (⇒ (⇒ (→ (→ (⇒ (
a m		h Pan CKET	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE		SIZE mm	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE			
p I	Tare v	veight	Tare v	veight	Tare	weight	Tare v	weight	Tare \	veight	Tare	weight	Tare	weight	Tare	weight	Tare	weight		URFAC ATERIAI	
e s	Sample v	veights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two I	DATA argest pa	rticles)
3	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1																			No	. Dia.	WT.
3																			1 2		
4																			l		
5																			Bucket + materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials weight		0
11																			Materials less	6	
12																			than:		mm
13																				Be sure to	
14																				separate r weights to	grand
15 Net wt	total	0		0		0		0		0		0		0		0		0		total	
		#####		#####		#####		#####		#####		#####		#####		#####		#####	0	7	
	ı. % =<	#####		#####	>	#####	>	#####	>	#####	>	#####		#####	>	#####		100%	1	RAND TO	TAI
			- 1										J		J .				<u>.</u> Gr	VAIND IC	/IAL
S	ample lo	cation no	otes				Sar	nple loca	ation ske	etch											

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River-2-419.14	Valley Type: X
Observers:	KD, JB	Date: 9/29/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River Stream Type: C6c-												
Location: Red River-2-419.14 Valley Type: X Observers: KD, JB Date: 9/29/2011												
Observers: KD, JB			Da	ate: 9/29/2011								
Lateral stability criteria		Selected										
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)							
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2							
,	(2)	(4)	(6)	(8)								
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1							
,	(1)	(2)	(3)	(4)								
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3							
,	(1)		(3)									
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)								
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1							
(Worksheet 3-9)	(1)	(2)	(3)	(4)								
Total points												
	La	teral stability c	ategory point ra	nge	-							
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-								
Location: Red River-2-4	bservers: KD, JB Date: 9/29/2011											
Observers: KD, JB			Date:	9/29/2011								
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected							
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)							
Sediment 1 competence (Worksheet 3-14)	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)								
Sediment capacity (POWERSED)	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)								
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2							
	(2)	(4)	(6)	(8)								
Stream succession 4 states (Worksheet 3- 16)	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)								
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1							
3-5)	(1)	(2)	(3)	(4)								
6 Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1							
	(1)	(2)	(3)	(4)								
Total points												
	Vertical stat		int range for exces	s deposition /								
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River			Stream Type:	C6c-					
Location: Red River-2-4	119.14		Valley Type:	X					
Observers: KD , JB			Date:	9/29/2011					
Vertical stability	Vertical Stabil	ity Categories for	Selected						
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2				
	(2)	(4)	(6)	(8)					
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2				
	(2)	(4)	(6)	(8)					
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8				
(WOIKSHEEL 3-1)	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4				
	(2)	(4)	(6)	(8)					
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1				
3-9)	(1)	(2)	(3)	(4)					
				Total points	17				
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 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-											
Location: Red River-2-41	9.14		Valley Type:	X							
Observers: KD, JB			Date:	9/29/2011							
Channel enlargement	Char	Selected									
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)						
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2						
	(2)	(4)	(6)	(8)							
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4						
	(2)	(4)	(6)	(8)							
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2						
(Worksheet 3-18)	(2)	(4)	(6)	(8)							
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4						
(Worksheet o 19)	(2)	(4)	(6)	(8)							
	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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Red River			Stream Type:	C6c-					
Lo	cation: Red River-2-419.	.14		Valley Type:	X					
Ob	servers: KD, JB			Date:	9/29/2011					
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points					
		Stable		1						
1	Lateral stability	Mod. unstab	ole	2	2					
! '	(Worksheet 3-17)	Unstable		3	2					
		Highly unsta	able	4						
	Vertical stability	No deposition	on	1						
2	excess deposition/	Mod. deposi	ition	2	1					
	aggradation	Excess depo	osition	3	1					
	(Worksheet 3-18)	Aggradation	1	4						
	Vertical stability	Not incised		1						
3	channel incision/	Slightly inci	sed	2	2					
٦	degradation	Mod. Incised	d	3	2					
	(Worksheet 3-19)	Degradation	1	4						
	Channal anlargement	No increase		1						
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2					
"	3-20)	Mod. increas	se	3	2					
	0 20)	Extensive		4						
	Pfankuch channel	Good: stable	e	1						
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2					
ľ	10)				_					
	10)	Poor: unsta	ble	4						
	Total Points 9									
	Category point range									
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □					

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River			Loc	ation:	Red River-2	-419.14		
Observers:	KD, JB	Dat	e: 9/29/2	2011	Strean	n Type: C6c-	Valle	еу Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 11.5	Mean bankfull width (ft):	150.6	Cross-section area (ft²):	1/25	Width of flood prone area (ft)	/un 5	Entrenchment ratio:	5.2
Channel Pattern	Mean: Range: MWR:	14.9 Lm/\		14.9	Rc/	/W _{bkf} :	5.1	Sinuosity:	2.18
	Check: Riffle/pool	☐ Step/pool	□ Plane		verge	nce/divergence	Dunes	s/antidunes/smo	oth bed
River Profile and Bed	Max Riffle	Pool Dept	h ratio	Riffle P	ool		tio	Slope	
Features	bankfull depth (ft):	(max/	mean):	1.4		pool spacing:	Valley:		verage Inkfull: 7E-05
	Tupanan	nt composition/density:	Po	tential composition/o	density:	Remar	ks: Condition, vi	igor and/or usage of	existing reach:
	vegetation								
	Flow P1, 2, Stream regime: 7, 9 and or	N-4	Meand patterr	IVI	2	Depositional pattern(s):	NONE	Debris/channe blockage(s):	D1-3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.9 Degree stability	of incisior rating:	Deeply Inc	cised	Modified Pfan (numeric and			Fair
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	13.1	Width/depth ra (W/d) / (W/d _{ref})		1.	()	atio state ty rating:	Stable
	Meander Width Ratio (MWR):	14.9 Reference MWR _{ref} :	14.9	Degree of conf (MWR / MWR _n		ent 1.	0	/ MWR _{ref} ty rating:	Unconfined
Bank Erosion Summary	Length of reach studied (ft):	##	eambank tons/yr)	erosion rate: 0.26 (tons/yr/	ft)	Curve used: Fig 3-9	Remarks	:	
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient ca	apacity	☐ Excess cap	pacity	Remar	ks:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$	τ		sting th _{bkf} :	Require depth		kisting ope _{bkf} :	Required slope _{bkf} :
Successional Stage Shift	→ -	→	_	→ —	→	Existing st state (type		Potential s	Chc-
Lateral Stability	☐ Stable 🔽	Mod. unstable	☐ Unst	table 🗆	High	ly unstable	Remarks/caus	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	☐ Ex. 0	deposition	Aggr	radation	Remarks/caus	es:	
Vertical Stability (Degradation)	Not incised	Slightly incised	☐ Mod	. incised	Degr	radation	Remarks/caus	es:	
Channel Enlargement	☐ No increase ☑	Slight increase	☐ Mod	. increase \qed	Exte	nsive	Remarks/caus	es:	
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High	☐ Very high	Remar	rks/causes:			

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

	Riparian Vegetation										
Stre	eam: Red R	liver		Location:	Red	I River - 3 - 4	440.57				
Obs	servers: KD, JI	В	Reference reach	Disturbed (impacted reach) X Date:			11/21/2010				
spe	sting ocies nposition: small	shrubs		Potential species composition:	sma	all shrubs					
Riparian cover Percent aeria categories cover*			Percent of site coverage**	Species (Percent of total species composition						
7				trees			100%				
1. Overstory	Canopy layer	5% without leaves, 70% with leaves	1%								
							100%				
2. Understory	Shrub layer		5%	small shrub: cocklebur b		98	95% 5%				
							100%				
ıvel	Herbaceous		2%	grass			100%				
3. Ground level	Leaf or needle litter		1%	Remarks: Condition, vigo usage of existir			100%				
	Bare ground		91%	None							
	ed on crown closure. sed on basal area to s	surface area.	Column total = 100%								

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

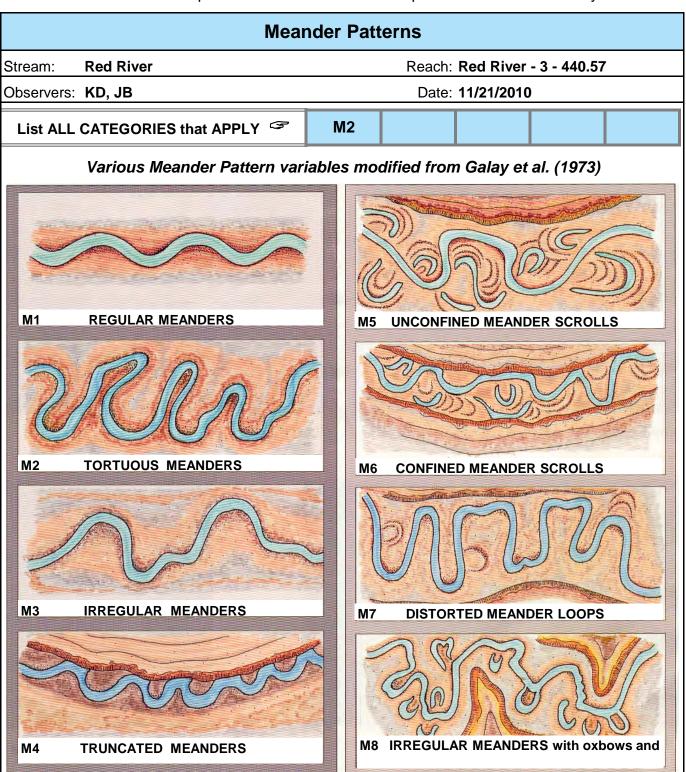
		F	FLOW I	REGIM	=							
Stream:	Red River		Location:	Red Rive	er - 3 - 44	0.57						
Observers:	KD, JB COMBINATIONS that						Date:	11/21/20	10			
	PLY	P1	P2	P7	P8	P9						
	General Category											
E Ephemeral stream channels: Flows only in response to precipitation												
S	Subterranean stream consurface flow that follows			llel to and	near the	surface fo	or various	s seasons	- a sub-			
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology wl	here			
Р	Perennial stream chanr	nels: Surf	face water	persists y	/earlong.							
Specific (Category											
1	Seasonal variation in st	treamflow	dominate	d primarily	/ by snow	melt runc	ff.					
2	Seasonal variation in st	treamflow	dominate	d primarily	/ by storm	nflow runc	off.					
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ndition, b	ackwater	r, etc.				
4	Streamflow regulated b	y glacial r	melt.									
5	Ice flows/ice torrents fro	om ice da	m breache	es.								
6	Alternating flow/backwa	ater due to	o tidal influ	ence.								
7	Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ring, etc.						
8	Altered due to developr conversions (forested to											
9	Rain-on-snow generate	ed runoff.										

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

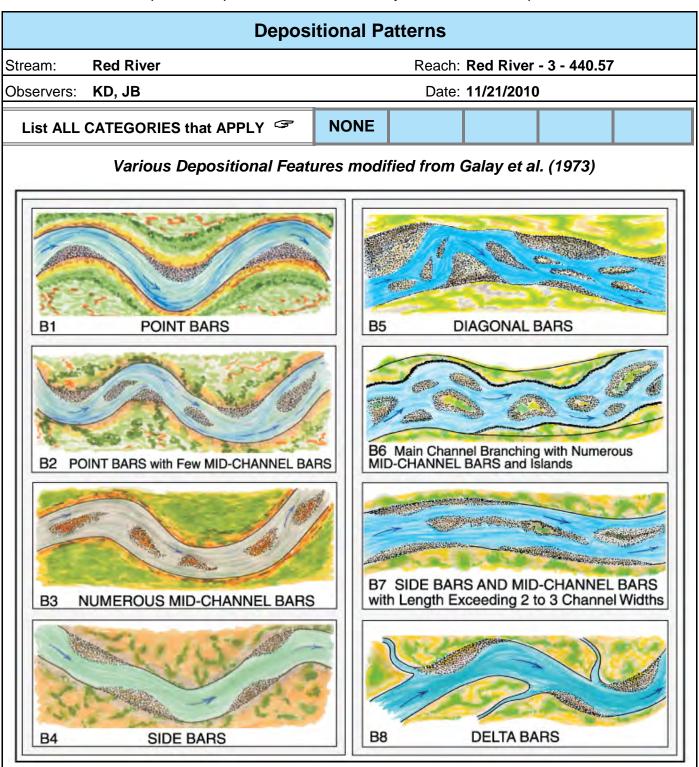
Stream Size and Order											
Stream:	Red River										
Location:	Red River - 3 -	440.57									
Observers:	KD, JB										
Date:	11/21/2010										
Stream Size Category and Order S-8											
STREAM SIZE: Bankfull Check (✓) Category width appropriate											
	meters	feet	category								
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 categori	es in parenthesis	for specific strea	m order of								

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

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



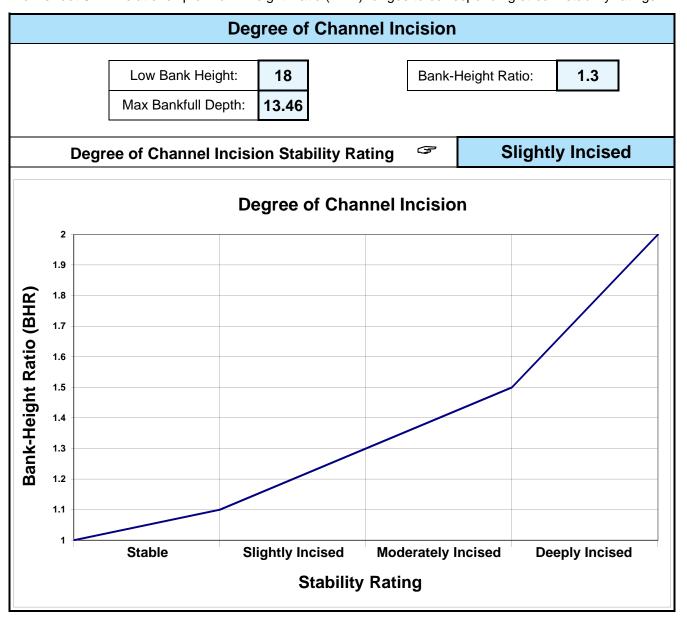
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



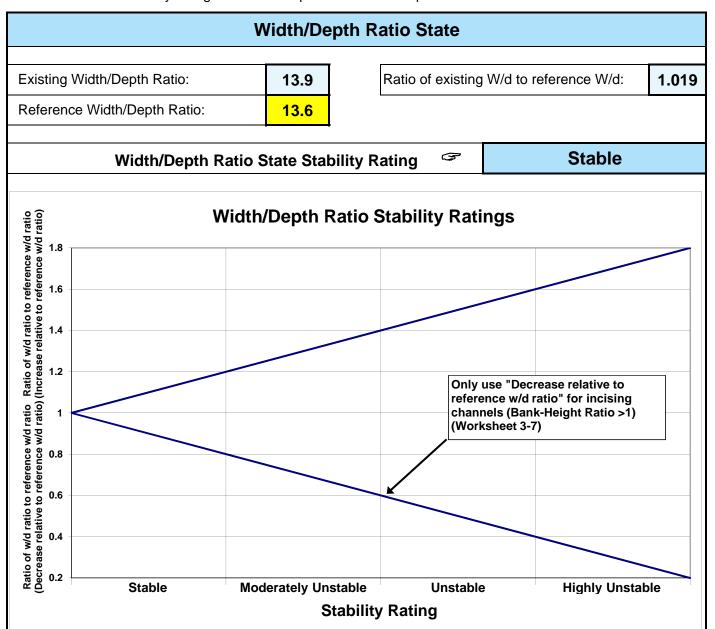
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Red River	Location: Red River - 3 - 440.57	
Obser	vers: KD, JB	Date: 11/21/2010	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	•
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

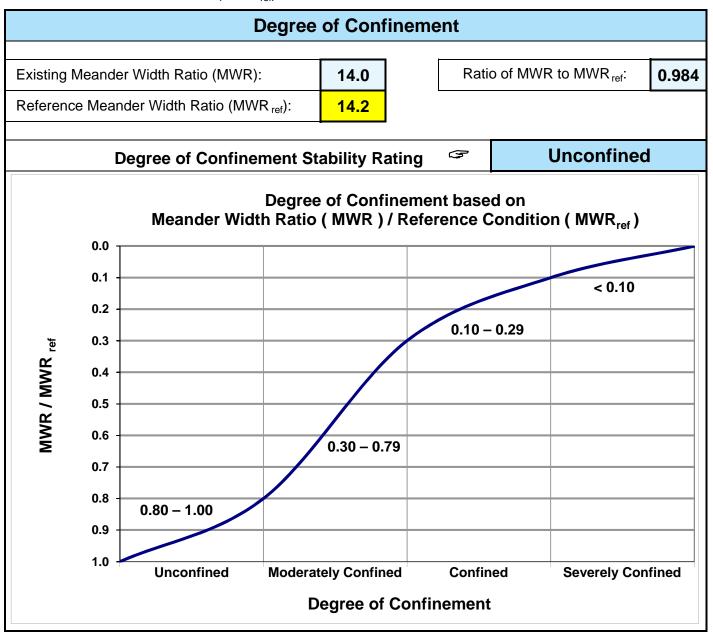
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



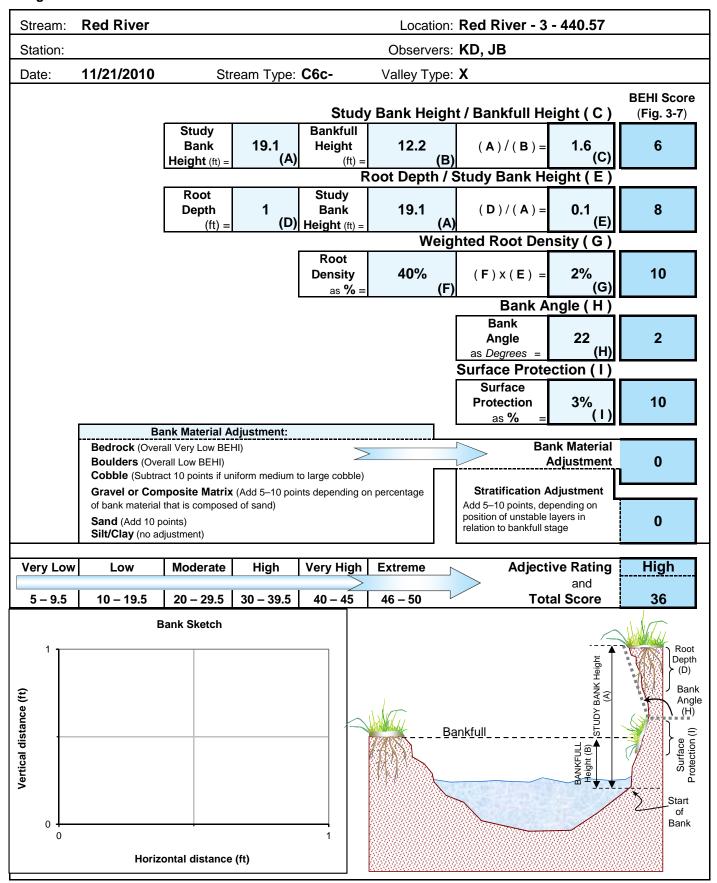
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River					Loc	ation:	Red F	River -	3 - 44	40.57		Valley	Type:	Χ		Obse	ervers:	KD,	JB	Date: 11/21/2010				
Loca-	Key	Categ	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Rey	Caleg	loi y			Descriptio	n		Rating		D	Description	n		Rating		[Description	on		Rating			Descr	iption	Rating
6	1	Landform slope	า	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-4 0%.		4	Bank sl	ope gra	dient 40	- 60%.		6	Bank slo	ope gra	adient >	60%.	8
Upper banks	2	Mass ero	sion	No evid erosion		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or lar		sing sed	iment	9				using sediment near t danger of same.	ly 12
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	izes.		ounts, m		6	Moderate to heavy amo predominantly larger siz			sizes.	8
)	4	Vegetative bank protection			t a deep	nsity. Vi			3		or sugge	y. Fewer est less			6	fewer s		rom a sl		ınd	9		dicating	poor,	ver species and less discontinuous and	12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/de width/dep (BHR) = 1	oth ratio	3	common v	vith flows rture fron	less than	ed; over-bank flows are n bankfull. Width/depth ce width/depth ratio > 1.4 1.3.	4
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula			٠,	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3	8
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly ir ting or d			2		and mind	using ero or pool fill m.			4		th high flo		able obst sing bank		6	cause b	ank er	osion ye	and deflectors earlong. Sediment tration occurring.	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks				ently at o aw bank			6				l" high. F ughing e		12				ts, some over 24" angs frequent.	16
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8		arse san		new gra d and so		12				redominantly fine bar development.	16
	10	Rock angularity		Sharp e surface:		nd corne	rs. Plan	е	1			rs and e th and fla	_		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.			nensions, surfaces	4
	11	Brightnes		Genera	lly not b				1	surface	S	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predom scoured	,	0 /	> 65%, exposed or	4
E	12	Consolidat particles		overlap	ping.	tightly p			2	overlap	oing.	ked with			4		parent overlap. 6 easily moved.		oose assortment,	8						
Bottom	13	Bottom s distribution		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable	16
	14	Scouring depositio		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr		constri			18				bottom in a state of yearlong.	24
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow- om may be present.	4
						Exc	ellent	total =	23				Good	total =	14				Fair	total =	9				Poor total	= 20
Stream ty	ре	A1	A2	А3	Α4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	ī	_	
Good (Stable	_		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	67-98	1	Grand total =	66
Fair (Mod. u	ınstable		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	99-125		Existing	C6c-
Poor (Unsta		48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+]	stream type =	- COC-
Stream ty	-		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6 80-95	G1	G2	G3	G4 85-107	G5 90-112	G6 85-107				*Potential stream type =	C6c-
Good (Stable			40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110			40-60	40-60	85-107								
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120		Modified channel						
Poor (Unsta	inie)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+	121+	126+	121+	ım tvne	not evi	istina	stability rat Good	_
	*Rating is adjusted to potential stream type, not existing. Good																i\d	uriy is d	ajusteu	io poter	iliai Sli Co	пп туре,	HOL EXI	oung.		

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.											
			Estim	ating Nea	r-Bank St	ress (NB	S)				
Stream	: Red Ri	iver			Location:	Red River	- 3 - 440.5	7			
Station:	: 0			S	tream Type:	C6c-	\	√alley Type:	Χ		
Observ	ers:	KD, JB						Date:	11/21/10		
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)				
(1) Char	nnel pattern	, transverse ba	r or split channe	el/central bar cre	eating NBS	Level I	Reconaissance				
(2) Ratio	o of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	orediction		
(3) Ratio	of pool slo	pe to average v	water surface sl	ope (S _p / S)			Level II	General	prediction		
(4) Ratio	o of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction		
(5) Ratio	of near-ba	ınk maximum de	epth to bankfull	mean depth (d	_{nb} / d _{bkf})		Level III	Detailed	prediction		
(6) Ratio	of near-ba	ınk shear stress	to bankfull she	ar stress (τ _{nb} /	τ _{bkf})		Level III	Detailed	prediction		
							Level IV	Valid	lation		
Transverse and/or central bars-short and/or discontinuousNBS = High / Very High											
Level	(1)				-channel)						
				meander mig	gration, conve	rging flow		NE	so = Extreme		
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress						
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)						
			, ,								
_					Near-Bank						
el I	(2)	Pool Slope	Average		Stress			inant			
Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)	,		nk Stress			
							Very	Low			
		D 101	D:/// OI	Datia C /	Near-Bank						
	(4)	Pool Slope S _p	Riffle Slope S _{rif}	Ratio S _p / S _{rif}	Stress (NBS)						
		Ор	Oni	Oni	(NDO)						
		Near-Bank			Near-Bank	l					
	(-)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress						
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d_{bkf}	(NBS)	ļ					
=											
Level III				Near-Bank Shear			Bankfull				
ĭ	(6)	Near-Bank Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	A	Shear Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank		
	(6)	d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	d _{bkf} (ft)	Average Slope S	Ib/ft ²)	$ au_{\mathrm{bkf}}$	Stress (NBS)		
		TID ()	1 110	,	- DRI (·)	0.000	,)	· DRI	(1.120)		
>				Near-Bank							
Level IV	(7)	Velocity Grad	dient (ft/sec								
-e	(')		ft)	(NBS)	1						
			0	Very Low							
			verting Va	lues to a N	lear-Bank	Stress (NE	3S) Rating				
Near-		ess (NBS)		1 45:		ethod numb					
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	Very L		N/A N/A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50		
l	Low		N/A 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		
		ait		2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80 1.81 – 2.50	1.06 – 1.14	1.01 – 1.60		
			See	101 000			1 X 1 — 2 50 I				
	High		See (1)	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00		1.15 – 1.19	1.61 – 2.00		
	High Very H	igh	(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		
	High	igh		1.50 – 1.80 < 1.50		1.01 – 1.20 > 1.20	2.51 – 3.00 > 3.00	1.20 – 1.60 > 1.60			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	Red River -	3 - 440.57				
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	10364.3	Date: 11/21/2010					
Observers:	KD, JB		Valley Type:		Stream Type: C6c-					
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	10364.3	19.1	32663	0.15			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Col	umn (7) for ead	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	32663				
Convert eros	sion in ft³/yr to yd	s ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	1210					
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	1573				
	osion per unit len total length of stre	Total Erosion (tons/yr/ft)	0.15							

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

Stream:	Red River		S	tream Type:	C6c-						
Location:	Red River	- 3 - 440.57	,	Valley Type:	Χ						
Observers:	KD, JB			Date:	11/21/2010						
Enter Req	uired Infor	mation for Existing Co	ndition								
	D ₅₀	Riffle bed material D_{50} (r	mm)								
	D ₅₀	Bar sample D ₅₀ (mm)									
	D _{max}	Largest particle from bar	r sample (ft)		(mm)	304.8 mm/ft					
	S	Existing bankfull water s	surface slope (ft/ft)								
	d	Existing bankfull mean o	depth (ft)								
1.65	γ_s	Submerged specific wei	ght of sediment								
Select the	Appropria	te Equation and Calcu	late Critical Dimensio	nless She	ar Stress						
#DIV/0!	D ₅₀ /D [^] ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless	Shear Stress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean	depth (ft) $d = \frac{\tau}{2}$	$S \times \gamma_s D_{max}$	(use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggradi									
Calculate Sample	Bankfull W	ater Surface Slope Re	quired for Entrainme	nt of Large	st Particle	in Bar					
#DIV/0!	s	Required bankfull water	surface slope (ft/ft) S:	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggradi	ng Degrading								
Sediment	Competen	ce Using Dimensional	Shear Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft	²) (substitute hydraulic ra	dius, R, with	mean depth,	, d)					
	$\gamma = 62.4, c$	d = existing depth, S = exis	sting slope								
	Predicted	largest moveable particle s	size (mm) at bankfull shea	ar stress τ (F	igure 3-11)						
	Predicted	shear stress required to in	itiate movement of measu	ured D _{max} (m	m) (Figure 3	-11)					
#DIV/0!		mean depth required to inited shear stress % = 62.4		ired D _{max} (mi	$\mathbf{d} = \frac{7}{1}$	T VS					
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, slope required to initiate m	ovement of measured D _n	_{nax} (mm)	$S = \frac{\tau}{vd}$. 					
	$\tau = \text{predic}$	ted shear stress, $\gamma = 62.4$,	d = existing depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	SAMPLE DATA: Size Distribution Analysis Observers: KD, JB														
u b	Strea	ım:	Red R	River					Loca	tion:	Red R	liver -	3 - 440	.57					Date: 11/21/2010			
		→		→		⇒ (→		⇒ (⇒(→		→		⇒(
a a		h Pan	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve	SIZE	Sieve	SIZE				
m p		CKET weight	Tare	mm weight	Tare	mm weight	Tare	mm weight	Tare v	mm	Tare	mm weight	Tare	mm weight	Tare	mm weight	Tare	mm weight		SU	JRFACE	.
1	Taic	veignt	Tale	weight	Tare	weight	Taic	veignt	l ale v	veignt	Tare	weight	Tale	weight	Tale	Weight	Tale	weight			TERIAL DATA	S
e s	Sample		Sample	_	Sample		Sample		Sample		Sample	_	Sample		Sample	_	Sample		(Tw		rgest par	ticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		1	5:)
2																				No.	Dia.	WT.
3																				2		
4																			Bucket			
5																			materia	ls		
6																			weight	i		
7																			Bucket ta weight			
9																						
10																			Materia weight		()
11																			Materials	less		
12																			than:			mm
13																					e sure to a	
15																			1/3	W	eights to (tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	10		
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		/		
Accum	n. % =<	#####	\longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	#####	\Longrightarrow	#####	$\qquad \qquad \Longrightarrow$	#####		100%		GRA	AND TO	TAL
S	ample lo	cation no	otes				Sar	nple loca	ation ske	etch												

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River - 3 - 440.57	Valley Type: X
Observers:	KD, JB	Date: 11/21/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-						
Location: Red River - 3 - 44	10.57		Valley Ty	_{/pe:} X						
Observers: KD, JB			Da	ate: 11/21/2010						
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected					
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)					
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2					
	(2)	(4)	(6)	(8)						
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1					
	(1)	(2)	(3)	(4)						
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3					
	(1)		(3)							
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)						
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1					
(Worksheet 3-9)	(1)	(2)	(3)	(4)						
				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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River Stream Type: C6c-											
Location: Red River - 3	- 440.57		Valley Type:	X							
Observers: KD, JB			Date:	11/21/2010							
Vertical stability criteria	Vertical Stabi	lity Categories fo	Selected								
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)						
Sediment 1 competence (Worksheet 3-14)	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)							
Sediment capacity (POWERSED)	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)							
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2						
	(2)	(4)	(6)	(8)							
Stream succession 4 states (Worksheet 3- 16)	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)							
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1						
3-5)	(1)	(2)	(3)	(4)							
6 Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1						
	(1)	(2)	(3)	(4)							
Total points											
	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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River			Stream Type:	C6c-						
Location: Red River - 3	- 440.57		Valley Type:	X						
Observers: KD, JB			Date:	11/21/2010						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	annel Incision / Degradation						
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	Selected points (from each row)					
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
	(2)	(4)	(6)	(8)						
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
	(2)	(4)	(6)	(8)						
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4					
(WOIKSHEEL 3-1)	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
	(2)	(4)	(6)	(8)						
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
3-9)	(1)	(2)	(3)	(4)						
				Total points	13					
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 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-								
Location: Red River - 3 - 440.57 Valley Type: X								
Observers: KD, JB Date: 11/21/2010								
Channel enlargement	Char	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase Slight increase		Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Worksheet 5-15)	(2)	(4)	(6)	(8)				
Total points								
Category point range								
Channel enlargement prediction (use total points and check stability rating) No increase 8 − 10								

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

Stream: Red River Stream Type: C6c-								
Lo	X							
Ob	servers: KD, JB	Date:	11/21/2010					
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points			
		Stable		1				
1	Lateral stability	Mod. unstab	ole	2	•			
'	(Worksheet 3-17)	Unstable		3	2			
		Highly unsta	able	4				
	Vertical stability	No deposition	on	1				
2	excess deposition/	Mod. deposi	ition	2	1			
-	aggradation	Excess depo	osition	3	1			
	(Worksheet 3-18)	Aggradation	1	4				
	Vertical stability	Not incised		1				
3	channel incision/	Slightly inci	sed	2	2			
٦	degradation	Mod. Incised	d	3	2			
	(Worksheet 3-19)	Degradation	1	4				
	Channal anlargement	No increase		1				
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2			
~	3-20)	Mod. increas	se	3	2			
	0 20)	Extensive		4				
	Pfankuch channel	Good: stable	e	1				
5	stability (Worksheet 3-	Fair: mod ur	nstable	2	1			
ľ	10)				•			
	10)	Poor: unsta	ble	4				
	Total Points 8							
	Category point range							
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □			

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River			Location:	Red River - 3	- 440.57		
Observers:	KD, JB	Date:	11/21/2010	Stream	Туре: С6с-	Valle	у Туре: Х	
Channel Dimension	Mean bankfull 9.79 depth (ft):	Mean bankfull 1: width (ft):	36 Cross-section area (ft ²):	n 1334	Width of flood- prone area (ft):	619.25	Entrenchment ratio:	4.6
Channel Pattern	Mean: Range: MWR:	14.0 Lm/W _b		Rc/\	W _{bkf} :	2.1		2.15
	Check: Riffle/pool	☐ Step/pool ☑		Convergen	ce/divergence	<u></u> Dunes/	antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rati	0	Slope	
Features	bankfull depth (ft): 13.5	(max/me	ean): 1.4		pool spacing:	Valley:	Average bankfull:	6.8E-05
	Nipanan	nt composition/density:	Potential composi	tion/density:	Remarks	: Condition, vig	or and/or usage of existing	reach:
	vegetation							
	Flow P1, 2, Strear regime: 7, 8, 9 and or		Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.3 Degree of stability rat	ing:	y iliciseu	Modified Pfankı (numeric and a	djective rating	g):	ood
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	13.6 Width/dept (W/d) / (W/		e 1.0		tio state y rating:	ıble
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of (MWR / MV		^{nt} 1.0	I	MWR _{ref} unco	nfined
Bank Erosion Summary	Length of reach studied (ft):	·##	mbank erosion rate s/yr) 0.15 (tor	ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :		sting Requir	
Successional Stage Shift	→ -	→ →	→	→	Existing stre	eam Ce	Potential stream state (type):	C6c-
Lateral Stability	☐ Stable 🔽	Mod. unstable ☐	Unstable	☐ Highly	y unstable R	emarks/cause	S: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	emarks/cause	None	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degra	adation	emarks/cause	S: None	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exten	nsive	emarks/cause	S: None	
Sediment Supply (Channel Source)	□ Low ▼	Moderate	High 🔲 Very hi	gh	ks/causes: N	one		

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

	Riparian Vegetation							
Stre	eam: Red R	iver		Location: Red River - 4 - 452.52				
	servers: KD, JI		Reference reach	Disturbed (impacted reach) Date: 11/16/2010				
spe	Existing species composition: Trees, briar bushes, grass			Potential species composition: Trees, briar bushes, grass				
			Percent of site coverage**	Species composition	Percent of total species composition			
1. Overstory	Canopy layer	5% without leaves, 80% with leaves	1%	trees	100%			
	I				100%			
2. Understory	Shrub layer		2%	briars	100%			
					100%			
level	Herbaceous		5%	grass	100%			
3. Ground level	Leaf or needle litter		1%	Remarks: Condition, vigor and/or usage of existing reach:	100%			
	Bare ground		91%	NONE				
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%					

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

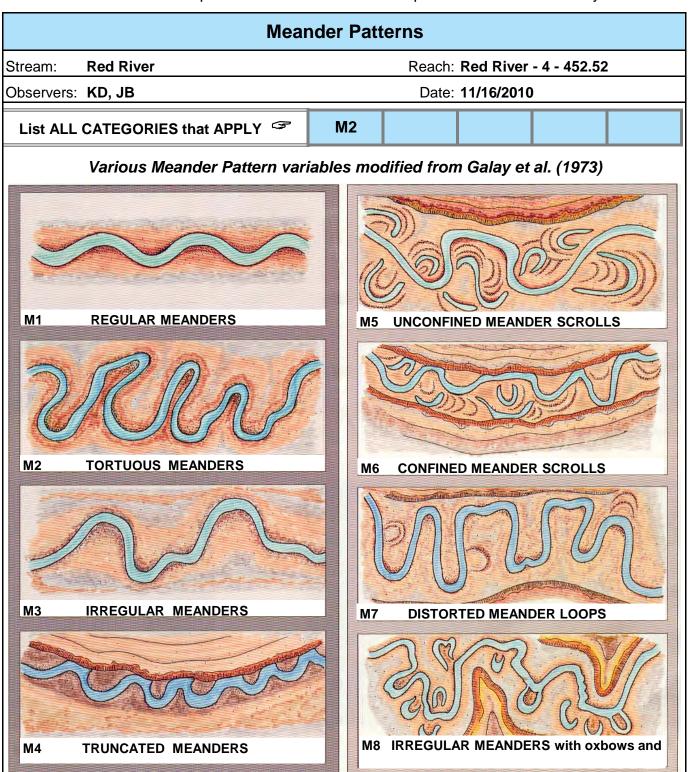
FLOW REGIME									
Stream: Red River Location: Red River - 4 - 452.52									
	Observers: KD, JB Date: 11/16/2010								10
List ALL	List ALL COMBINATIONS that P1 P2 P7 P8 P9								
APPLY									
General C	ategory								
E	Ephemeral stream chai	nnels: Flo	ows only in	response	e to precip	oitation			
S	Subterranean stream c surface flow that follows			llel to and	near the	surface fo	or various	seasons	- a sub-
ı	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology w	here
Р	Perennial stream chanr	nels: Surf	face water	persists y	/earlong.				
Specific (Category								
1	Seasonal variation in st	treamflow	dominate	d primarily	y by snow	melt runo	off.		
2	Seasonal variation in st	treamflow	dominate	d primarily	y by storm	nflow runc	off.		
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 generate	ed runoff.							

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

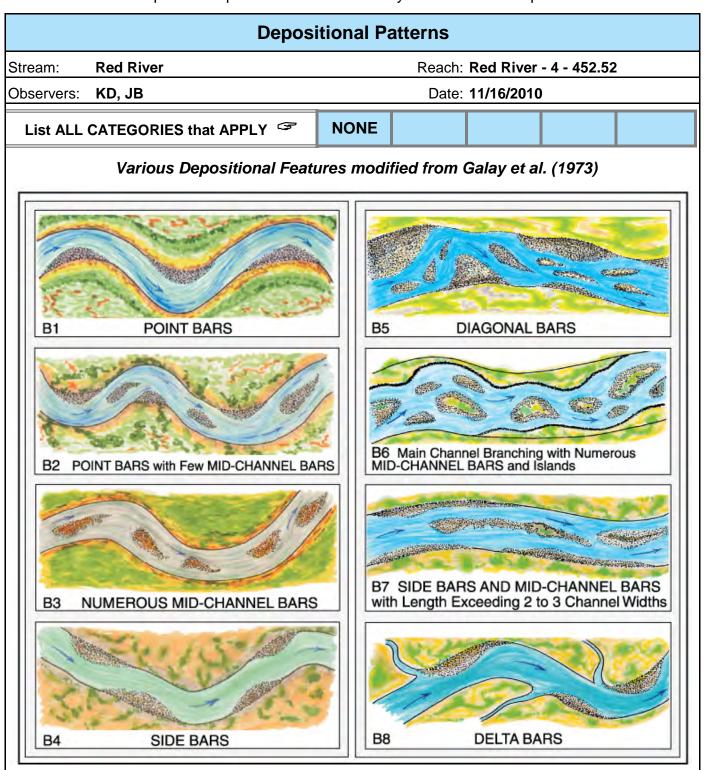
Stream Size and Order							
Stream: Red River							
Location:	Red River - 4 -	452.52					
Observers:	KD, JB						
Date:	11/16/2010						
Stream Siz	Stream Size Category and Order S-9						
Category	STREAM SIZE: Bankfull Check (🗸) Category width appropriate						
	meters	feet	category				
S-1	0.305	<1					
S-2	0.3 – 1.5	1 – 5					
S-3	1.5 – 4.6	5 – 15					
S-4	4.6 – 9	15 – 30					
S-5	9 – 15	30 – 50					
S-6	15 – 22.8	50 – 75					
S-7	22.8 - 30.5	75 – 100					
S-8	30.5 – 46	100 – 150					
S-9	46 – 76	150 – 250	~				
S-10	76 – 107	250 – 350					
S-11	107 – 150	350 – 500					
S-12	150 – 305	500 – 1000					
S-13 >305 >1000							
Stream Order							

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

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



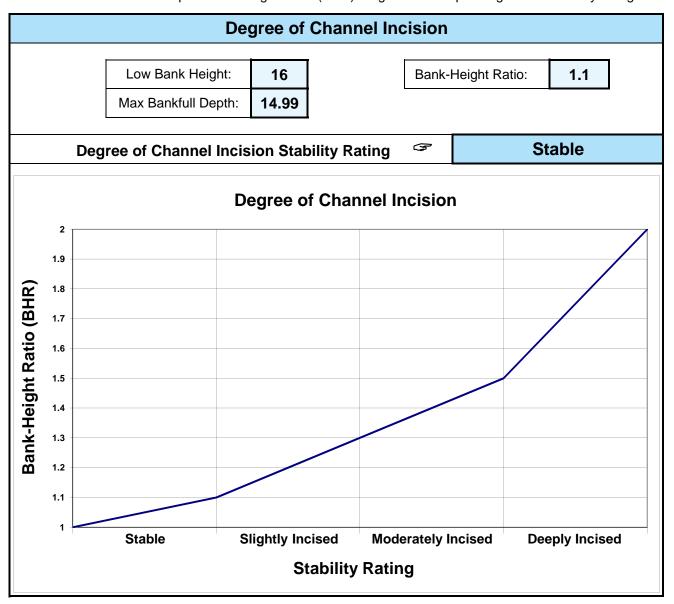
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



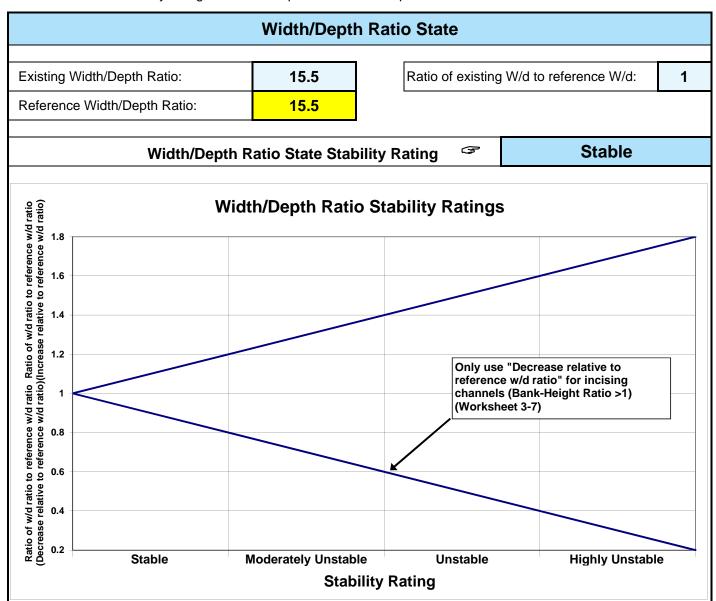
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Red River	Location: Red River - 4 - 452.52	
Obser	rvers: KD, JB	Date: 11/16/2010	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	•
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

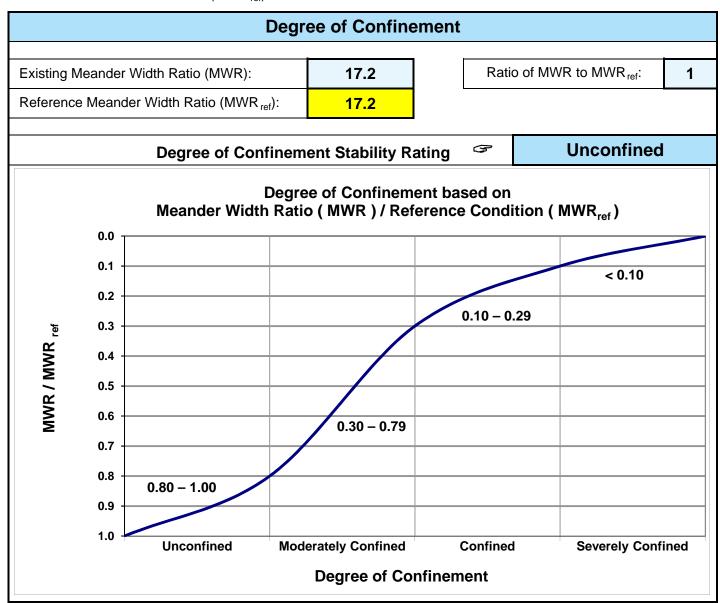
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



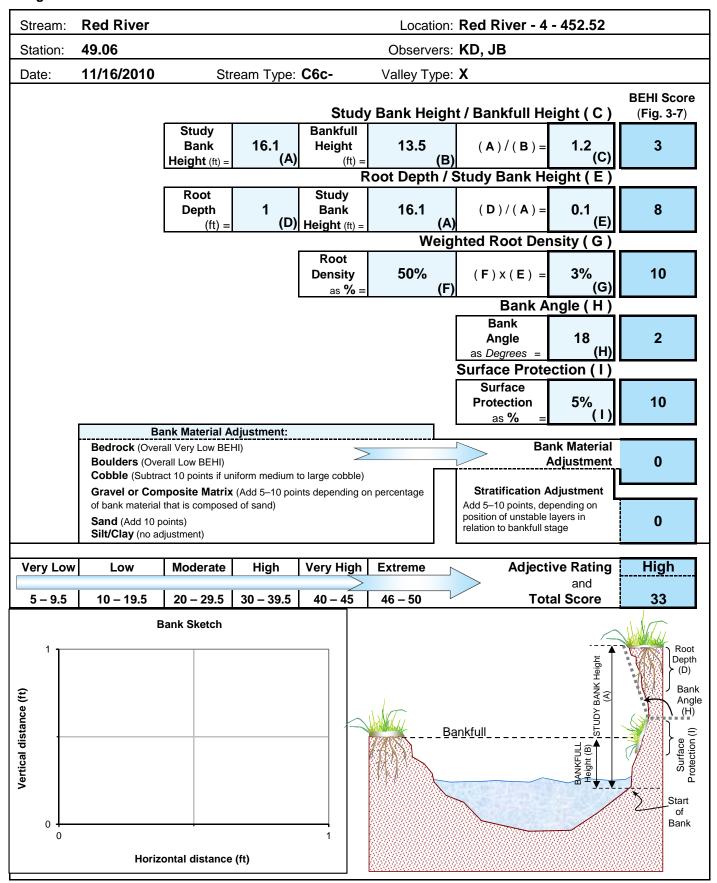
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

1	am: R	Red	River					Loc	ation:	Red F	River -	4 - 4	52.52		Valley	Type:	Χ		Obse	ervers:	KD, J	JB				Date: 11/16/	2010	
1 Limitor Samik slope gradient 30-0%. 2 Samk slope gradient 30-0%. 6 Samk slope gradi	ca-	Kov	Caton	orv			Exce	llent					Go	od					Fa	air						Poor		
Sum supple gladent 4-U-Vs. 4 Soft is supple gladent 4-U-Vs. 5 Soft is supple gladent 4-U-Vs. 5 Soft is supple gladent 4-U-Vs. 6 Soft is supple gladent 4-U-Vs. 6 Soft is supple gladent 4-U-Vs. 6 Soft is supple gladent 4-U-Vs. 7 Soft is suppl	on '	itey	Caleg	Ol y			Descriptio	n		Rating			Description	n		Rating		[Description	n		Rating			Descri	ption	R	Rating
South Debrish Debris	0	1		1	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe grad	ient >	60%.		8
South Debrish Debris		2	Mass ero	sion			past or	future m	ass	3				ed over.	Low	6				ing sedi	iment	9				ırly	12	
Part Common Com		3	potential		channel	l area.				2	limbs.		-	_		4	larger s	izes.	-		-	6	predomi	nantly la	arger s	izes.		8
Page Channel Superior Sup		4	bank		suggest	a deep		_			less vig	or sugg	,			6	fewer s	pecies f	rom a sl	nallow,	nd	9	vigor ind	icating p	oor, c			12
Some new bar increase, mostly from consideration of new gravel. 19 Constructions and deflections and deflections and deflections and deflections and deflections to the constructions and deflections are the constructions and deflections the constructions are designed to the constructions and deflections are the constructions and deflections are the constructions. Raw banks may be up to 12". The construction of the constructions and deflections are the constructions and deflections are the constructions. Raw banks may be up to 12". Some new bar increase, mostly from constructions and believe the constructions. Raw banks may be up to 12". Some new bar increase, mostly from constructions and deflections are designed to the constructions. Raw banks may be up to 12". Some new bar increase, mostly from constructions and deflections and deflections are designed to 12". Almost overhange and stoughing evident. Like and coarse sand on old and some particles and coarse sand on old and some point bars. The constructions and wards are constructions and deflections and deflections and deflections and deflections. Raw banks may be up to 12". Almost overhange evident. Some deposition of new gravel and coarse sand on old and some particles. Accelerated bar development. It is a surfaces. Some deposition of the deposition of the constructions and where grades some deposition in pools.		5	Channel		stage. Wid reference	dth/depth i width/dep	ratio depar	ture from		1	Width/dep	th ratio de th ratio = 1	eparture fro	m referer	nce	2	ratio departure from reference width/depth ratio		leparture from reference width/depth ratio		3	common w ratio depar	ith flows le ture from r	ess than referenc	bankfull. Width/depth e width/depth ratio > 1		4	
Part	2	6			12"+ co	mmon.				2			y boulde	rs and s	small	4		6. Most	in the 3-	-6" diam	neter	6	or less.				3"	8
Part	D C	7		ons	pattern	w/o cutt				2	currents fewer an	and mind d less fir	or pool fill m.	ing. Obs	tructions	4	move wi	th high flo				6	cause ba	ank eros	sion ye	arlong. Sediment		8
9 Deposition Utility of no emargement of channel of point bars. 2 Some new bart increase, mostly from 8 8 and coarse sand on old and some new bars. 12 Exertisive deposit of precommanity frine particles. Accelerated bar development. 1 Rounded corners and edges. 2 Gorners and edges well rounded in 2 3 Well rounded in all dimensions, surfaces smooth. 3 Well rounded in 2 3 Well rounded in 2 3 Well rounded in 3 3 Well		8	Cutting			none. Ii	nfrequer	nt raw ba	anks	4	constric		•			6	_	Significant. Cuts 12–24" high. Root					-,		16			
10 Angularity Surfaces rough. 1 Surfaces smooth and flat. 2 dimensions. 3 mixture dull and bright, i.e., 35–65% 3 Predominantly bright, > 65%, exposed or mixture range. 2 mixture range. 2 mixture range. 3 mixture range. 3 Predominantly bright, > 65%, exposed or mixture range. 4 Mostly dull, but may have <35% bright 2 mixture range. 4 Mostly dull and bright, i.e., 35–65% 3 Predominantly bright, > 65%, exposed or mixture range. 3 Predominantly bright, > 65%, exposed or mixture range. 4 Mostly ducle assortment with no apparent overlap. 6 easily moved. 12 Souring and deposition 4 Mostly ducle assortment with no apparent overlap. 6 easily moved. 12 Moderate change in sizes. Stable materials 20–50%. 12 Moderate change in sizes. Stable materials 20–50%. 13 Moderate change in sizes. Stable materials 20–50%. 14 More than 50% of the bottom in a state of the position. 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 Doctor thanks tooks slick. 2 Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. 2 Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. 2 Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick. 2 Province that a 2 Province that 2 Provinc		9	Depositio	on			irgement	t of char	nel or	4			increase	, mostly	y from	8	and coa	arse san rs.	d on old	l and so	me	12					16	
1 Stream type A1 A2 A3 A4 A5 A6 B1 B2 B3 B4 B5 B6 C1 C2 C3 C4 C5 C6 D3 D4 D5 D6 C3 C4 C5 C6 D3 D4 D5 D6 C5 C6 C6 D3 D4 D5 D6 C5 C5 C5 C5 C5 C5 C5 C		10		y	surfaces	s rough.	-		е	1	Surface	s smoo	th and fla	at.		2	dimens	ions.				3	smooth.			·		4
Scuring and deposition Size personal language evident Stable Size personal language Size pers		11		ss	General	lly not b	right.				surface	3.			% bright	2	mixture range.		3	scoured	surface	s.		r	4			
14 Scouring and deposition 45% of bottom affected by scour or deposition. 6 6 6 6 6 6 6 6 6	Į L	12	particles		overlap	ping.				2	overlap	oing.				4	appare	nt overla	ар.			6						8
14 Scouring and deposition Scouring and deposition Scouring and deposition Advantage Advan		13				•		. Stable		4	50–80%	· .			aterial	8	materia	ıls 20–50	0%.			12				ange. Stable		16
Adundant grown moss-like, dark green perennial. In swift water too. 1		14	•				affected	by scou	ir or	6	constric	tions ar	nd where	grades		12	at obstr	uctions,	constri	ctions ar		18					of	24
Stream type		15				•										2	backwa	iter. Sea	sonal a		wth	3						4
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 67-98 Fair (Mod. unstable 44-47 44-47 91-129 96-132 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 Proor (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 108-132 1		•		•			Exc	ellent	total =	21				Good	total =	8				Fair	total =	30				Poor tota	I =	12
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 67-98 Fair (Mod. unstable 44-47 44-47 91-129 96-132 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 Proor (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 G6 G0-85 G0-85 G0-85 85-110 85-110 90-115 80-95 40-60 40-60 85-107 85-107 90-112	am tvne	e	Δ1	Δ2	Δ3	Δ4	Δ5	Δ6	R1	B2	ВЗ	B4	B5	B6	C1	C2	C3	C4	C5	C6	DЗ	D4	D5	D6				
Fair (Mod. unstable																										Grand total :		71
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 64-86 64-86 64-86 86-105 86-105 111-125 1	Mod. uns	stable	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				С	C6c-
Good (Stable) 40-63 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 Stream type = Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 87-99 97+ 87+ 106+ 106+ 126+ 126+ 126+ 131+ 111+ 79+ 79+ 121+ 121+ 126+ 126																							- 1					
Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 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																											_ C	:6c-
		-	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				Modified c	nanne	el .
	(Unstable	le)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability ra	ting =	-
*Rating is adjusted to potential stream type, not existing. Good																		*Ra	ting is a	djusted t	to poten	tial strea	am type, i	not exist	ting.	Goo	t	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	rosion rate.											
			Estim	ating Nea	r-Bank St	ress (NB	S)					
Stream:	Red Ri	ver			Location:	Red River	- 4 - 452.5	2				
Station:	49.06			S	tream Type:	C6c-	\	/alley Type:	X			
Observe	rs:	KD, JB						Date:	11/16/10			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chanr	nel pattern	, transverse ba	or split channe	el/central bar cr	eating NBS		Level I	Recona	nissance			
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})		Level II	General	prediction				
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ_{nb}	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Veloci	ty profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation			
_												
Levell	(1)											
				meander mig		ging flow		Nt	oo = Extreme			
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)							
			()									
_					Near-Bank							
= 	(2)	Pool Slope	Average		Stress			inant				
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)		Near-Bai	nk Stress				
_							Very	Low				
					Near-Bank							
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress							
	(-)	S _p	S _{rif}	S _{rif}	(NBS)							
		Near Deal										
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress							
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)							
=												
Level III				Near-Bank			Bankfull					
Le		Near-Bank	Naar Daul	Shear			Shear		Near-Bank			
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Stress			
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
≥		Velocity Grad	lient (ft / sec	Near-Bank Stress								
Level IV	(7)	/ f	·	(NBS)								
Le		0.		Very Low								
					J	04	10) D. (
Noor B	ank Ct-	Cor ess (NBS)	iverting Va	liues to a l	Near-Bank	Stress (NE ethod numb						
iveai-b	rating		(1)	(2)	(3)	etnoa numi (4)	(5)	(6)	(7)			
	Very Lo		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			
	Modera		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 Hi		(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			
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40			
				Overall Near-Bank Stress (NBS) rating Very Low								

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Stream: Red River - 4 - 452.52									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	14428.3		Date:	11/16/2010			
Observers:	KD, JB		Valley Type:	Χ		Stream Type:	C6c-			
(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.	High	Very Low	0.165	14428.3	16.1	38329	0.13			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Col	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft³/yr)	38329				
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (ft ³ /yr) by 27}	Total Erosion (yds³/yr)	1420				
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds³/yr)	Total Erosion (tons/yr)	1845				
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.13										

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

Stream:	Red River				Stream Type:	C6c-		
Location:	Red River	- 4 - 452.52			Valley Type:	Х		
Observers:	KD, JB				Date:	11/16/2010		
Enter Req	uired Infor	mation for Exist	ing Condit	tion				
0.0028	D ₅₀	Riffle bed mater	ial D ₅₀ (mm)					
0.0028	D ₅₀	Bar sample D ₅₀	(mm)					
9.19E-06	D_{max}	Largest particle	from bar san	nple (ft)	0.0028	(mm)	304.8 mm/ft	
0.00017	S	Existing bankfull	l water surfac	ce slope (ft/ft)				
13.7	d	Existing bankfull	l mean depth	n (ft)				
1.65	γ_{s}	Submerged spe	cific weight c	of sediment				
Select the	Appropria	te Equation and	Calculate	Critical Dimen	sionless She	ar Stress		
1	D ₅₀ /D [^] ₅₀	Range: 3-7		Use EQUATION	1: $\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}	
1	D _{max} /D ₅₀	Range: 1.3 – 3.	0	Use EQUATION 2	2: $\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}	
0.0384	τ*	Bankfull Dimens	sionless Shea	ar Stress	EQUATIO	ON USED:	2	
Calculate E	Bankfull Me	an Depth Requir	ed for Entr	ainment of Larg	est Particle ir	Bar Sampl	е	
0.003424	d	Required bankfu	ıll mean dept	th (ft) d =	$=\frac{\tau * \gamma_s D_{max}}{s}$	(use	D _{max} in ft)	
	Check:	□ Stable □ A	Aggrading	☐ Degrading				
Calculate Sample	Bankfull W	ater Surface Slo	ope Requir	ed for Entrainn	nent of Large	st Particle	in Bar	
4.25E-08	S	Required bankfu	ıll water surfa	ace slope (ft/ft)	$S = \frac{\tau * \gamma_s L}{d}$) max (use	D _{max} in ft)	
	Check:	☐ Stable ☐ A	Aggrading I	□ Degrading				
Sediment	Competen	ce Using Dimen	sional She	ar Stress				
0.14533	Bankfull st	near stress τ = γd	IS (lbs/ft ²) (se	ubstitute hydraulio	radius, R, with	mean depth,	d)	
γ = 62.4, d = existing depth, S = existing slope								
9 Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)								
0.002 Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)								
13.7		mean depth requir			asured D _{max} (m	Q = -	<u></u>	
	•	ted shear stress, γ slope required to in			D (mm)	τ	'S	
0.00017		slope required to it ted shear stress, γ			D _{max} (IIIII)	$S = \frac{\iota}{\gamma d}$		

Worksheet 3-15. Bar sample data collection and sieve analysis form.

Su	Strea		Red R				SAMP		Loca				4 - 452		ervers:	110,0			Date: 1 1	1/16/201	0
b		→		→(⇒(⇒(→		⇒(⇒(→(⇒(
a m		h Pan ICKET	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm			
p I	Tare v	weight	Tare	weight	Tare	weight	Tare v	veight	Tare v	veight	Tare v	veight	Tare v	weight	Tare	weight	Tare	weight		SURFAC 1ATERIA	
e s	Sample		Sample		Sample	_	Sample		Sample		Sample		Sample	_	Sample		Sample		(Two	DATA largest pa	articles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	N	o. Dia.	WT.
2																				-	VV 1.
3																			l —	2	
4																			Bucket +		
5																			materials		
6																			weight		
7 8																			Bucket tare weight	9	
9																			Materials		
10																			weight		0
11																			Materials les	ss	
12																			man.		mm
14																				Be sure to	
15															-					weights to	o grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0		
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		V	
Accum	n. % =<	#####	\Rightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####	\longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	#####	\Longrightarrow	100%	G	RAND TO	OTAL
S	ample lo	cation no	otes				Sar	nple loc	ation ske	etch											

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River - 4 - 452.52	Valley Type: X
Observers:	KD, JB	Date: 11/16/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-	
Location: Red River - 4 - 45	52.52		Valley Ty	_{/pe:} X	
Observers: KD, JB			Da	ate: 11/16/2010	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-		
Location: Red River - 4	- 452.52		Valley Type:	Х		
Observers: KD, JB			Date:	11/16/2010		
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected	
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)	
Sediment 1 competence (Worksheet 3-14)	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)		
Sediment capacity (POWERSED)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2	
	(2)	(4)	(6)	(8)		
Stream succession 4 states (Worksheet 3- 16)	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)		
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1	
3-5)	(1)	(2)	(3)	(4)		
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1	
	(1)	(2)	(3)	(4)		
				Total points	10	
	Vertical stal		int range for exces adation	ss deposition /		
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River Stream Type: C6c-										
Location: Red River - 4	- 452.52		Valley Type:	X						
Observers: KD, JB			Date:	11/16/2010						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected					
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
	(2)	(4)	(6)	(8)						
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
	(2)	(4)	(6)	(8)						
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	2					
(Worksheet 3-7)	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2					
	(2)	(4)	(6)	(8)						
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
3-9)	(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 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-										
Location: Red River - 4 -	452.52		Valley Type:	X						
Observers: KD, JB			Date:	11/16/2010						
Channel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected					
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)					
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2					
	(2)	(4)	(6)	(8)						
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4					
	(2)	(4)	(6)	(8)						
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2					
(Worksheet 3-18)	(2)	(4)	(6)	(8)						
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2					
(Worksheet o 15)	(2)	(4)	(6)	(8)						
Total points 10										
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	Stream: Red River Stream Type: C6c-										
Lo	cation: Red River - 4 - 4	52.52		Valley Type:	Х						
Ob	servers: KD, JB			Date:	11/16/2010						
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points						
		Stable		1							
1	Lateral stability	Mod. unstab	ole	2	2						
'	(Worksheet 3-17)	Unstable		3	2						
		Highly unsta	able	4							
	Vertical stability	No deposition	on	1							
2	excess deposition/	Mod. depos	ition	2	1						
-	aggradation	Excess dep	osition	3	'						
	(Worksheet 3-18)	Aggradation	1	4							
	Vertical stability	Not incised		1							
3	channel incision/	Slightly inci	sed	2	4						
3	degradation	Mod. Incised	d	3	1						
	(Worksheet 3-19)	Degradation	1	4							
	Channel anlargement	No increase		1							
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1						
~	3-20)	Mod. increa	se	3	•						
	3 20)	Extensive		4							
	Pfankuch channel	Good: stable	e	1							
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	1						
١	10)				•						
	10)	Poor: unsta	ble	4							
				Total Points	6						
			Category p	oint range							
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 —	Very High 16 – 20 □						

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River				Location	: Red R	iver - 4 -	452.52		
Observers:	KD, JB	Dat	e: 11/16	/2010	Strea	ım Type:	C6c-	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 10.3	Mean bankfull , width (ft):	159.5	Cross-section area (ft ²):	1633	Width o	f flood- rea (ft):	709	Entrenchment ratio:	4.4
Channel Pattern	Mean: Range: MWR:	17.2 Lm/V		17.2	Ro	c/W _{bkf} :	3	.6	Sinuosity:	2.17
	Check: Riffle/pool	 	Plane		Converge	ence/dive		✓ Dunes/	antidunes/smooth	bed
River Profile and Bed	Max Riffle	Pool	h ratio	Riffle	Pool	_ Pool t			Slope	
Features	bankfull depth (ft):	(max/	mean):	1.5		pool spacin	g:	Valley:	Avera bankf	ull: 0.00017
	Tupanan	nt composition/density:	Po	tential composit	ion/density	y:	Remarks:	Condition, vig	or and/or usage of exis	ting reach:
	vegetation									
	Flow P1, 2, Strear regime: 7, 8, 9 and or	N-4	Meand patter		M2	Deposit pattern	(s):	NONE	Debris/channel blockage(s):	D2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.1 Degree of stability	of incisior rating:	ີ Sta	able			h stability ractive ratino	•	Good
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	15.5	Width/depth (W/d) / (W/d)		tate	1.0		tio state / rating:	Stable
	Meander Width Ratio (MWR):	17.2 Reference MWR _{ref} :	17.2	Degree of o		nent	1.0		MWR _{ref} / rating:	confined
Bank Erosion Summary	Length of reach studied (ft):	428	eambank tons/yr)	erosion rate: 0.13 (ton	s/yr/ft)	Curve Fig		Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient ca	apacity	□ Excess	capacity	,	Remarks:			
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$	1	_	Existing depth _{bkf} :		Required depth _{bkf} :		_	quired pe _{bkf} :
Successional Stage Shift	C → E -	→	_	→	—		sting strea e (type):	m Ce	Potential streated state (type):	C6c-
Lateral Stability	☐ Stable 🔽	Mod. unstable	□ Uns	table	☐ High	hly unsta	ble Rer	narks/cause	^{S:} None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	□ Ex.	deposition	☐ Agg	gradation	Ren	narks/cause	s: None	
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	☐ Mod	l. incised	□ Deg	gradation	Ren	narks/cause	s: None	
Channel Enlargement	✓ No increase	Slight increase	☐ Mod	l. increase	□ Exte	ensive	Ren	narks/cause	^{S:} None	
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High	☐ Very hiç	Rema	arks/caus	es: No i	ne		

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

			Riparian Ve	getation	
Stre	eam: Red R	iver		Location: Red River - 5 -	463 56
	servers: KD, JI		Reference reach	Disturbed (impacted reach) Date:	11/19/2010
spe	sting cies nposition: Trees	, cockleburs, g	rass	Potential species composition: Trees, cockleb	urs, grass
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	80% with leaves, 5% without leaves	1%	trees	100%
	I.				100%
2. Understory	Shrub layer		3%	cockleburs	100%
					100%
level	Herbaceous		5%	grass	100%
3. Ground level	Leaf or needle litter		0%	Remarks: Condition, vigor and/or usage of existing reach:	100%
	Bare ground		91%	None	
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%		

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

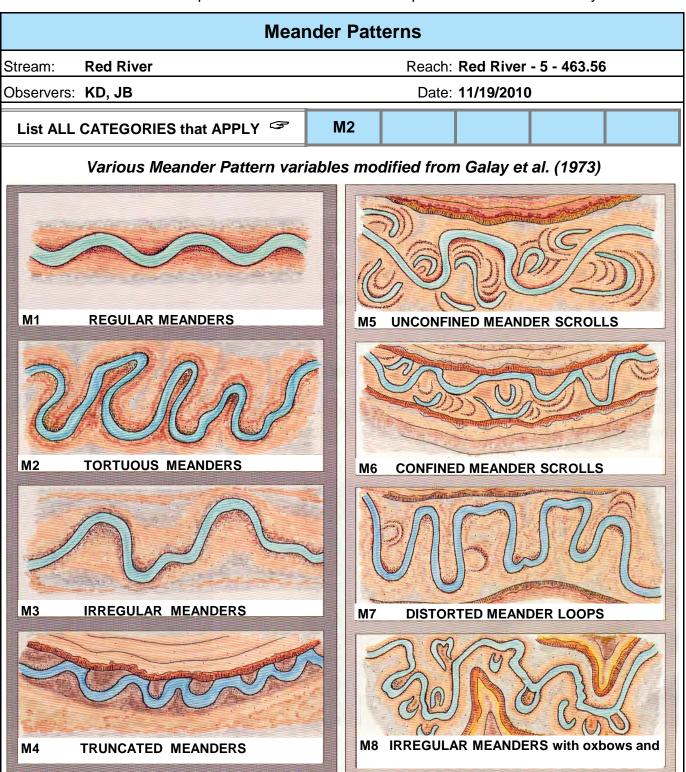
FLOW REGIME													
			LOW	KEGIIVII									
Stream:	Red River		Location:	Red Rive	er - 5 - 46	3.56							
Observers:							Date:	11/19/20	10				
	COMBINATIONS that	P1	P2	P7	P9								
APF	APPLY												
General C	General Category												
E													
S	Subterranean stream ch surface flow that follows			llel to and	l near the	surface fo	or various	seasons	- a sub-				
ı	Intermittent stream char associated with sporadic losing/gaining reaches c	and/or s	seasonal f	lows and	also with	Karst (lim	estone) g	jeology w	here				
Р	Perennial stream chann	Perennial stream channels: Surface water persists yearlong.											
Specific (Category												
1	Seasonal variation in str	eamflow	dominated	d primarily	y by snow	melt runc	ff.						
2	Seasonal variation in str	eamflow	dominated	d primarily	y by storm	nflow runc	off.						
3	Uniform stage and asso	ciated str	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.					
4	Streamflow regulated by	/ glacial r	melt.										
5	Ice flows/ice torrents fro	m ice daı	m breache	es.									
6	Alternating flow/backwa	ter due to	tidal influ	ence.									
7	Regulated streamflow d	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	d runoff.											

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

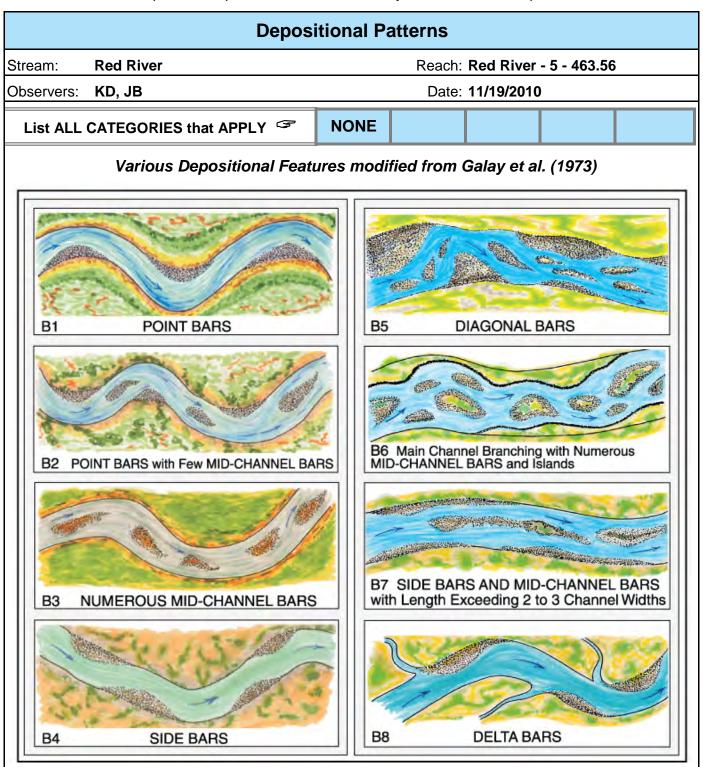
Stream Size and Order											
Stream:	Red River										
Location:	Red River - 5 -	463.56									
Observers:	KD, JB										
Date:	11/19/2010										
Stream Siz	e Category and	l Order 🍜	S-8								
STREAM SIZE: Bankfull Check (✓) Category width appropriate											
meters feet category											
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									
	Strear	n Order									
Add categoria	as in naranthasis	for enacific etras	m order of								

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

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



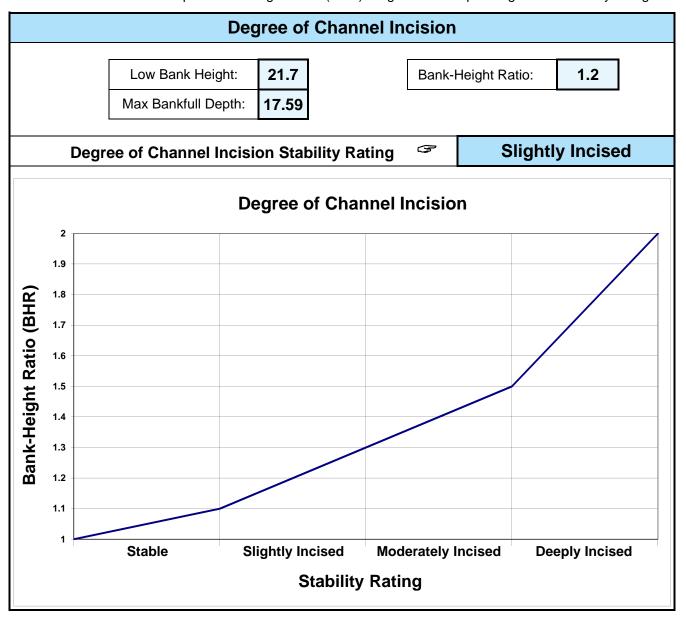
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



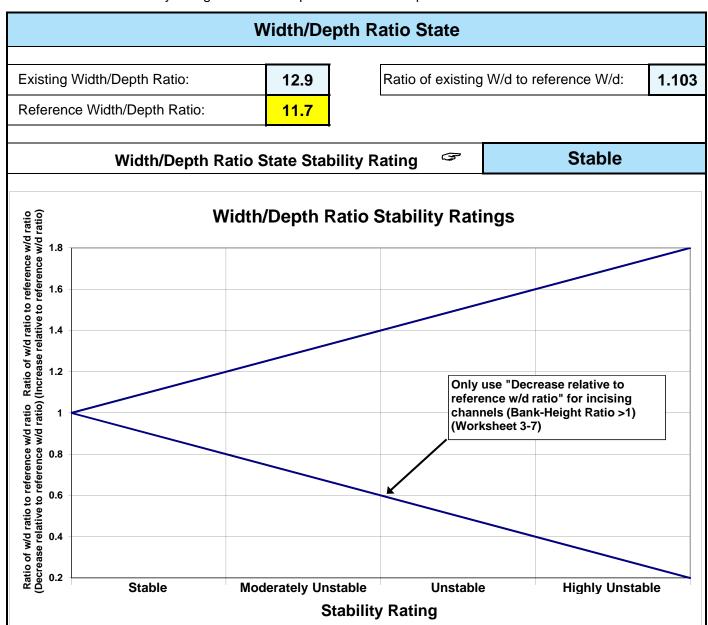
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages							
Strea	m: Red River	Location: Red River - 5 - 463.56						
Obse	rvers: KD, JB	Date: 11/19/2010						
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply					
D1	None	Minor amounts of small, floatable material.						
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	~					
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.						
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.						
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.						
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.						
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.						
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.						
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.						
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.						

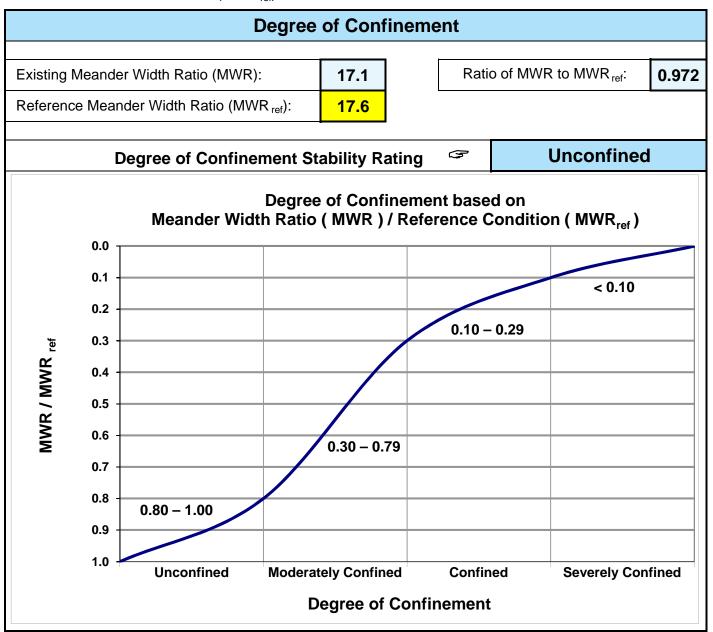
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



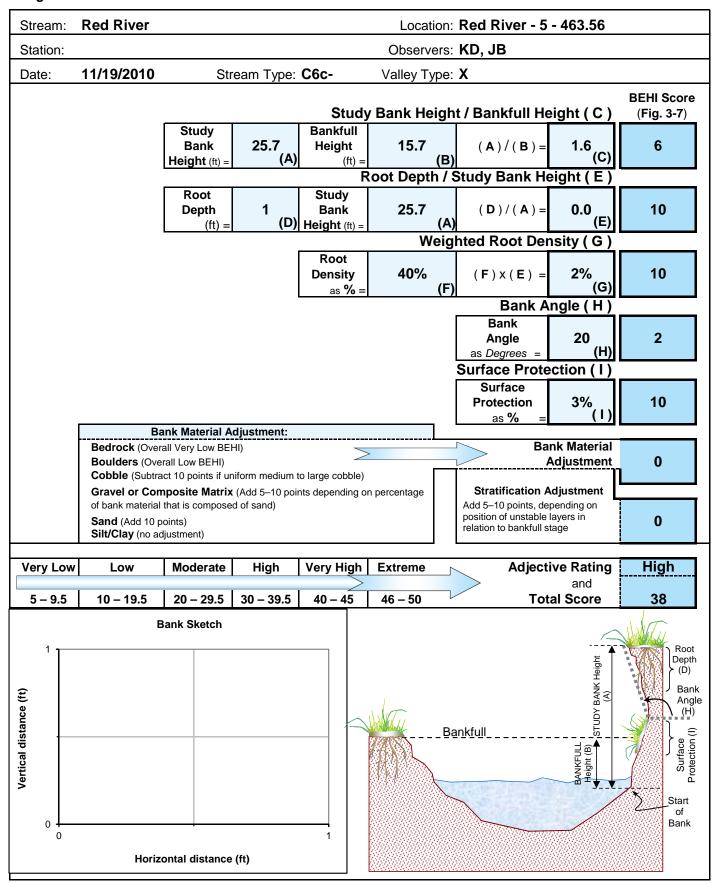
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River					Loc	ation:	Red F	River -	5 - 46	63.56		Valley	Type:	Χ		Obse	ervers:	KD, .	IB				Date: 11/19/2	010
Loca-	Key	Categ	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Ney	Caleg	JOI Y			Descriptio	n		Rating		D	Description	n		Rating		[Description	on		Rating			Descri	ption	Rating
6	1	Landforn slope	n	Bank sle	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	- 60%.		6	Bank slo	ope gra	dient >	60%.	8
Upper banks	2	Mass ero	osion	No evid erosion		past or	future m	nass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9		requent or large, causing sedime earlong OR imminent danger of s			12
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	izes.		ounts, m		6	Moderat predomi	inantly I	arger s	izes.	8
O	4	Vegetati bank protectio			t a deep	nsity. Vi			3		or sugge	y. Fewer est less			6	fewer s		rom a sl		ind	9		dicating	poor, c	rer species and less discontinuous and	12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/d	oth ratio	3	common w	vith flows rture from	less than referenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4 .3.	4
nks	6	Bank roo content	ck	12"+ co	mmon.	ge angula			2	cobbles	6–12".	y boulde			4	class.			-6" diam		6	or less.			of gravel sizes, 1–3	8
Lower banks	7	Obstruct to flow	tions		w/o cutt	s firmly ir ting or d			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		th high flo		able obst sing bank		6	Frequent obstructions cause bank erosion ye traps full, channel migr			arlong. Sediment	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks				ently at o aw bank			6				l" high. I ughing (12				s, some over 24" ings frequent.	16
	9	Deposition	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba	arse san		new gra		12				predominantly fine ed bar development.	
	10	Rock angularit		surface	s rough.			е	1	Surface	s smoot	rs and e th and fla	at.		2	dimens	ions.		ll rounde		3	smooth.			nensions, surfaces	4
	11	Brightne		Genera	lly not b				1	surface	S	may hav		6 bright	2	mixture	range.		i.e., 35-		3	scoured	surface	es.	> 65%, exposed or	4
шc	12	Consolida particles		overlap	ping.	tightly p			2	overlap	oing.	ked with			4	apparei	nt overla	ap.	nt with n		6	No packing evident. Loc easily moved.		•	8	
Bottom	13	Bottom s distributi		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable	16
	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions an	nd where depositi	grades		12	at obstr		constri	ctions a		18				bottom in a state of earlong.	24
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow- m may be present.	4
						Exc	ellent	total =	23				Good	total =	10				Fair	total =	15				Poor total	= 20
Stream ty	pe	A1	A2	А3	Α4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stabl	le)	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		Grand total =	68
Fair (Mod. u Poor (Unsta	ıble)	48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110 111+	91-110 111+	106+	133+	133+	32 108-132 99-125 133+ 126+		Existing stream type =	C6c-	
Stream ty	_	DA3 40-63	DA4	DA5 40-63	DA6 40-63	E3 40-63	E4 50-75	E5 50-75	E6 40-63	F1 60-85	F2 60-85	F3 85-110	F4 85-110	F5 90-115	F6 80-95	G1 40-60	G2 40-60	G3 85-107	G4 85-107	G5 90-112	G6 85-107				*Potential stream type =	C6c-
Good (Stabl			40-63																							
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified ch	
Poor (Unsta	inie)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+ ting is a	121+ djusted	126+ to poten	121+ tial strea	ım type,	not exis	sting.	stability rat Good	•
	*Rating is adjusted to potential stream type, not existing. Good																									

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.													
			Estim	ating Nea	r-Bank St	ress (NB:	S)						
Stream:	Red Ri	ver			Location:	Red River	- 5 - 463.5	6					
Station:	0			S	tream Type:	C6c-	1	/alley Type:	Χ				
Observe	rs:	KD, JB						Date:	11/19/10				
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)						
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance				
(2) Ratio	of radius o	of curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction				
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction				
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction				
(5) Ratio	Ratio of near-bank maximum depth to bankfull mean depth (d _{nb} / d _{bkf}) Level III Detailed predict												
(6) Ratio	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb}/τ_{bkf}) Level III Detailed predict												
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation				
=					or discontinuo								
(1) Extensive deposition (continuous, cross-channel)													
Ľ				meander mig	ration, conver	ging flow		NL	BS = Extreme				
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank								
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)								
		,	()	5.0									
					Near-Bank								
e	(2)	Pool Slope	Average		Stress		Dom	inant	Ī				
Level II	(3)	Sp	Slope S	Ratio S _p / S	(NBS)	1	Near-Bai	nk Stress					
_							Very	Low					
					Near-Bank				_				
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress								
	(- /	S _p	S _{rif}	S _{rif}	(NBS)	1							
		N. D. I				ļ							
		Near-Bank Max Depth	Mean Depth	<i>Ratio</i> d _{nb} /	Near-Bank Stress								
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)								
=													
Level III				Near-Bank			Bankfull						
Le		Near-Bank	Na an Danie	Shear			Shear		Near-Bank				
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	3 -	Stress τ _{bkf} (Ratio τ _{nb} /	Stress				
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)				
≥		Velocity Cros	dient (ft / sec	Near-Bank Stress									
Level IV	(7)	/ f		(NBS)									
Le			02	Very Low]								
			Į.		y 	04	10) D. (
Noor B	lank St-	Cor ess (NBS)	iverting Va	liues to a l	Near-Bank	Stress (NE ethod numb							
iveai-E	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)				
	Very Lo		N/A	> 3.00	< 0.20	< 0.40							
	Low		N/A 2.21 – 3.00 0.20 – 0.40 0.41 – 0.60										
	Modera		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					1.15 – 1.19	1.61 – 2.00				
	Very Hi		(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	1.81 – 2.50 2.51 – 3.00	1.20 – 1.60	2.01 – 2.40				
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40				
-					lear-Bank S				Low				

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	: Red River - 5 - 463.56									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4916.7		Date:	11/19/2010			
Observers:	KD, JB		Valley Type:			Stream Type:				
(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)] (ft³/yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	4916.7	25.7	20849	0.20			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosion	n subtotals in Colu	ımn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	20849				
Convert eros	sion in ft ³ /yr to yd:	s ³ /yr {divide T	otal Erosion (f	ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	772				
Convert eros by 1.3}	sion in yds ³ /yr to t	ons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	1004				
	osion per unit leng total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.20				

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

Stream:	Red River		S	tream Type:	C6c-					
Location:	Red River	- 5 - 463.56		Valley Type:						
Observers:	KD, JB			Date:	11/19/2010)				
Enter Req	uired Infor	mation for Existing Con	dition							
	D ₅₀	Riffle bed material D ₅₀ (m	m)							
	D ₅₀	Bar sample D ₅₀ (mm)								
	D _{max}	Largest particle from bar	sample (ft)		(mm)	304.8 mm/ft				
	S	Existing bankfull water su	ırface slope (ft/ft)							
	d	Existing bankfull mean de	epth (ft)							
1.65	γ_s	Submerged specific weig	ht of sediment							
Select the	Appropria	te Equation and Calcula	ate Critical Dimensio	nless She	ar Stress					
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	$ au^*$	Bankfull Dimensionless S	hear Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample										
#DIV/0!	d	Required bankfull mean c	depth (ft) $d = \frac{\tau}{2}$	$S \times \gamma_s D_{max}$	(use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggradin								
Calculate Sample	Bankfull W	ater Surface Slope Req	uired for Entrainmer	nt of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water s	surface slope (ft/ft) S:	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggradin	g Degrading							
Sediment	Competen	ce Using Dimensional S	Shear Stress							
0	Bankfull sl	hear stress $\tau = \gamma dS$ (lbs/ft ²)) (substitute hydraulic ra	dius, R, with	mean depth,	d)				
	$\gamma = 62.4$, c	d = existing depth, S = existi	ing slope							
	Predicted	largest moveable particle siz	ze (mm) at bankfull shea	ar stress τ (F	igure 3-11)					
	Predicted	shear stress required to initi	ate movement of measu	ured D _{max} (m	m) (Figure 3	-11)				
#DIV/0!		mean depth required to initiated shear stress $N = 62.4$		ired D _{max} (mi	$\mathbf{d} = \frac{7}{1}$	<u></u>				
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, slope required to initiate mo	vement of measured D _n	_{nax} (mm)	$S = \frac{\tau}{vd}$	<u> </u>				
	τ = predic	ted shear stress, γ = 62.4, α	d = existing depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, JI	В		_			
u b	Strea	m:	Red R	River					Loca	tion:	Red R	liver -	5 - 463	.56					Date:	11/1	9/2010)
		→		→		⇒ (→		⇒ (⇒(→		→		⇒ (
a a		h Pan	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve	SIZE	Sieve	SIZE				
m p	Tare	CKET	Tare	mm weight	Tare	mm veight	Tare	mm weight	Tare v	mm	Tare	mm weight	Tare v	mm weight	Tare	mm weight	Tare	mm weight		SL	JRFACE	
1	Tare	voigni	Taic	weight	Tare	voigni	Taro	voigiti	raicv	veignt	Tare	Weight	Tare	weight	Tare	Weight	Tale	Weight			TERIAL DATA	S
e s	Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		Sample		Sample	l .	(Tv		rgest par	ticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Di-	\A/T
2																			┨	1 1	Dia.	WT.
3																			1	2		
4																			Bucket	+		
5																			materia			
6																			weigh			
8																			Bucket to weigh			
9																			Materia	als		
10																			weigh		()
11																			Materials			
12																			than:			mm
13																					e sure to a eparate m	
15																			//	/ w	eights to g tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	7	
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####				
Accum	1. % =<	#####	\longrightarrow	#####	\Rightarrow	#####	\Longrightarrow	#####	\Rightarrow	#####	\longrightarrow	#####	\Longrightarrow	#####		#####		100%	<u> </u>	GR	AND TO	TAL
	omple le	cation no	******	<u> </u>			Cor	nple loca	ation old	atob												
	ample io	cation ne	nes				Sai	Tiple loca	ation Ske	HUII												

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River - 5 - 463.56	Valley Type: X
Observers:	KD, JB	Date: 11/19/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-								
Location: Red River - 5 - 46	3.56		Valley Ty	_{/pe:} X								
Observers: KD, JB												
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected							
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)							
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2							
	(2)	(4)	(6)	(8)								
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1							
	(1)	(2)	(3)	(4)								
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3							
	(1)		(3)									
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)								
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1							
(Worksheet 3-9)	(1)	(2)	(3)	(4)								
				Total points	11							
	La	teral stability c	ategory point ra	inge								
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-	
Location: Red River - 5	- 463.56		Valley Type:	X	
Observers: KD, JB			Date:	11/19/2010	
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	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)	
Sediment capacity (POWERSED)	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)	
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2
	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheet 3- 16)	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)	
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1
3-3)	(1)	(2)	(3)	(4)	
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1
	(1)	(2)	(3)	(4)	
				Total points	10
	Vertical stat		int range for exces adation	s deposition /	
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River			Stream Type:	C6c-	
Location: Red River - 5	- 463.56		Valley Type:	X	
Observers: KD, JB			Date:	11/19/2010	
Vertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
	(2)	(4)	(6)	(8)	
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
	(2)	(4)	(6)	(8)	
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4
	(2)	(4)	(6)	(8)	
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1
3-9)	(1)	(2)	(3)	(4)	
				Total points	13
	Vertical stab	oility category poi degra	nt range for chan dation	nel incision /	
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 3-20. Channel enlargement prediction summary.

Stream: Red River			Stream Type:	C6c-	
Location: Red River - 5 -	463.56		Valley Type:	X	
Observers: KD, JB			Date:	11/19/2010	
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2
	(2)	(4)	(6)	(8)	
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4
	(2)	(4)	(6)	(8)	
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2
(Worksheet 3-18)	(2)	(4)	(6)	(8)	
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4
(Worksheet o 15)	(2)	(4)	(6)	(8)	
				Total points	12
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Red River			Stream Type:	C6c-	
Lo	cation: Red River - 5 - 4	63.56		Valley Type:	X	
Ob	servers: KD, JB			Date:	11/19/2010	
p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points	
		Stable		1		
1	Lateral stability	Mod. unstab	ole	2	2	
'	(Worksheet 3-17)	Unstable		3	2	
		Highly unsta	able	4		
	Vertical stability	No deposition	on	1		
2	excess deposition/	Mod. depos	ition	2	1	
-	aggradation	Excess depo	osition	3	ı	
	(Worksheet 3-18)	Aggradation	1	4		
	Vertical stability	Not incised		1		
3	channel incision/	Slightly inci	sed	2	2	
3	degradation	Mod. Incised	d	3	2	
	(Worksheet 3-19)	Degradation	1	4	_	
	Channal anlargament	No increase		1		
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2	
4	3-20)	Mod. increas	se	3	2	
	3-20)	Extensive		4		
	Pfankuch channel	Good: stable	e	1		
5	stability (Worksheet 3-	Fair: mod u	nstable	2	1	
١	10)				•	
	10)	Poor: unsta	ble	4		
				Total Points	8	
			Category p	ooint range		
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	High 11 – 15 □	Very High 16 – 20 □		

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River			Location:	Red River - 5	- 463.56		
Observers:	KD, JB	Date:	11/19/2010	Stream	Туре: С6с-	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft):	Mean bankfull width (ft):	3.1 Cross-section area (ft ²):	1581	Width of flood- prone area (ft):	949	Entrenchment ratio:	6.6
Channel Pattern	Mean: Range: MWR:	17.2 Lm/W _b		Rc/V	V _{bkf} :	3.1	Sinuosity:	2.42
	Check: Riffle/pool	☐ Step/pool ✓		Convergen	ce/divergence	<u></u> Dunes ℓ	/antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rati	ס	Slope	
Features	bankfull depth (ft): 17.6	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull	4 91-05
	Nipanan	nt composition/density:	Potential composi	tion/density:	Remarks	: Condition, vig	or and/or usage of existin	g reach:
	vegetation							
	Flow P1, 2, Stream regime: 7, 9 and o	rder:	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.2 Degree of stability rat	ting:	y iliciseu (Modified Pfanku (numeric and ac	djective rating	g):	ood
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	11.7 Width/dept (W/d) / (W/	:h ratio state /d _{ref}):	1.1		tio state y rating:	able
	Meander Width Ratio (MWR):	17.1 Reference MWR _{ref} :	Degree of (MWR / MV	confinemen NR _{ref}):	t 1.0		/ MWR _{ref} y rating: Unc o	onfined
Bank Erosion Summary	Length of reach studied (ft):	917	mbank erosion rate	ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	capacity	Remark	5:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :		isting Requ pe _{bkf} : slope	
Successional Stage Shift	→ -	→	→	→	Existing stre state (type):	eam Co	Potential stream state (type):	C6c-
Lateral Stability	☐ Stable •	Mod. unstable ☐	Unstable	☐ Highly	unstable R	emarks/cause	es: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	dation	emarks/cause	es: None	
Vertical Stability (Degradation)	□ Not incised	Slightly incised	Mod. incised	☐ Degra	adation	emarks/cause	es: None	
Channel Enlargement	☐ No increase №	Slight increase	Mod. increase	☐ Exten	sive	emarks/cause	es: None	
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very hi	gh	s/causes: N	one		

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

			Riparian Ve	getation			
Stre	eam: Red R	liver		Location:	Red	l River - 6 - 4	70.23
Obs	servers: KD, JI		Reference reach	I I (Impacted I X I II			11/18/2010
spe	sting cies nposition: Trees	, small cockleb	our bushes	es, small cod	cklebur bushes		
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species (comp	oosition	Percent of total species composition
Z				trees			100%
1. Overstory	Canopy layer	20% without leaves, 85% with leaves	2%				
							100%
2. Understory	Shrub layer		1%	cockleburs			100%
							100%
evel	Herbaceous		1%	grass			100%
3. Ground leve	Leaf or needle litter		0%	Remarks: Condition, vigo usage of existir			100%
	Bare ground		96%	None			
	ed on crown closure. sed on basal area to s	surface area.	Column total = 100%				

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

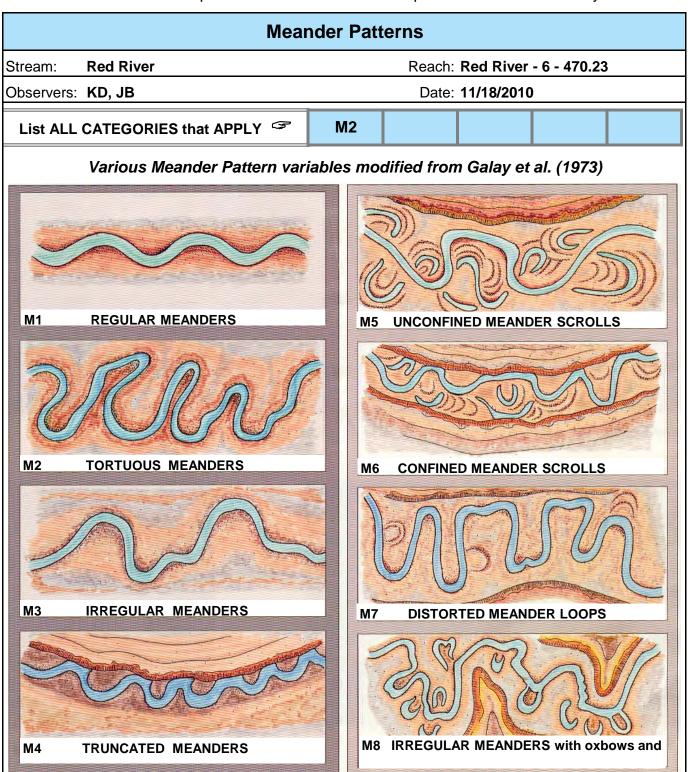
	·	F	LOW F	REGIMI	=						
		_									
Stream: Observers:	Red River		Location:	Red Rive	er - 6 - 47	0.23	Data:	11/18/20	10		
	COMBINATIONS that						Date.	11/10/20	10		
	PLY	P1	P2	P7	P9						
General Category											
E Ephemeral stream channels: Flows only in response to precipitation											
S	Subterranean stream char surface flow that follows the			llel to and	near the	surface fo	or various	seasons	- a sub-		
I	Intermittent stream channe associated with sporadic a losing/gaining reaches cre	and/or s	seasonal fl	ows and	also with	Karst (lim	estone) g	jeology w	here		
Р	Perennial stream channels	s: Surf	ace water	persists y	/earlong.						
Specific (Category										
1	Seasonal variation in strea	amflow	dominated	d primarily	/ by snow	melt runo	ff.				
2	Seasonal variation in strea	amflow	dominated	d primarily	by storm	nflow runc	off.				
3	Uniform stage and associa	ated str	eamflow c	lue to spr	ing-fed co	ondition, b	ackwater	, etc.			
4	Streamflow regulated by g	glacial n	nelt.								
5	Ice flows/ice torrents from	ice dar	m breache	s.							
6	Alternating flow/backwater	r due to	tidal influ	ence.							
7	Regulated streamflow due	to dive	ersions, da	ım releas	e, dewate	ring, etc.					
8	Altered due to developme conversions (forested to g										
9	Rain-on-snow generated r	runoff.									

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

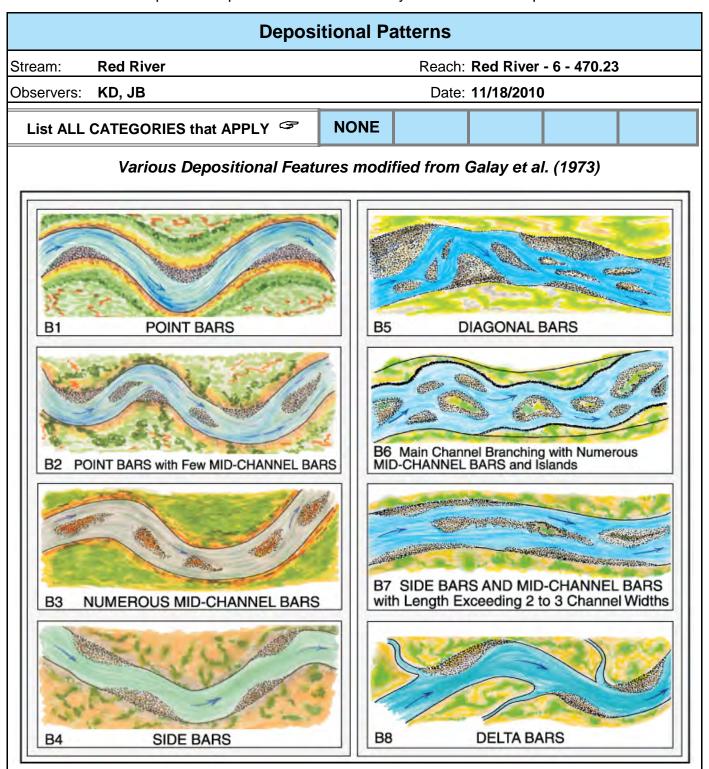
	Stream Siz	e and Orde	r							
Stream:	Red River									
Location:	Red River - 6 -	470.23								
Observers: KD, JB										
Date:	11/18/2010									
Stream Size Category and Order S-8										
STREAM SIZE: Bankfull Check (✓) Category width appropriate										
	meters	feet	category							
S-1	0.305	<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 categoria	es in parenthesis	for specific stream	m order of							

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

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



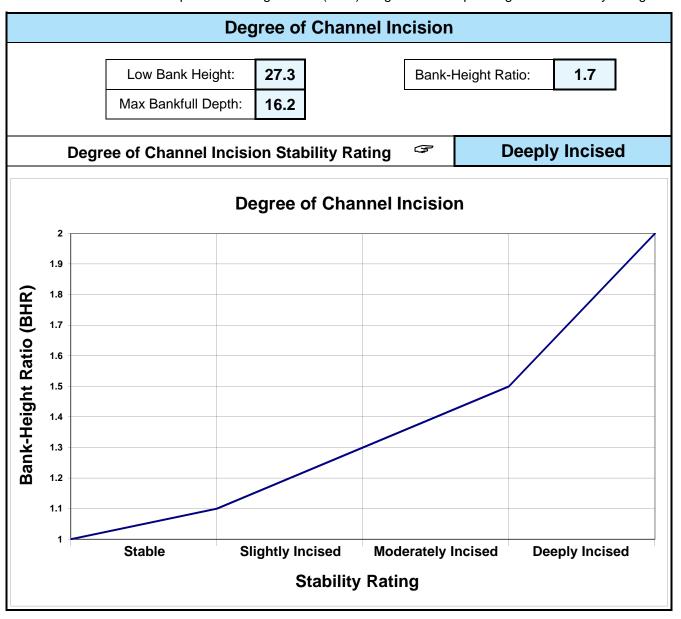
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



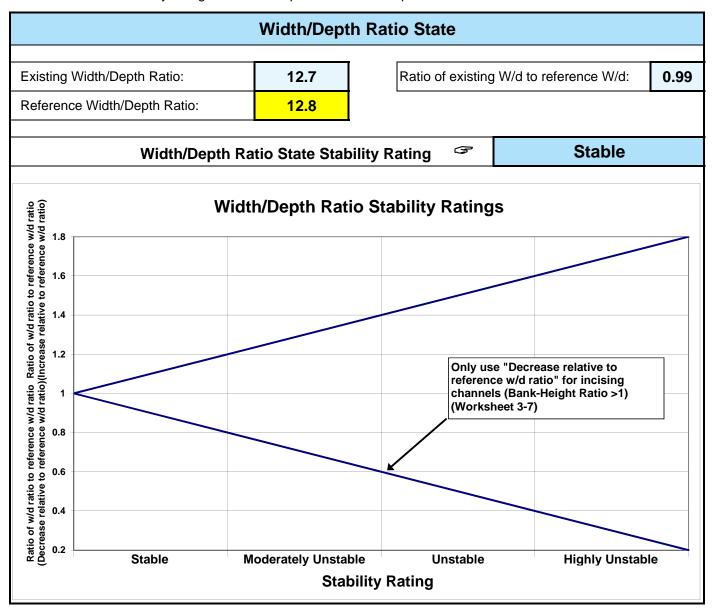
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Red River	Location: Red River - 6 - 470.23	
Obser	vers: KD, JB	Date: 11/18/2010	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	~
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

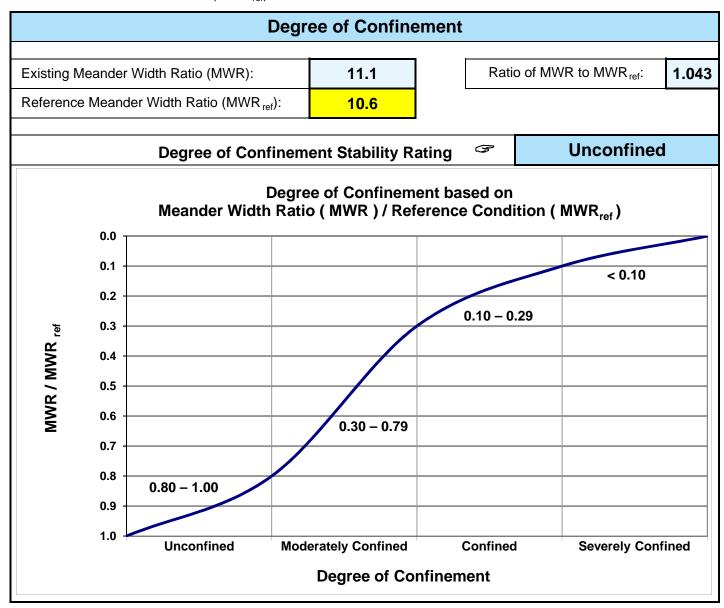
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



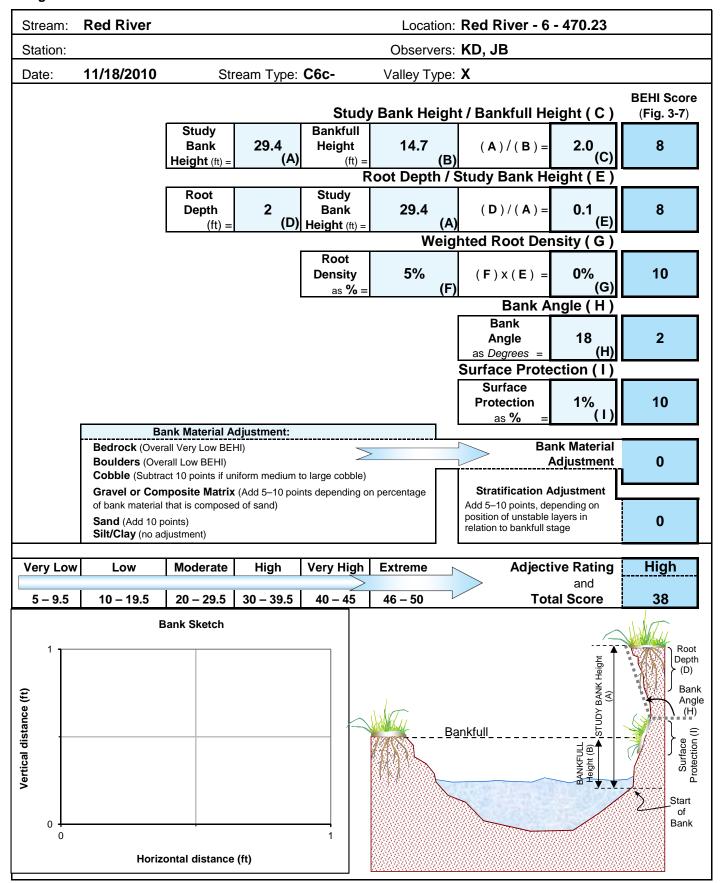
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River					Loc	ation:	Red F	River -	6 - 47	70.23		Valley	Type:	Χ		Obse	ervers:	KD,	JB				Date: 11/18/20	10																								
Loca-	Kov	Cotor	20 E)			Exce	llent					Go	od					Fa	air						Poor																									
tion	Key	Cate	gory		[Descriptio	n		Rating			Description	n		Rating		[Descriptio	n		Rating			Descr	iption	Rating																								
9	1	Landforr slope	m	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	lope gra	dient 40	-60%.		6	Bank s	lope gra	adient >	60%.	8																								
banks	2	Mass er	osion	No evid erosion		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or lar	ge, caus J.	ing sed	iment	9				sing sediment nearly t danger of same.	12																								
Upper	3	Debris ja potentia		Essenti channe	-	ent from	immedi	ate	2	Present limbs.	, but mo	ostly sma	all twigs	and	4	Modera larger s		avy amo	ounts, m	nostly	6		ate to he	•		8																								
ln	4	Vegetati bank protectio		sugges root ma	t a deep iss.	nsity. Vi , dense	soil-bind	ding	3	less vig root ma	or sugg ss.	y. Fewer est less	dense d	or deep	6	fewer s	pecies f	y. Lower rom a sl oot mas	nallow,	nd	9	vigor in shallow	dicating root m	g poor, (ass.	ver species and less discontinuous and	12																								
	5	Channel capacity		stage. Wi	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0–1.2. Ba	m referer	nce	2	ratio depa	arture from	t containe reference ight Ratio	width/dep	oth ratio	3	common	with flows	less than	ed; over-bank flows are a bankfull. Width/depth ce width/depth ratio > 1.4. 1.3.	4																								
ıks	6	Bank roo		12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	%. Most	in the 3-	-6" diam	neter	6	<20% r or less.	ock fraç	gments	of gravel sizes, 1–3"	8																								
Lower banks	7	Obstruct to flow			w/o cut	firmly ir ting or d			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		ith high fl	ent, unsta ows caus			6	cause l	oank ero	osion ye	and deflectors earlong. Sediment ration occurring.	8																								
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	_		s 12–24 and slo	_		12				s, some over 24" angs frequent.	16																								
	9	Depositi	ion	Little or point ba		ırgemen	t of char	nel or	4	Some n		increase	, mostly	/ from	8		arse sar	stion of ad on old			12		extensive deposit of predominantly finanticles. Accelerated bar development		,	16																								
	10	Rock angulari			edges ar s rough	nd corne	rs. Plan	е	1			rs and e	-		2	Corners dimens		dges wel	l rounde	ed in 2	3	smooth	/ell rounded in all dimensions, surfaces mooth.		4																									
	11	Brightne		Genera	lly not b				1	surface	S.	may hav		6 bright	2	mixture	range.	d bright,			3	Predominantly bright, scoured surfaces.				4																								
mo	12	Consolida	3	overlap	ping.	tightly p			2	overlap	ping.	ked with			4	appare	nt overla	•			6	easily moved.			·	8																								
Bottom	13	Bottom s distributi			change Il 80–10	e evident 0%.	. Stable		/	50–80%	, o.	ft light. S		aterial	8	materia	als 20–5	ge in siz 0%. ed. Depo			12		l distribu ils 0–20		ange. Stable	16																								
	14	Scouring deposition	_	<5% of deposit		affected	by scou	ır or	6	constric	tions ar	nd where depositi	grades		12	at obstr	ructions,		ctions a		18				bottom in a state of yearlong.	24																								
	15	Aquatic vegetation			Abundant growth moss-like, dark green perennial. In swift water too.		·		1		and pool areas. Moss here too		Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.		backwater. Seasonal algae growth		backwater. Seasonal algae growth		2 backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		backwater. Seasonal algae growth		3				e or absent. Yellow- om may be present.	4
						Exc	ellent	total =	23				Good	total =	0				Fair	total =	33				Poor total :	16																								
Stream ty	ре	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	Ī	One and 1 : 1 : 1	70																								
Good (Stab	•	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	67-98	1	Grand total =	72																								
Fair (Mod. u	ınstable		44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 91-110 91-110 86-105 108-132 108-132 108-			99-125 126+		Existing stream type =	C6c-																												
Stream ty		DA3	DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1 G2 G3 G4 G5 G6			_	*Potential	C6c-																													
Good (Stab		40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95				stream type =																															
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified cha																									
Poor (Unsta	able)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Pa	121+	121+	126+	121+	om tyrco	not ovi	icting	stability ratio	ng =																								
*Rating is adjusted to potential stream type, not existing.								Good																																										

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion	Tale.								
			Estim	ating Nea	r-Bank St	ress (NB:	S)		
Stream:	Red Ri	ver			Location:	Red River	- 6 - 470.2	3	
Station:	0			S	tream Type:	C6c-	\	/alley Type:	Χ
Observe	rs:	KD, JB						Date:	11/18/10
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)		
(1) Chanr	nel pattern	transverse ba	or split channe	el/central bar cr	eating NBS	Level I	Recona	aissance	
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p /S)			Level II	General	prediction
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction
(7) Veloci	ty profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation
=					or discontinuo				
Levell	(1)				channel) ration, conver				
				meander mig		ging now		INE	oo = Extreme
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress				
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)				
_					Near-Bank				-
Level II	(3)	Pool Slope	Average	5 / 6 / 6	Stress			inant	
Le	(0)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress	
							very	Low	ļ
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank				
	(4)	S _p	S _{rif}	S _{rif}	Stress (NBS)				
		F							
		Near-Bank			Near-Bank				
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress				
_	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)				
Level III				Naar Dark			Danlefull		ı
e ve		Near-Bank		Near-Bank Shear			Bankfull Shear		Name Danie
_	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank Stress
	(0)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)
>				Near-Bank					
Level IV	(7)	-	dient (ft/sec	Stress					
Lev	(-,	/ f		(NBS)	1				
_		0.	US	Very Low]				
			verting Va	lues to a l	Near-Bank		<u> </u>		
Near-B		ess (NBS)		(2)		ethod numb			
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Very Lo)W	N/A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 0.50
	Low	140	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
	Modera		N/A See	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)	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 Hi Extrem	_	Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40
	LAUGII	10	, 10016	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
	Overall Near-Bank Stress (NBS) rating Very Low								LOW

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	Red River -	6 - 470.23		
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	8419.4		Date:	11/18/2010	
Observers:	KD, JB		Valley Type:	X		Stream Type:	C6c-	
(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.	High	Very Low	0.165	8419.4	29.4	40843	0.23	
2.						0	#DIV/0!	
3.						0	#DIV/0!	
4.						0	#DIV/0!	
5.						0	#DIV/0!	
6.						0	#DIV/0!	
7.						0	#DIV/0!	
8.						0	#DIV/0!	
9.						0	#DIV/0!	
10.						0	#DIV/0!	
11.						0	#DIV/0!	
12.						0	#DIV/0!	
13.						0	#DIV/0!	
14.						0	#DIV/0!	
15.						0	#DIV/0!	
Sum erosior	n subtotals in Colo	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft³/yr) Total	40843		
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} Erosion (yds ³ /yr) 1513								
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	oly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	1966		
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.23		

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

Stream:	Red River		S	tream Type:	C6c-				
Location:	Red River	- 6 - 470.23	,	Valley Type:	Х				
Observers:	KD, JB			Date:	11/18/2010				
Enter Required Information for Existing Condition									
	D ₅₀ Riffle bed material D ₅₀ (mm)								
	D ₅₀	Bar sample D ₅₀ (mm)							
	D _{max}	Largest particle from bar	sample (ft)		(mm)	304.8 mm/ft			
	S	Existing bankfull water su	rface slope (ft/ft)						
	d	Existing bankfull mean de	pth (ft)						
1.65	γ_s	$\gamma_{ m s}$ Submerged specific weight of sediment							
Select the	Appropria	te Equation and Calcula	te Critical Dimensio	nless She	ar Stress				
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}			
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	τ* = 0.038	34 (D _{max} /D ₅	₀) ^{-0.887}			
#DIV/0!	τ*	Bankfull Dimensionless S	hear Stress	EQUATIO	ON USED:	#DIV/0!			
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample									
#DIV/0!	d	Required bankfull mean d	epth (ft) $d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggradin							
Calculate Sample	Bankfull W	ater Surface Slope Req	uired for Entrainmer	nt of Large	st Particle	in Bar			
#DIV/0!	s	Required bankfull water s	urface slope (ft/ft) S:	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggradin	g Degrading						
Sediment	Competen	ce Using Dimensional S	hear Stress						
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²)	(substitute hydraulic ra	dius, R, with	mean depth,	d)			
	$\gamma = 62.4$, o	d = existing depth, S = existi	ng slope						
	Predicted	largest moveable particle siz	ze (mm) at bankfull shea	ar stress τ (F	igure 3-11)				
	Predicted	shear stress required to initi	ate movement of measu	ıred D _{max} (m	m) (Figure 3	-11)			
#DIV/0!		mean depth required to initiated shear stress $N = 62.4.5$		red D _{max} (mı	$d = \frac{7}{1}$	<u>r</u> 'S			
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, S slope required to initiate mo	vement of measured D _n	_{nax} (mm)	$S = \frac{T}{2d}$	· •			
	τ = predic	ted shear stress, $\gamma = 62.4$, d	l = existing depth		γd				

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMF	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, J	В				
u b	Strea	ım:	Red R	liver					Loca	tion:	Red R	liver -	6 - 470).23					Date: 11/	18/201	0
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒(
a m		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE			
p I	Tare v	veight	Tare v	weight	Tare	weight	Tare	weight	Tare v	veight	Tare	weight	Tare	weight	Tare	weight	Tare	weight		URFACI ATERIAI	
e s	Sample v	veights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two l	DATA argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1																			No.	Dia.	WT.
3																			1 2		
4																					
5																			Bucket + materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials weight		0
11																			Materials less	3	
12																			than:		mm
13																				Be sure to separate n	
14																				weights to	grand
15 Net wt	total	0		0		0		0		0		0		0		0		0	0	total	
		#####		#####		#####		#####		#####		#####		#####		#####		#####		7	
	. % =<	#####		#####		#####	>	#####		#####		#####		#####	>	#####	\longrightarrow	100%		RAND TO	ΤΔΙ
			L						1 .		'						u (<u> </u>	CAND IC	/IAL
Sa	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream:	Red River	Stream Type: C6c-		
Location:	Red River - 6 - 470.23	Valley Type: X		
Observers:	KD, JB	Date: 11/18/2010		
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)		
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	✓ Stable		
	(E→C), (C→High W/d C)	☐ Moderately unstable		
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable		
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable		

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-				
Location: Red River - 6 - 47	0.23		Valley Ty	_{/pe:} X				
Observers: KD, JB Date: 11/18/2010								
Lateral stability criteria		Selected						
(choose one stability category for each criterion 1-5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)			
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2			
,	(2)	(4)	(6)	(8)				
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	В3	B5, B6, B7	1			
, ,	(1)	(2)	(3)	(4)				
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3			
,	(1)		(3)					
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)				
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1			
(Worksheet 3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-				
Location: Red River - 6	- 470.23		Valley Type:	X				
Observers: KD, JB			Date:	11/18/2010				
Vertical stability criteria	Vertical Stabil	Vertical Stability Categories for Excess Deposition / Aggradation						
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	Selected points (from each row)			
Sediment 1 competence (Worksheet 3-14)	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)				
Sediment capacity (POWERSED)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheet 3- 16)	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)				
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1			
3-5)	(1)	(2)	(3)	(4)				
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1			
	(1)	(2)	(3)	(4)				
				Total points	10			
	Vertical stat		int range for exces adation	s deposition /				
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River			Stream Type:	C6c-		
Location: Red River - 6	- 470.23		Valley Type:	X		
Observers: KD, JB			Date:	11/18/2010		
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected	
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)	
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
	(2)	(4)	(6)	(8)		
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
	(2)	(4)	(6)	(8)		
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8	
(WOIKSHEEL 3-1)	(2)	(4)	(6)	(8)		
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4	
	(2)	(4)	(6)	(8)		
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1	
3-9)	(1)	(2)	(3)	(4)		
				Total points	17	
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 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-								
Location: Red River - 6 - 4	470.23		Valley Type:	X				
Observers: KD, JB			Date:	11/18/2010				
Channel enlargement	Char	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Workshoot o 15)	(2)	(4)	(6)	(8)				
	Total points							
	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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	Stream: Red River Stream Type: C6c-								
Lo	cation: Red River - 6 - 4	70.23		Valley Type:	Х				
Ob	servers: KD, JB			Date:	11/18/2010				
C p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	/ Rating	Points	Selected Points				
		Stable		1					
1	Lateral stability	Mod. unstab	ole	2	2				
	(Worksheet 3-17)	Unstable		3	2				
		Highly unsta	able	4					
	Vertical stability	No deposition	on	1					
2	excess deposition/	Mod. depos	ition	2	1				
-	aggradation	Excess dep	osition	3	1				
	(Worksheet 3-18)	Aggradation)	4					
	Vertical stability	Not incised		1					
,	channel incision/ degradation	Slightly inci	sed	2	2				
l °		Mod. Incised	d	3					
	(Worksheet 3-19)	Degradation	1	4					
	Channel anlargement	No increase		1	2				
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2					
~	3-20)	Mod. increa	se	3					
	3 20)	Extensive		4					
	Pfankuch channel	Good: stable	e	1					
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	1				
١	10)				•				
	10)	Poor: unsta	ble	4					
				Total Points	8				
			Category p	oint range					
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15	Very High 16 – 20 □				

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River			Location:	Red River - 6	- 470.23		
Observers:	KD, JB	Date:	11/18/2010	Strean	n Type: C6c-	Valle	у Туре: Х	
Channel Dimension	Mean bankfull 9.28 depth (ft):	Mean bankfull 1' width (ft):	18 Cross-section area (ft ²):	n 1084	Width of flood- prone area (ft):	404.6667	Entrenchment ratio: 3	.4
Channel Pattern	Mean: Range: MWR:	11.1 Lm/W _b		Rc/	/W _{bkf} :	3.0	Sinuosity: 2.25	5
	Check: Riffle/pool	☐ Step/pool ✓		Converge	nce/divergence	✓ Dunes/	antidunes/smooth bed	
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull depth (ft): 16.2	(max/me	ean): 1.7		pool spacing:	Valley:	Average bankfull:	00014
	Nipanan	nt composition/density:	Potential composi	tion/density:	Remark	s: Condition, vig	or and/or usage of existing reac	ch:
	vegetation					<u></u>		
	Flow P1, 2, Stream regime: 7, 9 and on	der:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	blockage(s):)3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.7 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective rating	g): Good	
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12.8 Width/dept (W/d) / (W/		te 1.0		tio state y rating: Stable	
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of (MWR / M)		ent 1.0	I	/ MWR _{ref} Unconfin y rating:	ed
Bank Erosion	Length of reach	14	mbank erosion rate		Curve used:	Remarks:		
Summary	studied (ft):	1966 (ton	s/yr) 0.23 (tor	ns/yr/ft)	Fig 3-9			
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	capacity	Remark	s: 		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Require depth _{bkf} :		sting Required pe _{bkf} : slope _{bkf} :	
Successional Stage Shift	→ -	→	→	→	Existing stre state (type)		Potential stream state (type):	C6c-
Lateral Stability	☐ Stable 	Mod. unstable Г	Unstable	☐ High	ly unstable	emarks/cause	s: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	radation	emarks/cause	s: None	
Vertical Stability (Degradation)	■ Not incised	Slightly incised	Mod. incised	□ Degr	radation	emarks/cause	s: None	
Channel Enlargement	☐ No increase 	Slight increase	Mod. increase	☐ Exte	nsive	emarks/cause	S: None	
Sediment Supply (Channel Source)	□ Low □	Moderate	High 🔲 Very hi	Remar	rks/causes:	lone		

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

	Riparian Vegetation									
Stre	eam: Red R	liver		Location:	Red River-7-492	2.47				
	servers: KD, JI		Reference reach	Disturbed (impacted reach)	x	9/30/2011				
Existing species composition: Trees			Potential species composition:							
R	Riparian cover Percent aerial categories cover*		Percent of site coverage**	Species o	composition	Percent of total species composition				
ÿ				Trees		100%				
Overstory	_									
Over	Canopy layer	80%	3%							
1.										
						100%				
>				Weeds, shru	ıbs	100%				
Understory										
der	Shrub layer		40%							
2. Un										
N						100%				
_	Г			0	1_					
				Grass, weed	IS	100%				
	Herbaceous		20%							
	Tierbaceous		20 /6							
evel										
Ground leve						100%				
3rou	Leaf or needle litter		5%	Remarks:						
3. 0	11101			Condition, vigor usage of existing						
	Bare ground		32%	_						
	ed on crown closure. sed on basal area to	surface area.	Column total = 100%							

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

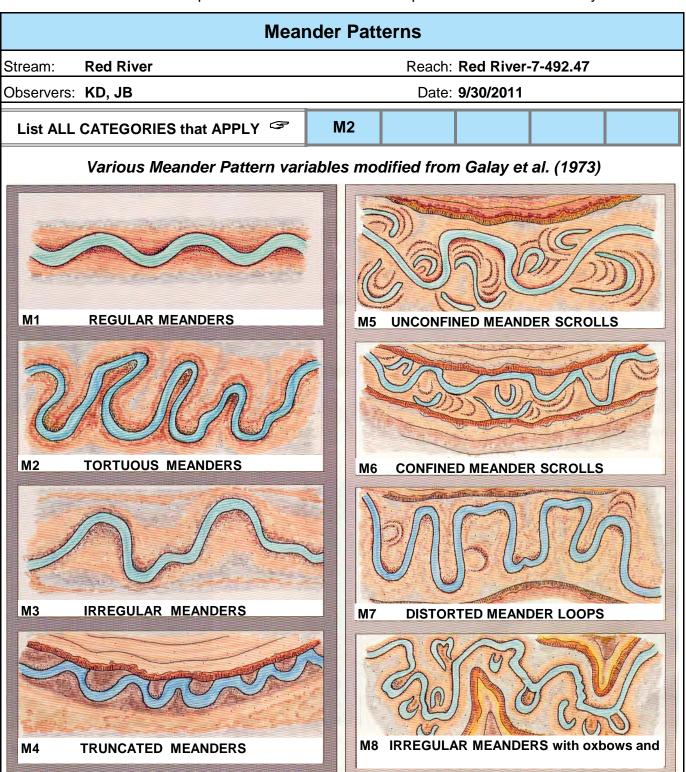
	FLOW REGIME								
Stream:	Stream: Red River Location: Red River-7-492.47								
Observers: KD, JB Date: 9/30/2011									
List ALL	List ALL COMBINATIONS that P1 P2 P7 P9								
APF	APPLY								
General Category									
E	Ephemeral stream channels: Flows only in response to precipitation								
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.								
ı	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.								
Р	Perennial stream channels: Surface water persists yearlong.								
Specific (Category								
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.								
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.								
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.								
4	Streamflow regulated by glacial melt.								
5	Ice flows/ice torrents from ice dam breaches.								
6	Alternating flow/backwater due to tidal influence.								
7	Regulated streamflow due to diversions, dam release, dewatering, etc.								
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.								
9	Rain-on-snow generated runoff.								

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

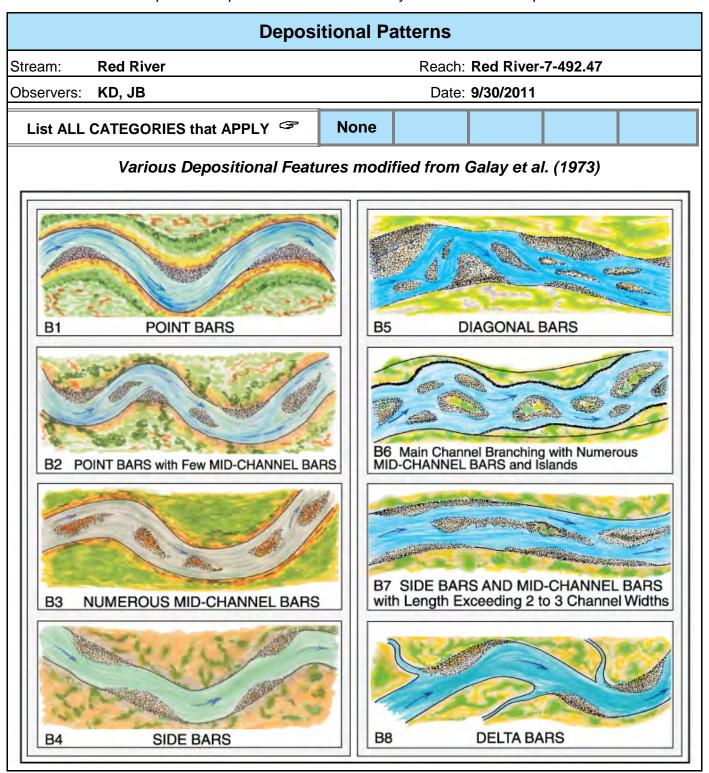
	Stream Size and Order							
Stream:	Red River							
Location:	Red River-7-49	2.47						
Observers:	KD, JB							
Date:	9/30/2011							
Stream Size Category and Order S-8								
Category	STREAM SIZ	Check (✓) appropriate						
	meters	feet	category					
S-1	0.305	<1						
S-2	0.3 – 1.5	1 – 5						
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	S-13 >305 >1000 \square							
	Stream	n Order						

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

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



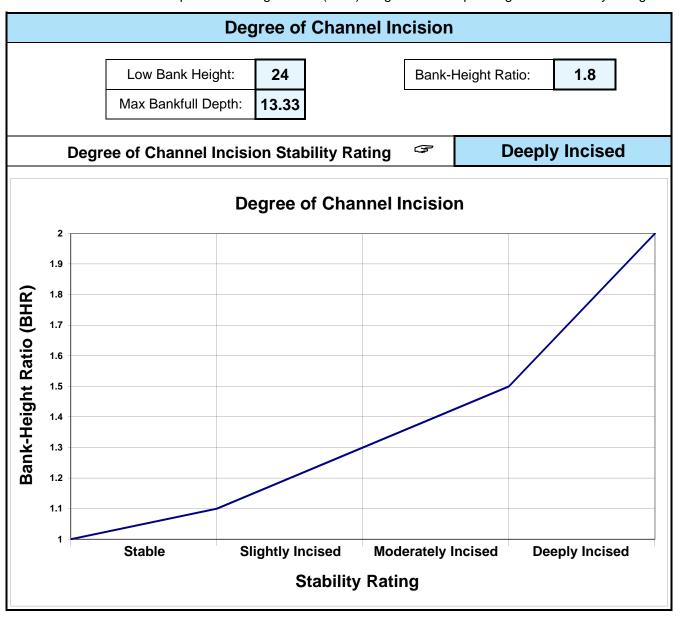
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



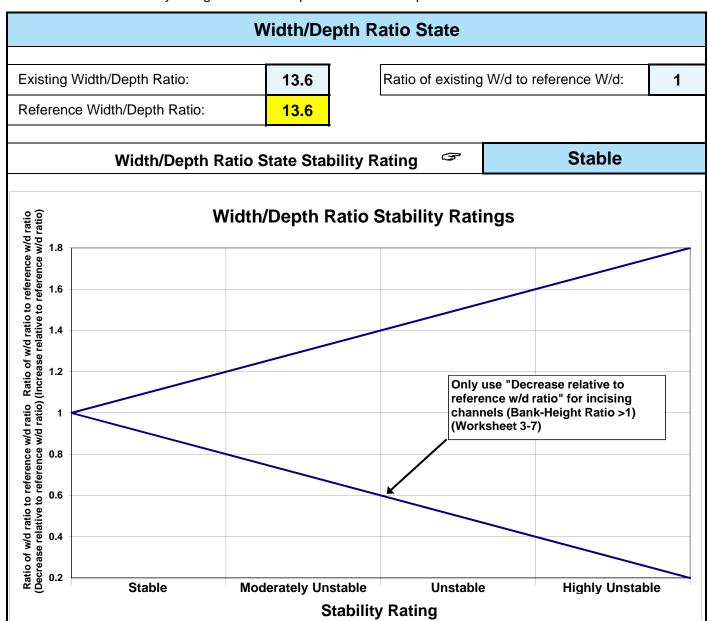
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: Red River Location: Red River-7-4			
Observers: KD, JB		Date: 9/30/2011	
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.	V
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	•
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

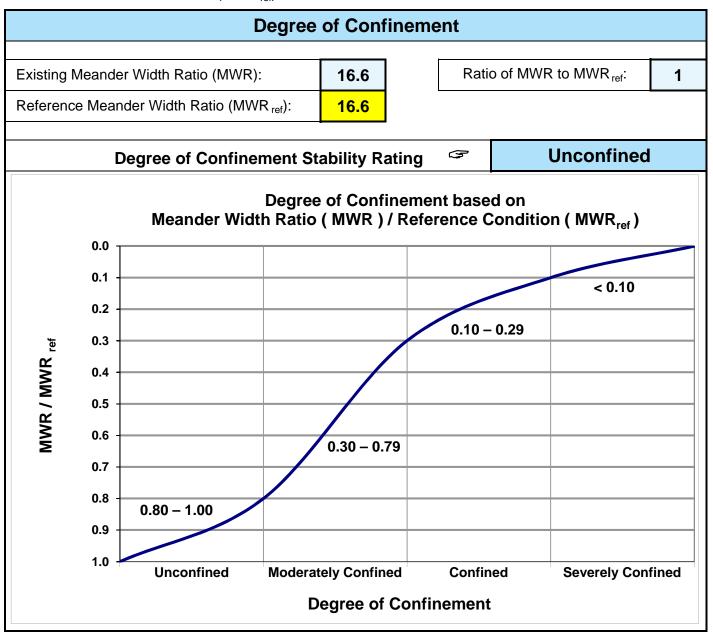
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



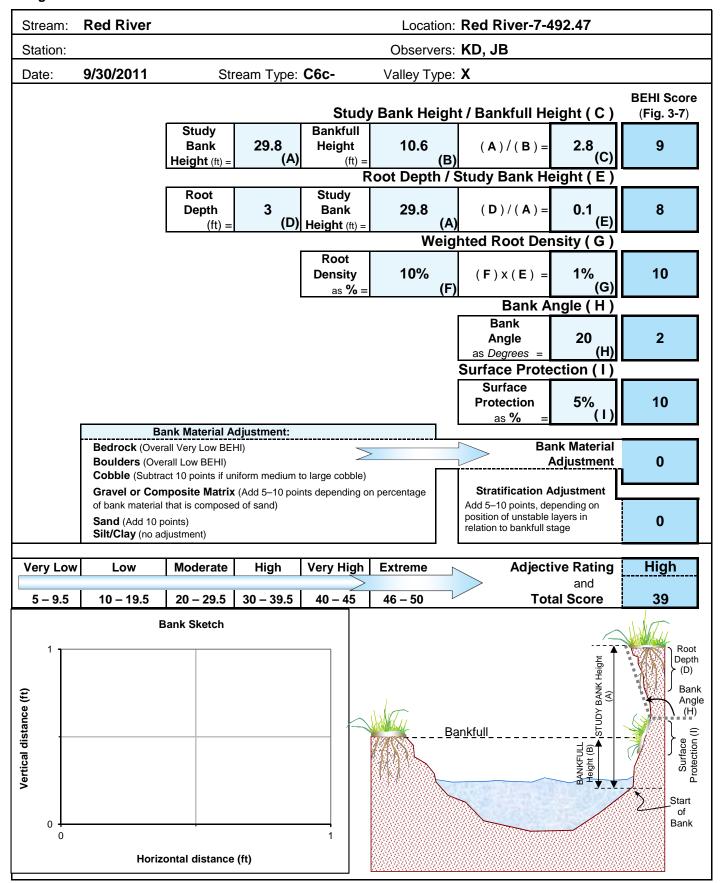
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Red	River					Loc	ation:	Red F	River-7	7-492.	.47		Valley	Type:	X		Obs	ervers:	KD, J	JB				Date: 9/30/	2011			
Loca-	Key	Catego	orv			Exce	llent					Go	od					F	air						Poor				
tion	Ney	Catego	Ji y		D	Description	n		Rating			Descriptio	n		Rating		Г	Description	on		Rating			Desc	ription		Rating		
S	1	Landform slope		Bank slo	ope grad	dient <30	0%.		2	Bank slo	ope grad	dient 30-	-4 0%.		4	Bank sl	lope gra	dient 40	- 60%.		6	Bank sl	lope gr	adient :	> 60%.		8		
banks	2	Mass eros	รเดท	No evide erosion.		past or f	uture m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sedi	ment	9				using sediment int danger of sam		12		
Upper I	3	Debris jan potential		channel	area.	ent from			2	limbs.		ostly sma			4	larger s		•		•	6	Moderate to heavy amo predominantly larger si			sizes.		8		
ם	4	Vegetative bank protection			a deep	nsity. Viç , dense				root mass. discontinuous root mass.				9		dicatin	ig poor,	wer species and discontinuous a		12									
	5	Channel capacity		Bank heigl stage. Wic	hts sufficie dth/depth r width/dep	ent to conta ratio depar th ratio = 1	ture from		1	Bankfull st Width/dep	age is cor th ratio de h ratio = 1	ntained wite parture fro 1.0–1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from I. Bank-He	t containe reference	d. Width/dep	th ratio	3	Bankfull stage is not contained common with flows less than b ratio departure from reference Bank-Height Ratio (BHR) > 1.3		n bankfull. Width/dep ce width/depth ratio	th	4			
nks	6	Bank rock content		12"+ co	mmon.	e angula			2	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	%. Most	in the 3	-6" diam	eter	6	or less.		Ū	of gravel sizes,	1–3"	8		
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in ing or de			2	currents fewer an	and mind d less fire		ing. Obs	tructions	4		tely freque ith high flo I filling.				6	cause b	oank e	rosion y	s and deflectors earlong. Sedime gration occurring		8		
Low	8	Cutting	Little or none. Infrequent raw banks -6". Little or none. Infrequent raw banks 			12				its, some over 2- angs frequent.	l"	16																	
	9	Deposition	n	point ba	ırs.	rgement			4	Some n coarse (increase	e, mostly	y from	8	and coa		d on old	d and so	me	12				oredominantly fir I bar developme		16		
	10	Rock angularity		Sharp e surfaces	0	nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	vell rounded in 2				3	smooth	١.		mensions, surfa		4
	11	Brightnes	S	General	lly not b					surfaces	3.	may ha		% bright	2	mixture	dull and range.				3	scoure	d surfa	ces.	> 65%, expose		4		
шc	12	Consolidati particles		overlapp	ping.	tightly pa			2	overlap	oing.	ked with			4	appare	nt overla	ар.			6	easily n	No packing evident. Loose assortme easily moved.			t,	8		
Bottom	13	Bottom siz		No size material	_	evident 0%.	. Stable		4	50–80%).	t light. S		aterial	8	materia	ate chan als 20–50 % affecte	0%.			12	Marked materia			hange. Stable		16		
	14	Scouring a deposition		<5% of deposition		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr	% arrecte ructions, Some fi	constri	ctions ar		18				e bottom in a sta yearlong.	e of	24		
	15	Aquatic vegetation			•	th moss- I. In swift			1		•	e forms i . Moss h			2	backwa	t but spo ater. Sea rocks sl	sonal a		wth	3				ce or absent. Yel		4		
						Exc	ellent	total =	7				Good	total =	28				Fair	total =	12				Poor to	tal =	52		
Stream ty	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6						
Good (Stable	-		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	3	Grand tota	I =	99		
Fair (Mod. u	nstable		14-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110 111+	91-110 111+	86-105 106+	108-132 133+	108-132 133+	-132 108-132 99-125 Existing		e =	C6c-				
Stream ty			DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6			_	*Potential		C6c-		
Good (Stable	e)		10-63	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				stream typ				
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78		108-120						Modified				
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability		g =		
																	*Ra	ting is a	djusted 1	to poten	tial strea	ım type,	not ex	kisting.	Fa	ıır			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.									
			Estim	ating Nea	r-Bank St	ress (NB:	S)		
Stream:	Red Ri	ver			Location:	Red River	-7-492.47		
Station:	0			S	tream Type:	C6c-	١	√alley Type:	X
Observe	ers:	KD, JB						Date:	9/30/11
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)		
(1) Chanı	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)	General prediction				
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})		Level II	General	prediction		
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	Detailed	prediction				
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	Detailed	prediction			
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	dation
_					or discontinuo				
Levell	(1)				-channel) gration, conver				
				meander mig		ging now		INI	33 = Extreme
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress				
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)	ļ			
=					Near-Bank				•
Level II	(3)	Pool Slope	Average	D # 0 /0	Stress			inant	
Le	(-)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress	
						ļ	very	Low	L
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank Stress				
	(4)	S _p	S _{rif}	S _{rif}	(NBS)				
		Near-Bank			Near-Bank	1			
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress				
_	(-)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	l			
Level III				Near-Bank			Bankfull	l	
-ev		Near-Bank		Shear			Shear		Near-Bank
_	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ _{nb} /	Stress
	()	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)
≥				Near-Bank					
Level IV	(7)	-	dient (ft/sec	Stress					
Le	, ,	/ f		(NBS) Very Low					
			Į.		<u> </u>				
			nverting Va	lues to a l	Near-Bank		<u> </u>		
Near-E		ess (NBS)	(4)	(0)		ethod numb		(0)	(7)
	rating Very L		(1) N/A	(2)	(3)	(4)	(5)	(6)	(7)
	Very Low		N/A	> 3.00 2.21 – 3.00	< 0.20 0.20 – 0.40	< 0.40 0.41 – 0.60	< 1.00 1.00 – 1.50	< 0.80	< 0.50
	Modera		N/A	2.21 – 3.00	0.20 - 0.40	0.41 - 0.60	1.51 – 1.80	0.80 - 1.05 1.06 - 1.14	0.50 - 1.00 1.01 - 1.60
	High		See	1.81 – 2.00	0.41 - 0.80	0.81 – 0.80	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00
	Very Hi		(1)	1.50 – 1.80	0.81 – 0.80	1.01 – 1.20	2.51 – 3.00	1.13 – 1.19	2.01 – 2.40
	Extren	_	Above	< 1.50 - 1.80			> 3.00	> 1.60	> 2.40
		-			•——				
				Overall N	lear-Bank S	711 692 (IAD	o, raining	very	Low

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	ocation: Red River-7-492.47					
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	12938.9		Date:	9/30/2011			
Observers:	KD, JB		Valley Type:	Χ		Stream Type:	C6c-			
(1) Station (ft)	(2) BEHI rating	(3) NBS rating	(4) Bank	(5) Length of	(6) Study bank	(7)	(8) Erosion			
Station (it)	(Worksheet 3-11) (adjective)	(Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	bank (ft)	height (ft)	subtotal [(4)×(5)×(6)] (ft³/yr)	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	12938.9	29.8	63621	0.24			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Col	umn (7) for ead	ch BEHI/NBS	combination	Total Erosion (ft³/yr)	63621				
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (f	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	2356				
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	3063				
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.24				

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

Stream:	Red River		S	Stream Type:	C6c-	
Location:	Red River-	7-492.47		Valley Type:		
Observers:	KD, JB			Date:	9/30/2011	
Enter Req	uired Infor	mation for Existing Co	ndition			
	D ₅₀	Riffle bed material D ₅₀ (r	mm)			
	D ₅₀	Bar sample D ₅₀ (mm)				
0	D _{max}	Largest particle from bar	r sample (ft)		(mm)	304.8 mm/ft
	s	Existing bankfull water s	surface slope (ft/ft)			
	d	Existing bankfull mean of	depth (ft)			
1.65	γ_{s}	Submerged specific wei	ght of sediment			
Select the	Appropria	te Equation and Calcu	late Critical Dimension	nless She	ar Stress	
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^) ^{-0.872}
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}
#DIV/0!	τ*	Bankfull Dimensionless	Shear Stress	EQUATIO	ON USED:	#DIV/0!
Calculate	Bankfull Me	an Depth Required for I	Entrainment of Larges	t Particle ir	Bar Sampl	е
#DIV/0!	d	Required bankfull mean	depth (ft) $d = \frac{7}{2}$	$S * \gamma_s D_{max}$	(use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggradi				
Calculate Sample	Bankfull W	ater Surface Slope Re	quired for Entrainme	nt of Large	st Particle	in Bar
#DIV/0!	s	Required bankfull water	surface slope (ft/ft) \$	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggradi	ng Degrading			
Sediment	Competen	ce Using Dimensional	Shear Stress			
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft	²) (substitute hydraulic ra	dius, R, with	mean depth,	, d)
	$\gamma = 62.4$, o	d = existing depth, S = exis	ting slope			
	Predicted	largest moveable particle s	size (mm) at bankfull she	ar stress τ (F	igure 3-11)	
	Predicted	shear stress required to ini	itiate movement of measo	ured D _{max} (m	m) (Figure 3	-11)
#DIV/0!		mean depth required to inited the shear stress, $\gamma = 62.4$,		ired D _{max} (mi	$\mathbf{d} = \frac{7}{1}$	z
#DIV/0!	Predicted	slope required to initiate m	ovement of measured D _r	_{nax} (mm)	$S = \frac{\tau}{vd}$	
	τ = predic	ted shear stress, $\gamma = 62.4$,	d = existing depth		γd	

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, JI	В					
u b	Strea	m:	Red R	River					Loca	tion:	Red R	liver-7	-492.4 ⁻	7			_		Date:	9/30	/2011	
		→		→		⇒ (⇒ (⇒ (⇒(→		→		⇒ (
s a		h Pan CKET	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE				
m p	Tare		Tare	weight		weight	Tare \		Tare v		Tare	weight	Tare v		Tare	weight	Tare	weight			JRFACE	
1	14101	volgili		oigint		wolgin	1010	roigin.		roigin	Taro	roigin	laio	roigin	1410	giit	1410	oigiit	MATERIALS DATA			
e s	Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		Sample		Sample	l .	(Two largest particl		ticles)	
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.
2																			 	1 1	Dia.	VVI.
3																				2		
4																			Bucket	+		
5																			materia weigh			
6																						
7																			Bucket t weigh			
9																			Materia	als		
10																			weigh	t	()
11																			Materials			
12																			than:			mm
13																				S	e sure to a eparate m	aterial
15																					eights to g	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	7	
-	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####	4 -			
Accum	1. % =<	#####	$\longrightarrow \hspace{0.5cm} \rangle$	#####	\longrightarrow	#####		#####		#####		#####		#####		#####		100%	<u> </u>	GR	AND TO	TAL
	Sample location notes Sample				nple loca	ation ska	atch															
	ampic io	cation ne	7.03				- Cai	TIPIC IOCI	ation six	2011												

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River-7-492.47	Valley Type: X
Observers:	KD, JB	Date: 9/30/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-	
Location: Red River-7-492.	47		Valley Ty	_{/pe:} X	
Observers: KD, JB			Da	ate: 9/30/2011	
Lateral stability criteria		Lateral Stabilit	y Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	ınge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River Stream Type: C6c-											
Location: Red River-7-4	92.47		Valley Type:	X							
Observers: KD, JB			Date:	9/30/2011							
Vertical stability criteria	Vertical Stabil	ity Categories fo	r Excess Deposition	on / Aggradation	Selected						
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)						
Sediment 1 competence (Worksheet 3-14)	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)							
Sediment capacity (POWERSED)	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)							
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2						
	(2)	(4)	(6)	(8)							
Stream succession 4 states (Worksheet 3- 16)	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)							
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1						
3-5)	(1)	(2)	(3)	(4)							
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	2						
	(1)	(2)	(3)	(4)							
				Total points	11						
	Vertical stat		int range for exces adation	s deposition /							
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River Stream Type: C6c-											
Lo	cation: Red River-7-4	192.47		Valley Type:	X						
Ob	oservers: KD, JB			Date:	9/30/2011						
٧	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected					
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
		(2)	(4)	(6)	(8)						
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
		(2)	(4)	(6)	(8)						
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8					
	(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)						
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
		(2)	(4)	(6)	(8)						
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
	3-9)	(1)	(2)	(3)	(4)						
					Total points	17					
		Vertical stab	ility category poi degra	nt range for char dation	nel incision /						
d p	Pertical stability for channel incision/legradation (use total points and check stability rating)	Not incised 9 – 11	Slightly incised 12 – 18 ✓	Moderately incised 19 – 27 □	Degradation > 27 □						

Worksheet 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-										
Lo	cation: Red River-7-49	2.47		Valley Type:	X					
Ob	servers: KD, JB			Date:	9/30/2011					
	hannel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected				
(c	rediction criteria choose one stability ategory for each criterion -4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)				
1	Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2				
		(2)	(4)	(6)	(8)					
2	Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4				
		(2)	(4)	(6)	(8)					
3	Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2				
	(Worksheet 3-18)	(2)	(4)	(6)	(8)					
4	Vertical stability incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4				
	(Worksheet o 19)	(2)	(4)	(6)	(8)					
					Total points	12				
			Category p	ooint range						
p p	hannel enlargement rediction (use total oints and check stability ating)	No increase 8 – 10	Slight increase 11 – 16 ✓	Moderate increase 17 – 24	Extensive > 24					

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

Stream: Red River Stream Type:									
Lo	cation: Red River-7-492	.47		Valley Type:	Х				
Ob	servers: KD, JB			Date:	9/30/2011				
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	/ Rating	Points	Selected Points				
		Stable		1					
1	Lateral stability	Mod. unstab	ole	2	2				
Ι'	(Worksheet 3-17)	Unstable		3	2				
		Highly unsta	able	4					
	Vertical stability	No deposition	on	1					
2	excess deposition/	Mod. depos	ition	2	1				
-	aggradation	Excess dep	osition	3	•				
	(Worksheet 3-18)	Aggradation	1	4					
	Vertical stability	Not incised		1					
3	channel incision/	Slightly inci		2	2				
ľ	degradation	Mod. Incised	d	3	2				
	(Worksheet 3-19)	Degradation	1	4					
	Channel enlargement	No increase		1					
4	prediction (Worksheet	Slight increa	ase	2	2				
	3-20)	Mod. increa	se	3	_				
	C	Extensive		4					
	Pfankuch channel	Good: stable		1					
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2				
ľ	10)				_				
	,	Poor: unsta	ble	4					
				Total Points	9				
			Category p	oint range					
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □				

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River				Location	: Red River-7	-492.47		
Observers:	KD, JB		Date: 9/ 3	30/2011	Strea	m Type: C6c-	Valle	еу Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 8.8	Mean bankt width (ft):	17H X	Cross-section area (ft ²):	n 1074	Width of flood prone area (ft	- 404	Entrenchment ratio:	3.3
Channel Pattern	Mean: Range:	16.6	Lm/W _{bkf} :	16.6	Ro	c/W _{bkf} :	4.1	Sinuosity:	2.56
	Check: Riffle/pool	☐ Step/pool	□ Pla		Converge	ence/divergenc	e 🔽 Dunes	s/antidunes/smo	ooth bed
River Profile and Bed	Max Riffle	Pool	Depth ratio	Riffle	Pool	Pool to Ra	ıtio	Slope	
Features	bankfull depth (ft):		(max/mean			pool spacing:	Valley:		verage Inkfull: 7.5E-05
	Nipuliuli	rent composition/der	nsity:	Potential composi	tion/density:	r: Rema	ks: Condition, vi	igor and/or usage of	existing reach:
	vegetation								
	Flow P1, 2, Stre regime: 7, 9 and	am size order:	5-K	ander tem(s):	M2	Depositional pattern(s):	NONE	Debris/channe blockage(s):	D1-4
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	10	egree of inci- ability rating:	LIPPOL	y Incised	Modified Pfan (numeric and			Fair
	Width/depth ratio (W/d):	Reference Waratio (W/d _{ref}):	Reference W/d ratio (W/d _{ref}):		h ratio sta /d _{ref}):	ate 1	.0 stabili	atio state ty rating:	Stable
	Meander Width Ratio (MWR):	16.6 Refere	161	Degree of co (MWR / MW		ent 1	0	/ MWR _{ref} ty rating:	Unconfined
Bank Erosion	Length of reach	TH H H	ual streamba	ank erosion rate	:	Curve used:	Remarks	:	
Summary	studied (ft):	3063	(tons/yr)	0.24 (tor	ns/yr/ft)	Fig 3-9			
Sediment Capacity (POWERSED)	✓ Sufficient capaci	ty 🗆 Insuffic	ient capacit	y 🗆 Excess	capacity	Rema	rks:		
Entrainment/	Largest particle from			*	Existing	Requir	ed Ex	kisting	Required
Competence	bar sample (mm):	1	7 =	τ*=	depth _{bkf} :	depth _b	d: slo	ope _{bkf} :	slope _{bkf} :
Successional Stage Shift	→	-	→			Existing state (type	:):	Potential state (type	Chc-
Lateral Stability	□ Stable	Mod. unstal	ble 🗆 L	Instable	☐ High	hly unstable	Remarks/caus		
Vertical Stability (Aggradation)	✓ No deposition	☐ Mod. depos	sition \square E	x. deposition	☐ Agg	gradation	Remarks/caus	es:	
Vertical Stability (Degradation)	□ Not incised	Slightly inci	sed 🗆 N	Nod. incised	□ Deg	gradation	Remarks/caus	es:	
Channel Enlargement	☐ No increase	Slight increa	ase 🗆 N	/lod. increase	□ Exte	ensive	Remarks/caus	es:	
Sediment Supply (Channel Source)	□ Low	Moderate Moderate	☐ Hig	h 🔲 Very hi	gh	arks/causes:			

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

			Riparian Ve	getation			
Stre	eam: Red R	liver		Location:	Red	River-8-521	1.18
	servers: KD, JI		Reference reach	Disturbed (impacted reach)	X		10/5/2011
spe	sting cies nposition:			Potential species composition:	- "		
Riparian cover categories cover*			Percent of site coverage**	Species c	osition	Percent of total species composition	
ry				Trees			100%
1. Overstory	Canopy layer	60%	2%				
							100%
>				Shrubs			100%
Understory	Shrub layer		35%				
Unde	Siliub layer		33 /6				
2.							4000/
	I						100%
				Grass, weeds	S		100%
	Herbaceous		15%				
<u>е</u>							
d lev							100%
3. Ground leve	Leaf or needle litter		5%	Remarks: Condition, vigor usage of existing			10078
	Bare ground		43%				
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%				

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

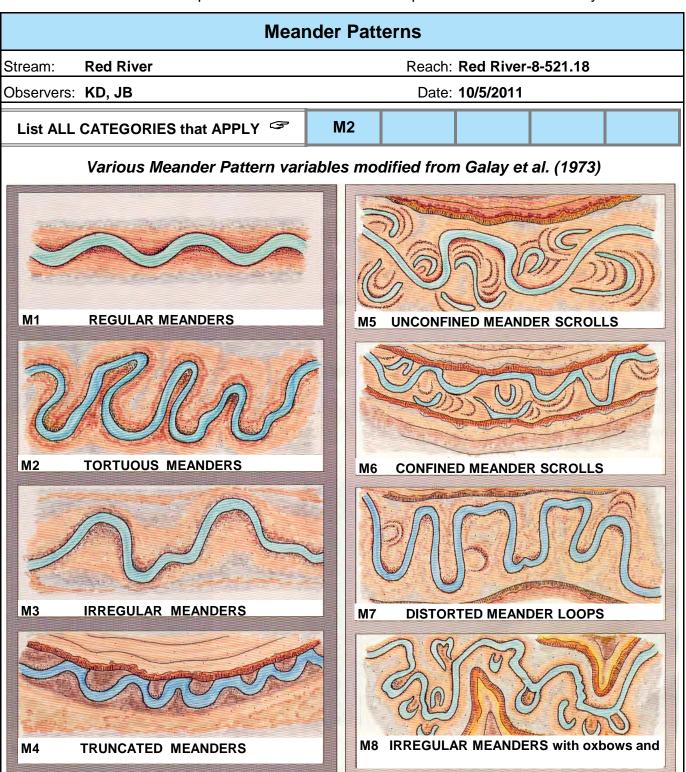
	FLOW REGIME								
[_									
Stream:	Red River Location: Red River-8-521.18								
Observers:	KD, JB Date: 10/5/2011 COMBINATIONS that								
	PLY P1 P2 P7 P9								
General C									
Е	Ephemeral stream channels: Flows only in response to precipitation								
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.								
ı	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.								
Р	Perennial stream channels: Surface water persists yearlong.								
Specific Category									
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.								
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.								
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.								
4	Streamflow regulated by glacial melt.								
5	Ice flows/ice torrents from ice dam breaches.								
6	Alternating flow/backwater due to tidal influence.								
7	Regulated streamflow due to diversions, dam release, dewatering, etc.								
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.								
9	Rain-on-snow generated runoff.								

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

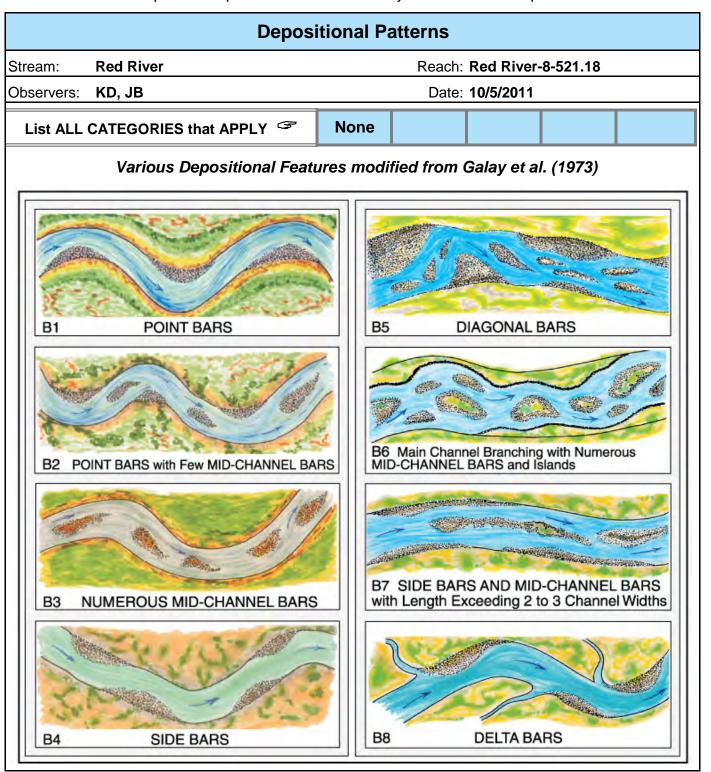
	Stream Size and Order										
Stream:	Red River										
Location:	Red River-8-52	21.18									
Observers:	KD, JB										
Date: 10/5/2011											
Stream Size Category and Order S-8 STREAM SIZE: Bankfull Check (🗸)											
Category	Check (✓) appropriate										
	meters	feet	category								
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									
	Strear	n Order									

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

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



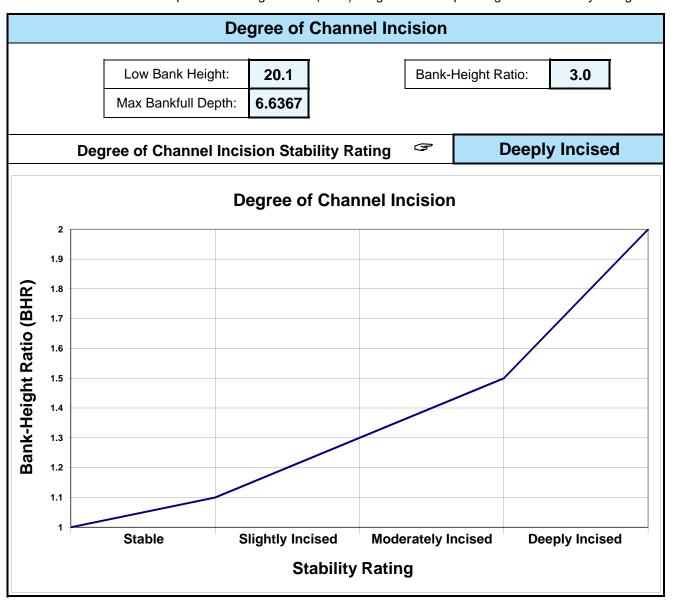
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



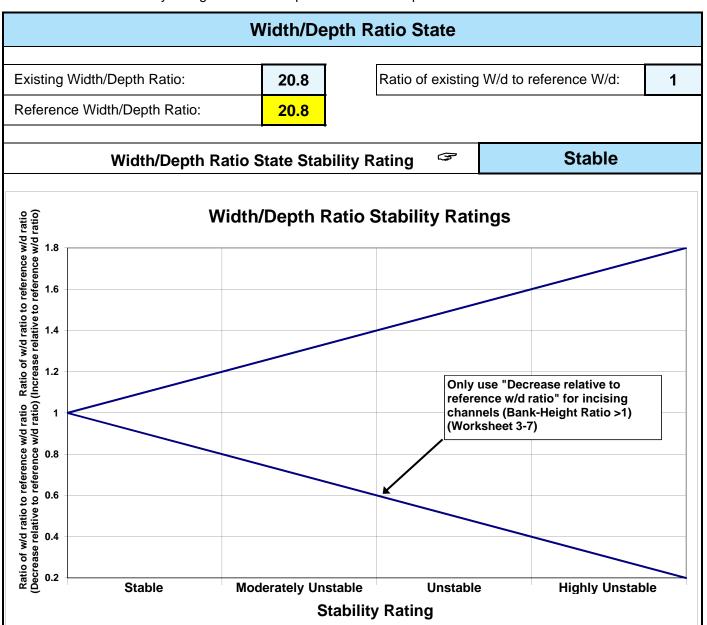
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Red River	Location: Red River-8-521.18	
Obser	vers: KD, JB	Date: 10/5/2011	
Desc	ription/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.	V
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

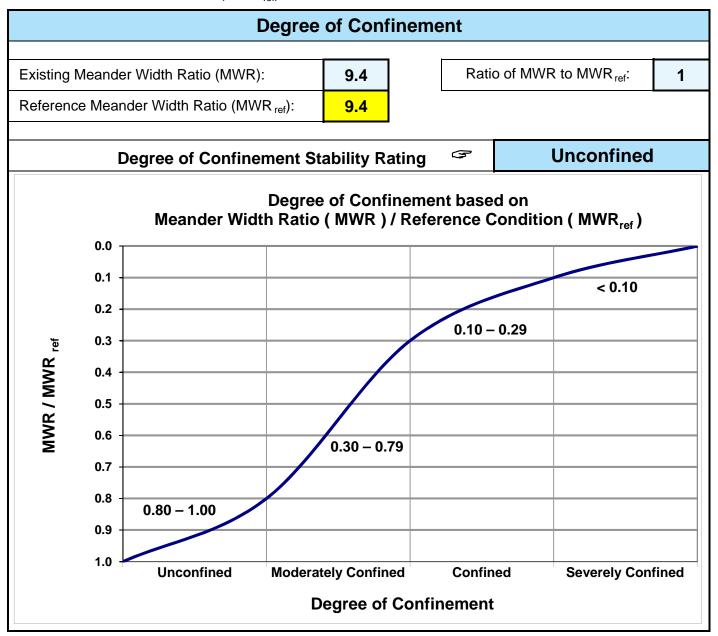
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



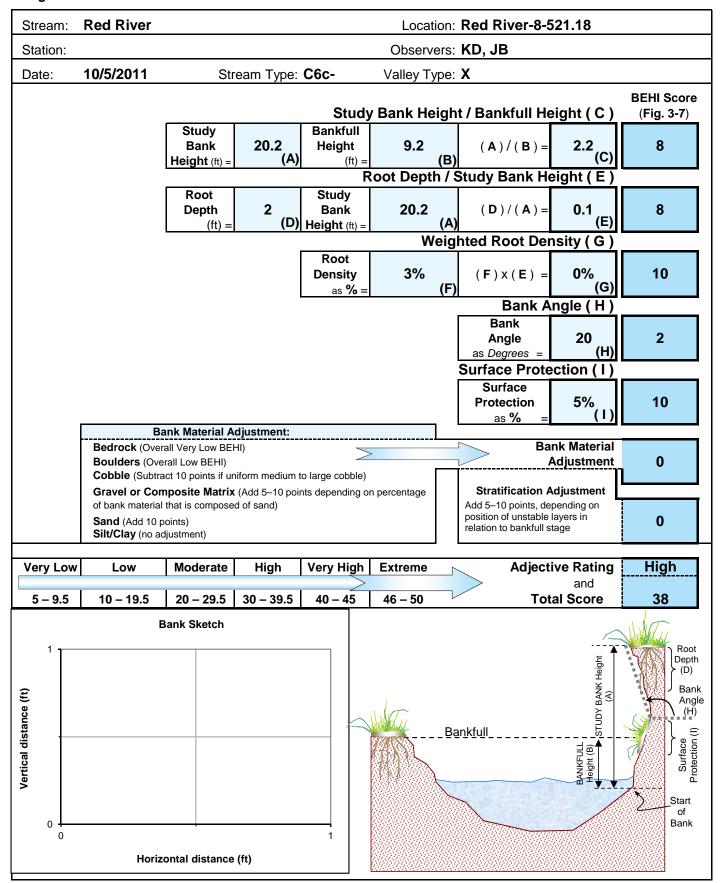
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Slope Slop	Good Description Bank slope gradient 30–40%. Infrequent. Mostly healed over. Low future potential. Present, but mostly small twigs and limbs. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. 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. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	2 4	Bank slope gra Frequent or la nearly yearlon Moderate to he larger sizes. 50–70% densi fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequency with high f and pool filling.	neavy amounts, mostly sity. Lower vigor and s from a shallow,	6 9 3	Bank slope gradient > Frequent or large, cause yearlong OR imminent Moderate to heavy am predominantly larger s <50% density plus few vigor indicating poor, of shallow root mass. Bankfull stage is not containe common with flows less than ratio departure from reference Bank-Height Ratio (BHR) > 1 <20% rock fragments of less. Frequent obstructions cause bank erosion yearlong OR imminent Stage 1.	60%. Issing sediment nearly t danger of same. Issing sediment nearly t danger of same. Issing sediment nearly transported to same. Issing sediment nearl	8 12 8 12 4 8
1 Landform slope 2 Mass erosion 3 Debris jam potential 4 Vegetative bank suggest a deep, dense soil-binding protection 5 Channel capacity 6 Bank rock content 7 Obstructions to flow 8 Cutting 8 Cutting 1 Landform slope Bank slope gradient <30%. 2 Sahk slope gradient <30%. 2 Sahk slope gradient <30%. 2 Sahk slope gradient <30%. 3 Debris jam potentially absent from immediate channel area. 2 Channel area. 2 Sahk heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio elparture from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. Channel capacity reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. Channel capacity reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. Channel capacity reference width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio gradient shaked by the potential stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. Channel capacity reference width/depth ratio departure from	Bank slope gradient 30–40%. Infrequent. Mostly healed over. Low future potential. Present, but mostly small twigs and limbs. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. 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. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	4 6 4 6 2 4 4 5 4	Bank slope gra Frequent or la nearly yearlon Moderate to he larger sizes. 50–70% densi fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequency with high f and pool filling.	radient 40–60%. arge, causing sediment of the control of the cont	6 9 9 9 3 3 6 6 nns	Bank slope gradient > Frequent or large, cau: yearlong OR imminent Moderate to heavy am predominantly larger s <50% density plus few vigor indicating poor, d shallow root mass. Bankfull stage is not containe common with flows less than ratio departure from referenc Bank-Height Ratio (BHR) > 1 <20% rock fragments of or less. Frequent obstructions cause bank erosion ye	60%. Issing sediment nearly t danger of same. Issing sediment nearly t danger of same. Issing sediment nearly transported to same. Issing sediment nearl	8 12 8 4 8
Slope Bank slope gradient <30%. 2	Infrequent. Mostly healed over. Low future potential. Present, but mostly small twigs and limbs. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio e1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	6 4 6 2 4 4 5 4	Frequent or la nearly yearlon Moderate to he larger sizes. 50–70% densi fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequence with high f and pool filling.	arge, causing sedimenting. The arge is a causing sedimenting sedimenting. The arge is a causing sedimenting sedimenting. The arge is a causing sedimenting sedimenting sedimenting. The arge is a causing sedimenting sedi	9 6 9 9 6 6 ns	Frequent or large, cause yearlong OR imminent Moderate to heavy am predominantly larger s <50% density plus few vigor indicating poor, destallow root mass. Bankfull stage is not containe common with flows less than ratio departure from reference and Height Ratio (BHR) > 1 <20% rock fragments of or less. Frequent obstructions cause bank erosion ye	sing sediment nearly t danger of same. nounts, sizes. ver species and less discontinuous and ed; over-bank flows are bankfull. Width/depth ew width/depth ratio > 1.4. 1.3. of gravel sizes, 1–3" and deflectors	12 8 12 4 8
4 bank suggest a deep, dense soil-binding root mass. 5 Channel stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. 6 Bank rock content 12"+ common. 7 Obstructions to flow pattern w/o cutting or deposition. 8 Cutting Little or none. Infrequent raw banks	future potential. Present, but mostly small twigs and limbs. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. 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. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	4 6 2 4 4 5 4	nearly yearlon Moderate to he larger sizes. 50–70% densi fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequency with high f and pool filling.	neavy amounts, mostly sity. Lower vigor and from a shallow, root mass. not contained. Width/depth om reference width/depth rat leight Ratio (BHR) = 1.1-1.3 st in the 3-6" diameter quent, unstable obstructio	6 9 3	yearlong OR imminent Moderate to heavy am predominantly larger s <50% density plus few vigor indicating poor, d shallow root mass. Bankfull stage is not containe common with flows less than ratio departure from referenc Bank-Height Ratio (BHR) > 1 <20% rock fragments of or less. Frequent obstructions cause bank erosion ye	t danger of same. nounts, sizes. ver species and less discontinuous and ed; over-bank flows are bankfull. Width/depth ce width/depth ratio > 1.4. 1.3. of gravel sizes, 1–3" and deflectors	8 12 4 8
4 bank suggest a deep, dense soil-binding root mass. 5 Channel stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. 6 Bank rock content 12"+ common. 7 Obstructions to flow pattern w/o cutting or deposition. 8 Cutting Little or none. Infrequent raw banks	limbs. 70–90% density. Fewer species or less vigor suggest less dense or deep root mass. Bankfull stage is contained within banks. Width/depth ratio eparture from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	2 4	larger sizes. 50–70% densi fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequency with high f and pool filling.	sity. Lower vigor and a from a shallow, a root mass. not contained. Width/depth and reference width/depth rat deight Ratio (BHR) = 1.1-1.3 at in the 3-6" diameter quent, unstable obstructio	9 3	predominantly larger s <50% density plus few vigor indicating poor, d shallow root mass. Bankfull stage is not containe common with flows less than ratio departure from referenc Bank-Height Ratio (BHR) > 1 <20% rock fragments o or less. Frequent obstructions cause bank erosion ye	izes. ver species and less discontinuous and ed; over-bank flows are a bankfull. Width/depth be width/depth ratio > 1.4. 1.3. of gravel sizes, 1–3" and deflectors	4 8
4 bank suggest a deep, dense soil-binding root mass. 5 Channel stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. 6 Bank rock content 12"+ common. 7 Obstructions to flow pattern w/o cutting or deposition. 8 Cutting Little or none. Infrequent raw banks	less vigor suggest less dense or deep root mass. 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. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	2 4 s 4	fewer species discontinuous Bankfull stage is n ratio departure fror = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequence with high f and pool filling.	s from a shallow, s root mass. not contained. Width/depth om reference width/depth rat deight Ratio (BHR) = 1.1-1.3 at in the 3-6" diameter	0 3	vigor indicating poor, d shallow root mass. Bankfull stage is not containe common with flows less than ratio departure from referenc Bank-Height Ratio (BHR) > 1 <20% rock fragments or or less. Frequent obstructions cause bank erosion ye	ed; over-bank flows are the bankfull. Width/depth width/depth ratio > 1.4. the distribution of gravel sizes, 1–3" and deflectors	4 8
Stage	Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1. 40–65%. Mostly boulders and small cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	4 4 5 4	ratio departure froi = 1.2–1.4. Bank-H 20–40%. Most class. Moderately frequency with high f and pool filling.	om reference width/depth rat Height Ratio (BHR) = 1.1-1.3 st in the 3-6" diameter Juent, unstable obstructio	6 ns	common with flows less than ratio departure from reference Bank-Height Ratio (BHR) > 1 <20% rock fragments or less. Frequent obstructions cause bank erosion ye	bankfull. Width/depth se width/depth ratio > 1.4. 1.3. of gravel sizes, 1–3" and deflectors	8
6 content 12"+ common. 2 7 Obstructions to flow Stable bed. 2 8 Cutting Little or none. Infrequent raw banks 4	cobbles 6–12". Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up	s 4	class. Moderately frequency with high fand pool filling.	uent, unstable obstructio	ns	or less. Frequent obstructions cause bank erosion ye	and deflectors	
7 Obstructions to flow Stable bed. Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. 8 Cutting Little or none. Infrequent raw banks 4	currents and minor pool filling. Obstructions fewer and less firm. Some, intermittently at outcurves and constrictions. Raw banks may be up		move with high f and pool filling.			cause bank erosion ye		_
8 Cutting Little or none. Infrequent raw banks 4	constrictions. Raw banks may be up	6	Significant, Cu			uaps tuli, channel migi	ration occurring.	8
4 6".			mat overnangs and slougning evident.		nt. 12	Almost continuous cuts high. Failure of overha	*	16
9 II)enosition 5	Some new bar increase, mostly from coarse gravel.	8		oostion of new gravel and on old and some	12	Extensive deposit of predominantly fine particles. Accelerated bar development.		16
angularity surfaces rough.	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and e dimensions.	edges well rounded in	3	Well rounded in all dim smooth.	·	4
11 Brightness 1	Mostly dull, but may have <35% bright surfaces.	t 2	Mixture dull ar mixture range.	nd bright, i.e., 35–65%	3	Predominantly bright, a scoured surfaces.	> 65%, exposed or	4
	Moderately packed with some overlapping.	4	Mostly loose a apparent overl	assortment with no rlap.	6	No packing evident. Lo easily moved.	oose assortment,	8
distribution material 80–100%.	Distribution shift light. Stable material 50–80%.	8	materials 20-5		12	Marked distribution change. Stable materials 0–20%.		16
Scouring and <5% of bottom affected by scour or 6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	at obstructions	eted. Deposits and sco s, constrictions and filling of pools.	ur 18	More than 50% of the flux or change nearly y		24
	Common. Algae forms in low velocity and pool areas. Moss here too.	2		potty, mostly in easonal algae growth slick.	3	Perennial types scarce green, short-term bloom		4
Excellent total = 21	Good total =	= 0		Fair tota	1= 12		Poor total =	52
Stream type A1 A2 A3 A4 A5 A6 B1 B2	B3 B4 B5 B6 C1	C2	C3 C4	C5 C6 D	B 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 85-1	07 85-107	85-107 67-98	Grand total =	85
Fair (Mod. unstable 44-47 44-47 91-129 96-132 96-142 81-110 46-58 46-58 Poor (Unstable) 48+ 48+ 130+ 133+ 143+ 111+ 59+ 59+	61-78 65-84 69-88 61-78 51-61 79+ 85+ 89+ 79+ 62+	62+	106+ 111+	111+ 106+ 13	133+	2 108-132 99-125 133+ 126+	Existing stream type =	C6c-
Stream type DA3 DA4 DA5 DA6 E3 E4 E5 E6 Good (Stable) 40-63 40-63 40-63 40-63 40-63 50-75 50-75 40-63	F1 F2 F3 F4 F5 60-85 60-85 85-110 85-110 90-115	F6 80-95	G1 G2 40-60			_	*Potential stream type =	C6c-
	86-105 86-105 111-125 111-125 116-130						Modified chan	nel
Poor (Unstable) 87+ 87+ 87+ 87+ 87+ 97+ 97+ 87+	106+ 106+ 126+ 126+ 131+		79+ 79+	121+ 121+ 126		<u> </u>	stability ratin	
			*Ra	ating is adjusted to po	tential stre	eam type, not existing.	Good	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

CIOSIOII	osion rate.										
			Estim	ating Nea	r-Bank St	ress (NB:	S)				
Stream:	Red Ri	ver			Location:	Red River	-8-521.18				
Station:	0			S	tream Type:	C6c-	\	/alley Type:	X		
Observe	rs:	KD, JB						Date:	10/5/11		
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)				
(1) Chanr	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance		
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction		
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction		
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction		
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction		
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction		
(7) Veloci	ty profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation		
					or discontinuo						
Levell	(1)				-channel)						
				meander mig	ration, conver	ging flow		NL	oo = Extreme		
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress						
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)						
_					Near-Bank				_		
<u> </u>	(3)	Pool Slope	Average		Stress			inant			
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)	1		nk Stress			
_							Very	Low			
					Near-Bank						
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress						
	,	S _p	S _{rif}	S _{rif}	(NBS)	l					
		Near-Bank			Na an Danie						
		Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress						
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)						
=											
Level III				Near-Bank			Bankfull				
Le		Near-Bank	Near-Bank	Shear			Shear	Dotio - /	Near-Bank		
	(6)	Max Depth	Slope S _{nb}	Stress τ _{nb} (Mean Depth	3 -	Stress τ _{bkf} (Ratio τ _{nb} /	Stress		
		d _{nb} (ft)	Globe Gub	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)		
				No. D.							
Level IV		Velocity Grad	dient (ft/sec	Near-Bank Stress							
eve	(7)	/ f		(NBS)							
Ľ		0.	01	Very Low							
		Cor	worting Va	dues to a N	Near-Bank	Strees (NE	RS) Pating				
Near-B	ank Str	ess (NBS)	iverting va	iiues io a l		ethod numb					
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)		
	Very Lo		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		
	Modera	ate	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 Hi	gh	(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		
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40		
	Overall Near-Bank Stress (NBS) rating Very Low										

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Red River			Location:	Red River-8	-521.18		
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	13236.8		Date:	10/5/2011	
Observers:	KD, JB		Valley Type:	Χ		Stream Type: C6c-		
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}	
1.	High	Very Low	0.165	13236.8	20.2	44118	0.16	
2.						0	#DIV/0!	
3.						0	#DIV/0!	
4.						0	#DIV/0!	
5.						0	#DIV/0!	
6.						0	#DIV/0!	
7.						0	#DIV/0!	
8.						0	#DIV/0!	
9.						0	#DIV/0!	
10.						0	#DIV/0!	
11.						0	#DIV/0!	
12.						0	#DIV/0!	
13.						0	#DIV/0!	
14.						0	#DIV/0!	
15.						0	#DIV/0!	
Sum erosion	n subtotals in Colu	combination	Total Erosion (ft ³ /yr)	44118				
Convert eros	sion in ft ³ /yr to yd:	Total Erosion (yds³/yr)	1634					
Convert eros by 1.3}	sion in yds ³ /yr to t	on (yds ³ /yr)	Total Erosion (tons/yr)	2124				
	osion per unit leng total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.16		

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

Stream:	Red River		S	Stream Type:	C6c-						
Location:	Red River-	-8-521.18		Valley Type:							
Observers:	KD, JB			Date:	10/5/2011						
Enter Req	uired Infor	mation for Existing Co	ndition								
	D ₅₀	Riffle bed material D_{50} (i	mm)								
	D ₅₀	Bar sample D ₅₀ (mm)									
0	D _{max}	Largest particle from ba	r sample (ft)		(mm)	304.8 mm/ft					
	S Existing bankfull water surface slope (ft/ft)										
	d	Existing bankfull mean of	depth (ft)								
1.65 $\gamma_{\rm s}$ Submerged specific weight of sediment											
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress											
#DIV/0! $D_{50}^{\wedge}/D_{50}^{\wedge}$ Range: 3 – 7 Use EQUATION 1: $\tau^* = 0.0834$ ($D_{50}^{\wedge}/D_{50}^{\wedge}$) $^{-0.872}$											
#DIV/0!	D _{max} /D ₅₀	max/ D_{50} Range: 1.3 – 3.0 Use EQUATION 2: $\tau^* = 0.0384 (D_{max}/D_{50})^{-0.887}$									
#DIV/0!	τ*	Bankfull Dimensionless	Shear Stress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	$\tau * v D_{max}$									
Check: ☐ Stable ☐ Aggrading ☐ Degrading											
Calculate Sample	Bankfull W	ater Surface Slope Re	quired for Entrainme	nt of Large	est Particle	in Bar					
#DIV/0!	s	Required bankfull water	surface slope (ft/ft) \$	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggradi	ing □ Degrading								
Sediment	Competen	ce Using Dimensional	Shear Stress								
0	Bankfull sl	near stress τ = γdS (lbs/ft	r ²) (substitute hydraulic ra	idius, R, with	mean depth,	d)					
<u> </u>	$\gamma = 62.4, c$	d = existing depth, S = exis	sting slope								
	Predicted	largest moveable particle s	size (mm) at bankfull she	ar stress τ (F	igure 3-11)						
	Predicted	shear stress required to in	itiate movement of measi	ured D _{max} (m	m) (Figure 3	-11)					
#DIV/0!		mean depth required to ini		ured D _{max} (m	$\mathbf{d} = \frac{7}{2}$	<u>r</u>					
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, slope required to initiate m	ovement of measured D _r	_{nax} (mm)	$S = \frac{\tau}{2 d}$. .					
	τ = predic	ted shear stress, γ = 62.4,	d = existing depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S u	Strea		Red R		IVIAIL	INIALO	SAMP		Loca				-521.18		ervers:	KD, J	В		Date: 10	/5/2011	
b	Olice		- I	·	<u> </u>	. (. (Loca	ilon.	- Tour	. (52111					. (Date. 10	75/2011	
s	Cato	h Pan	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE			
a m	or BU	CKET		mm		mm		mm		mm		mm		mm		mm		mm		SURFAC	
p I	Tare	weight	Tare \	weight	Tare	weight	Tare \	weight	Tare v	weight	Tare v	veight	Tare v	veight	Tare \	weight	Tare v	weight		ATERIA	
e s	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two	DATA largest pa	articles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
2																			No.	-	WT.
3																			2	_	
4																			Bucket +		L
5																			materials		
6																			weight		
7 8																			Bucket tare weight	•	
9																			Materials		
10																			weight		0
11																			Materials les than:	S	mm
13																				Be sure to	mm add
14																				separate i	material
15																				total	grana
Net wt		0		0		0		0		0		0		0		0		0	0	7	
-	and total	##### #####		##### #####		##### #####		##### #####		##### #####	4	##### #####		##### #####	_	##### #####		##### 100%			
Accuir	1. 70 = <	*************************************		*****		******		*****		*************************************		*****		******		*****		100 /6		RAND TO	OTAL
S	ample lo	cation n	otes				Sar	nple loc	ation ske	etch											

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

Stream:	Red River	Stream Type: C6c-
Location:	Red River-8-521.18	Valley Type: X
Observers:	KD, JB	Date: 10/5/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Red River			Stream Ty	_{/pe:} C6c-						
Location: Red River-8-521.	18		Valley Ty	_{/pe:} X						
Observers: KD, JB			Da	ate: 10/5/2011						
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected					
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)					
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2					
	(2)	(4)	(6)	(8)						
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1					
	(1)	(2)	(3)	(4)						
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3					
	(1)		(3)							
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)						
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1					
(Worksheet 3-9)	(1)	(2)	(3)	(4)						
Total points										
	La	teral stability c	ategory point ra	inge						
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Red River			Stream Type:	C6c-					
Location: Red River-8-5	21.18		Valley Type:	X					
Observers: KD, JB			Date:	10/5/2011					
Vertical stability criteria	Vertical Stabil	ity Categories fo	r Excess Deposition	on / Aggradation	Selected				
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	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)					
Sediment capacity (POWERSED)	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)					
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheet 3- 16)	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)					
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1				
3-3)	(1)	(2)	(3)	(4)					
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1				
	(1)	(2)	(3)	(4)					
Total points									
	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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Red River Stream Type: C6c-									
Location: Red River-8-521.18 Valley Type: X									
Observers: KD, JB Date: 10/5/2011									
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected				
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2				
	(2)	(4)	(6)	(8)					
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2				
	(2)	(4)	(6)	(8)					
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8				
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4				
	(2)	(4)	(6)	(8)					
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1				
3-9)	(1)	(2)	(3)	(4)					
Total points									
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 3-20. Channel enlargement prediction summary.

Stream: Red River Stream Type: C6c-								
Location: Red River-8-521.18 Valley Type: X								
Observers: KD, JB Date: 10/5/2011								
Channel enlargement	Char	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Worksheet 6 15)	(2)	(4)	(6)	(8)				
Total points								
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	C6c-								
Lo	cation: Red River-8-521.	Valley Type:	X						
Ob	servers: KD, JB	Date:	10/5/2011						
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points				
		Stable		1	2				
1	Lateral stability	Mod. unstab	ole	2					
'	(Worksheet 3-17)	Unstable		3	2				
		Highly unsta	able	4					
	Vertical stability	No deposition	on	1					
2	excess deposition/	Mod. deposi	ition	2	1				
	aggradation	Excess depo	osition	3	1				
	(Worksheet 3-18)	Aggradation	1	4					
	Vertical stability	Not incised		1					
3	channel incision/	Slightly inci	sed	2	2				
٦	degradation	Mod. Incised	d	3	2				
	(Worksheet 3-19)	Degradation	1	4					
	Channal anlargement	No increase		1					
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2				
"	3-20)	Mod. increas	se	3	2				
	3-20)	Extensive		4					
	Pfankuch channel	Good: stable	e	1					
5	stability (Worksheet 3-	Fair: mod ur	nstable	2	1				
ľ	10)				•				
	10)	Poor: unsta	ble	4					
	Total Points 8								
	Category point range								
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15	Very High 16 – 20 □				

Worksheet 3-22. Summary of stability condition categories.

Stream:	Red River				Location	n: Red Ri	ver-8-52	21.18			
Observers:	Date: 10/5/2011 Stream Type: C6c- Valley Type: X										
Channel Dimension	Mean bankfull depth (ft): 6.64	Mean bankfull width (ft):	138	Cross-sectio area (ft ²):	n 914.	.5 Width o	f flood- rea (ft):	788	Entrenchn ratio:	nent	5.7
Channel Pattern	Mean: MWR:		/W _{bkf} :	9.4	R	Rc/W _{bkf} :	3	3.7	Sinuosity:		2.6
	Check: Riffle/pool	Step/pool	☐ Pla		Converg	gence/dive		✓ Dunes	/antidunes/		t
River Profile and Bed	Max Riffle	Pool	oth ratio	Riffle	Pool	Pool to	Ratio		Slo	ре	
Features	bankfull depth (ft): 6.6	(max	x/mean)	1.0		pool spacing		Valley:		Average bankfull:	0.00016
	Tupanan	nt composition/density:		Potential composi	tion/densit	ty:	Remarks:	Condition, vi	gor and/or usa	ge of existing	reach:
	vegetation										
	Flow P1, 2, Stream regime: 7, 9 and or	N-X		ander tem(s):	M2	Deposit pattern(s):	NONE	Debris/chable blockage(D1-3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	30 -	e of incisy rating:	oion Deepl	y Incised			ch stability ective ratin		Go	od
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	20.8	Width/dept (W/d) / (W		tate	1.0		atio state sy rating:	Sta	ble
	Meander Width Ratio (MWR):	9.4 Reference MWR _{ref} :	9.4	Degree of (MWR / MV		nent	1.0		/ MWR _{ref} ry rating:	Uncor	nfined
Bank Erosion Summary	Length of reach studied (ft):	Annual st 2124	treamba (tons/yr)	nk erosion rate 0.16 (to	e: ns/yr/ft)	Curve t		Remarks:			
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient	capacity	y 🗆 Excess	capacit	ty	Remarks:				
Entrainment/ Competence	Largest particle from bar sample (mm):	τ =		τ*=	Existing depth _{bkf} :		Required depth _{bkf} :		isting pe _{bkf} :	Require slope _{bk}	
Successional Stage Shift	→ -	→		→	-		ting strea (type):	am C	6c- Potent state (ial stream type):	C6c-
Lateral Stability	☐ Stable 🔽	Mod. unstable	<u>□</u> U	Instable	□ Hig	ghly unstat	ole Re	marks/caus	es:		
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition		x. deposition	☐ Ag	gradation	Re	marks/caus	es:		
Vertical Stability (Degradation)	■ Not incised	Slightly incised	□ N	lod. incised	□ De	gradation	Re	marks/caus	es:		
Channel Enlargement	☐ No increase ☑	Slight increase		lod. increase	□ Ext	tensive	Re	marks/caus	es:		
Sediment Supply (Channel Source)	□ Low ☑	Moderate [☐ High	n 🔲 Very h	igh Rem	arks/cause	es:				

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

Riparian Vegetation								
Stre	eam: Rush	River		Location: Rush River - 1 - 0.08				
Obs	servers: KP, A	L	Reference reach	Disturbed (impacted reach)	X Date:	11/17/2010		
spe	sting cies nposition:			Potential species composition:				
Riparian cover Percent aerial categories cover*			Percent of site coverage**	Species c	Percent of total species composition			
1. Overstory	Canopy layer	0%	0%					
						100%		
2. Understory	Shrub layer							
		Allilling				100%		
level	Herbaceous							
3. Ground level	Leaf or needle litter		_	Remarks: Condition, vigor usage of existing		100%		
	Bare ground			None				
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%					

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

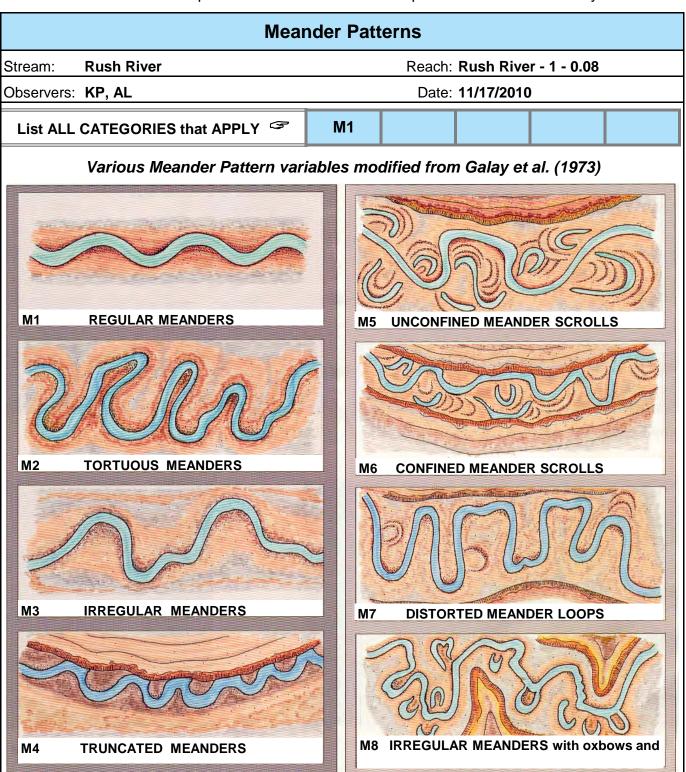
noiogical interpretations.											
	FLOW REGIME										
Stream:	Rush River Location: Rush River - 1 - 0.08										
Observers:	·										
	COMBINATIONS that P1 P2 P9										
General Category											
E	Ephemeral stream channels: Flows only in response to precipitation										
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.										
ı	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.										
Р	P Perennial stream channels: Surface water persists yearlong.										
Specific (Category										
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.										
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.										
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.										
4	Streamflow regulated by glacial melt.										
5	Ice flows/ice torrents from ice dam breaches.										
6	Alternating flow/backwater due to tidal influence.										
7	Regulated streamflow due to diversions, dam release, dewatering, etc.										
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.										
9	Rain-on-snow generated runoff.										

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

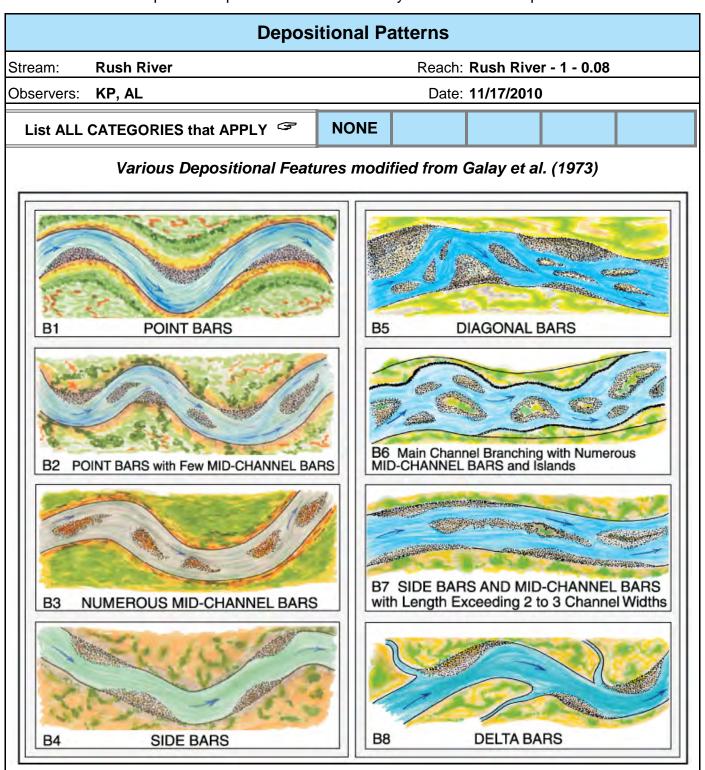
Stream Size and Order												
Stream:	Rush River											
Location:	Rush River - 1	- 0.08										
Observers:	KP, AL											
Date: 11/17/2010												
Stream Size Category and Order 🤝 S-5												
STREAM SIZE: Bankfull Check (✓) Category width appropriate												
meters feet category												
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 \square												
S-12	150 – 305	500 – 1000										
S-13	>305	>1000										
Stream Order												

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

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



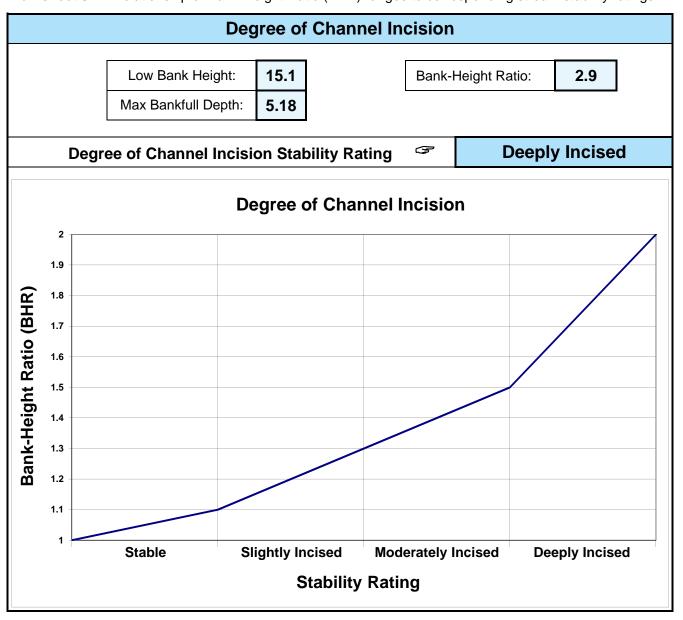
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



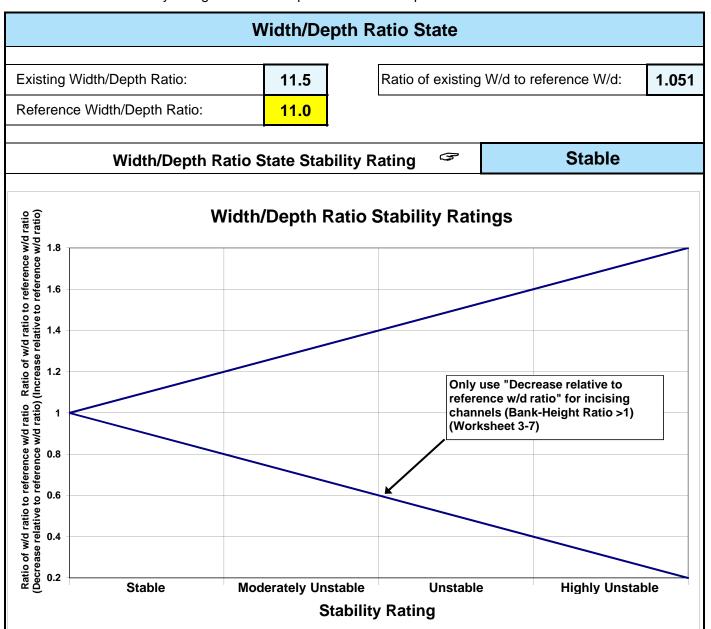
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages						
Strear	m: Rush River	Location: Rush River - 1 - 0.08						
Obser	rvers: KP, AL	Date: 11/17/2010						
Desc	ription/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.						
D1	None	Minor amounts of small, floatable material.	7					
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.						
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.						
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.						
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.						
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.						
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.						
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.						
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.						
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.						

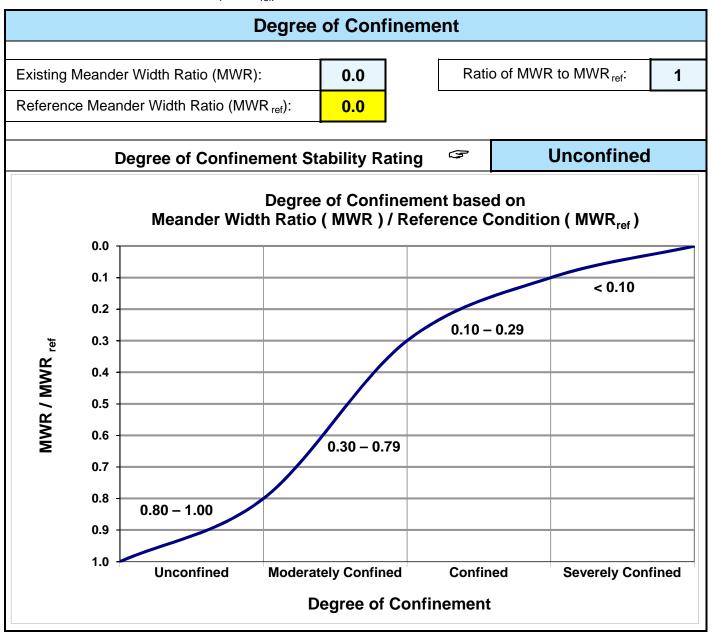
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



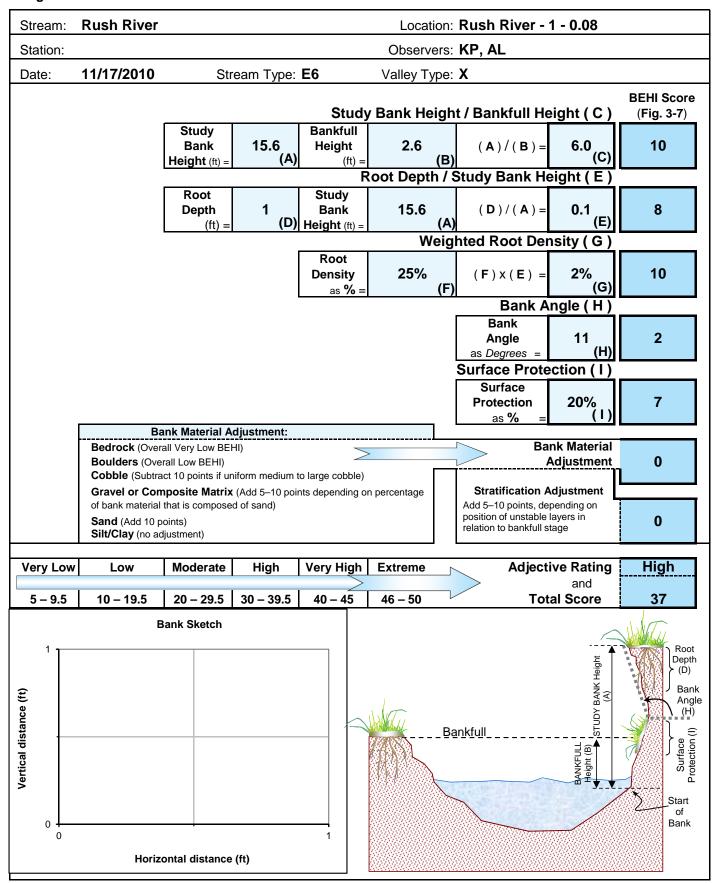
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Category Excellent Description Rating Rating Description Rating Rating Rating Rating Properties Proper	Stream:	Rus	h Rive	r				Loc	ation:	Rush	River	- 1 - (0.08		Valley	Type:	Х		Obs	ervers:	KP, A	۸L				Date: 11/17/	2010	,
1 Landorn Sank stope gradient 30-40%. 2 Sank stope gradient 30-40%. 4 Bank stope gradient 40-40%. 5 Sank stope gradient 30-40%. 6 Frequent or large, causing sediment nearly excellent potential protection. 7 Prequent or large, causing sediment nearly excellent potential protection. 7 Prequent or large, causing sediment nearly excellent potential protection. 7 Prequent or large, causing sediment nearly excellent potential. 7 Prequent or large, causing sediment nearly excellent potential. 8 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent or large, causing sediment nearly excellent potential. 9 Prequent potential. 9 Prequent potent	Loca-	Kov	Cotos	105/			Exce	llent					Go	od					F	air						Poor		
Same stock grasherit <a 2"="" 4="" 5="" 6="" class.="" cobbies="" common.="" g-12".="" href="https://www.components.</th><th>tion</th><th>ney</th><th>Categ</th><th>JOIY</th><th></th><th></th><th>Descriptio</th><th>n</th><th></th><th>Rating</th><th></th><th>D</th><th>Descriptio</th><th>n</th><th></th><th>Rating</th><th></th><th>[</th><th>Description</th><th>n</th><th></th><th>Rating</th><th></th><th></th><th>Descri</th><th>iption</th><th>F</th><th>Rating</th></tr><tr><td> 4</td><td>6</td><td>1</td><td></td><td>n</td><td>Bank slo</td><td>ope gra</td><td>dient <3</td><td>0%.</td><td></td><td>2</td><td>Bank sl</td><td>ope grad</td><td>dient 30-</td><td>-40%.</td><td></td><td>4</td><td>Bank sl</td><td>ope gra</td><td>dient 40</td><td>-60%.</td><td></td><td>6</td><td>Bank slo</td><td>pe grad</td><td>dient ></td><td>60%.</td><td></td><td>8</td></tr><tr><td> A pank suggest a deep, dense sol-binding 3 sus-vigor suggest lease dense or deep 6 december 6 d</td><td>bank</td><td>2</td><td>Mass er</td><td>osion</td><td></td><td></td><td>past or</td><td>future m</td><td>nass</td><td>3</td><td></td><td></td><td>•</td><td>ed over.</td><td>Low</td><td>6</td><td></td><td></td><td></td><td>sing sed</td><td>iment</td><td>9</td><td colspan=3></td><td></td><td></td><td>12</td></tr><tr><td> A pank suggest a deep, dense sol-binding 3 sus-vigor suggest lease dense or deep 6 december 6 d</td><td>pper</td><td>3</td><td>-</td><td></td><td>channel</td><td>l area.</td><td></td><td></td><td></td><td>2</td><td>limbs.</td><td></td><td>-</td><td></td><td></td><td>4</td><td>larger s</td><td colspan=3>larger sizes.</td><td>6</td><td colspan=3>•</td><td>sizes.</td><td></td><td>8</td></tr><tr><td> Second Temporary Communication of Second Programs afficients occurring the product of Expanding Second Programs afficients occurring the product of Expanding Second Programs afficients occurring the programs of the progr</td><td>n</td><td colspan=5>4 bank suggest a deep, dense soil-binding 3 less vigor suggest less dense or deep 6 fewer species from a shallow, 9 vigor indicating poor, disc</td><td></td><td></td><td>12</td></tr><tr><td> Page Content 12" td="" ="" <=""><td></td><td colspan="4">Bank heights sufficient to contain the bankfull stage is contained within banks. Channel capacity reference width/depth ratio eleparture from reference width/depth ratio = 1.0. Bank-Height reference width/depth ratio = 1.0-1.2. Bank-Height Ratio 1 Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio = 1.0-1.2. Bank-Height Ratio</td><td>bankfull. Width/depth e width/depth ratio ></td><td></td><td>4</td>		Bank heights sufficient to contain the bankfull stage is contained within banks. Channel capacity reference width/depth ratio eleparture from reference width/depth ratio = 1.0. Bank-Height reference width/depth ratio = 1.0-1.2. Bank-Height Ratio 1 Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio = 1.0-1.2. Bank-Height Ratio				bankfull. Width/depth e width/depth ratio >		4																				
Some new bar increase, mostly from point bars. Some new bars. Corners and edges well rounded in 2 dimensions. Surfaces dull, dark or stained. Generally not bright. Some new bars. Some new bars. Corners and edges well rounded in 2 dimensions. Surfaces dull, dark or stained. Sourfaces dull, dark or stained. Sourfaces dull, dark or stained. Sourfaces dull, but may have <35% bright Surfaces dull,	nks	6		ck	12"+ co	mmon.				2			y boulde	rs and s	small	4		6. Most	in the 3-	-6" diam	neter	6	or less.				-3"	8
Some new bar increase, mostly from polyment of channel or point bars. Some new bar increase, mostly from point bars. Some new bars. Corners and edges well rounded in 2 dimensions. Corners and edges well rounded in 2 dimensions. Surfaces and Unit particles. Accelerated bar development. Surfaces and Indiana point bars. Some new bars. Corners and edges well rounded in 2 dimensions. Surfaces and Unit particles. Surfaces and Indiana point bars. Surfaces and Indiana. Surfaces and Indiana point bars. Surfaces and I	/er ba	7		tions	pattern	w/o cutt	•				currents fewer an	and mind d less firr	or pool fill m.	ing. Obs	tructions	4	move wi	th high flo				6	cause b	ank ero	sion ye	earlong. Sedimen	t	8
Page	Low	8	Cutting			none. I	nfrequer	nt raw ba	anks	4	constric		,			6	-			_		12				•		16
10 angularity surfaces rough. 1 Surfaces smooth and flat. 2 dimensions. 3 smooth. 1 Brightness Surfaces dull, dark or stained. 2 Surfaces dull, dark or stained. 3 Smooth. 4 Smo		9	Depositi	on			irgemen	t of char	nnel or	4			increase	, mostly	/ from	8	and coa	arse san				12				16		
Surfaces 1		10			surfaces rough.			е	1				•		2			dges we	ll rounde	ed in 2	3			all din	nensions, surface	S	4	
Battom size distribution Size change evident. Stable A Distribution shift light. Stable material 80–100%. A Distribution shift light. Stable material 80–100%. B Moderate change in sizes. Stable material 80–20%. Marked distribution change. Stable material 80–20%. So-80%. So-80%. So-80%. So-80%. So-80% affected. Scour at constrictions and where grades steepen. Some deposition in pools. Some deposition in pools. Some deposition in pools. Steepen. Some deposition in pools. 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 Bood total 12 Steem type A1 A2 A3 A4 A5 A6 B1 B2 B3 B4 B5 B6 C1 C2 C3 C4 C5 C6 D3 D4 D5 D6 C6 C6 C6 C7 C7 C7 C7 C		11	Brightne		Genera	lly not b	right.			1	surface	S			6 bright	2			d bright,	i.e., 35-	-65%	3	3 1 7 7 7 1			> 65%, exposed	or	4
14 Scouring and deposition 45% of bottom affected by scour or deposition. 6 6 6 6 6 6 6 6 6	E	12			overlap	ping.				2	overlap	oing.				4	apparei	nt overla	ар.			6	easily m	oved.				8
14 Scouring and deposition 15 Aquatic vegetation 15 Aquatic vegetation 15 Aquatic vegetation 16 Aquatic vegetation 16 Aquatic vegetation 16 Aquatic vegetation 16 Aquatic vegetation 17 Aquatic vegetation 18 Aquatic vegetation 16 Aquatic vegetation 16 Aquatic vegetation 17 Aquatic vegetation 18 Aquatic vegetation 16 Aquatic vegetation 16 Aquatic vegetation 17 Aquatic vegetation 18 Aquatic vegetation 18 Aquatic vegetation 19 Aquatic vegetation 19 Aquatic vegetation 19 Aquatic vegetation 19 Aquatic vegetation 10 Aquati	Botto	13				_		. Stable		4	50–80%	· .			aterial	8	materia	ıls 20–50	0%.			12				ange. Stable		16
1 1 1 2 2 2 2 2 2 2		14					affected	by scot	ır or	6	constric	tions an	nd where	grades		12	at obstr	uctions,	constri	ctions a		18					of	24
Stream type		15	-			•				1		_				2	backwa	iter. Sea	asonal a		wth	3						4
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 67-98 Fair (Mod. unstable 44-47 44-47 91-129 96-132 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 Stream type DA3 DA4 DA5 DA6 E3 E4 E5 E6 F1 F2 F3 F4 F5 F6 G1 G2 G3 G4 G5 Good (Stable) 40-63 40-63 40-63 40-63 40-63 40-63 50-75 50-75 40-63 60-85 86-105 86-105 111-125 111-125 116-130 96-110 61-78 61-78 108-120 108-120 108-120 113-125 108-120 Modified chann							Exc	ellent	total =	27				Good	total =	12				Fair	total =	0				Poor tot	al =	16
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 67-98 Fair (Mod. unstable 44-47 44-47 91-129 96-132 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 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 40-63 50-75 50-75 40-63 60-85 86-105 86-105 111-125 116-130 96-110 61-78 61-78 108-120 108-120 113-125 108-120 Modified chann	Stream tv	/ne	Δ1	Δ2	Δ3	Δ4	Δ5	Δ6	R1	R2	B3	R4	R5	B6	C1	C2	C3	C4	C5	C6	D3	2 D4 D5 D6						
Poor (Unstable) 48+ 48+ 130+ 133+ 143+ 111+ 59+ 59+ 79+ 85+ 89+ 79+ 62+ 62+ 106+ 111+ 111+ 106+ 133+ 133+ 133+ 133+ 126+ Stream type Stream type DA3 DA4 DA5 DA6 E3 E4 E5 E6 F1 F2 F3 F4 F5 F6 G1 G2 G3 G4 G5 G6 *Potential stream type G4-86 64-8	Good (Stab	ole)	38-43	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			=	55																				
Good (Stable) 40-63 40-63 40-63 40-63 40-63 50-75 50-75 40-63 60-85 85-110 85-110 90-115 80-95 40-60 40-60 85-107 85-107 90-112 85-107 Stream type = Modified chann	Poor (Unsta	able)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+				stream type	=	E6
Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 86-105 86-105 86-105 111-125 111-125 111-125 116-130 96-110 61-78 108-120 108-120 113-125 108-120 Modified chann		-																									_	E6
																												ام
The state of the s																												
*Rating is adjusted to potential stream type, not existing. Good	(230	/											<u> </u>	<u> </u>	1			I	L	·	1	1	ım type,	not exis	sting.	•		

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.										
			Estim	ating Nea	r-Bank St	ress (NB:	S)			
Stream:	Rush F	River			Location:	Rush Rive	er - 1 - 0.08			
Station:	0			S	tream Type:	E6	\	/alley Type:	X	
Observe	rs:	KP, AL						Date:	11/17/10	
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)			
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr	Level I	Reconaissance				
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})	Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction	
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction	
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction	
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction	
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation	
Levell	(1)									
-				meander mig		ging flow		Nt	oo = Extreme	
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress					
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)					
_					Near-Bank				_	
el I	(3)	Pool Slope	Average		Stress			inant		
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)			nk Stress		
							Very	Low		
		D 101	D:/// 01	Datia C /	Near-Bank					
	(4)	Pool Slope S _p	Riffle Slope S _{rif}	Ratio S _p / S _{rif}	Stress (NBS)					
		Ор	o _m	o _{ni}	(NBC)					
		Near-Bank			Near-Bank					
	(E)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress					
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)					
=									_	
Level III				Near-Bank Shear			Bankfull Shear			
Ţ	(6)	Near-Bank Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank	
	(6)	d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	d _{bkf} (ft)	Slope S	Ib/ft ²)	$ au_{bkf}$	Stress (NBS)	
		110 (7	· III	.3, /	JNI (17)	2.000	,	· DNI	,,,,,,,,	
,				Near-Bank						
Level IV	(7)	Velocity Grad	dient (ft/sec	Stress						
.eve	(7)	/ f	t)	(NBS)	1					
7				Very Low						
		Cor	nverting Va	lues to a N	Near-Bank	Stress (NE	SS) Rating			
Near-B	ank Str	ess (NBS)				ethod numb				
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
	Very Lo		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	
	Modera		N/A	2.01 – 2.20	0.41 – 0.60	0.61 - 0.80	1.51 – 1.80			
	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 Hi	_	(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	
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40	
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Stream: Rush River - 1 - 0.08										
Graph Used:	Fig 3-9	Total	Bank Length (ft):	4896.1		Date: 11/17/2010					
Observers:	KP, AL		Valley Type:		Stream Type: E6						
(1)	(2)		(4)	(5)	(6)	(7)	(8)				
Station (ft)	BEHI ra (WorksI 3-11) (adjecti	heet (Worksho	eet erosion rate (Figure	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.	Higl	h Very Lo	w 0.165	4896.1	15.6	12603	0.12				
2.						0	#DIV/0!				
3.						0	#DIV/0!				
4.						0	#DIV/0!				
5.						0	#DIV/0!				
6.						0	#DIV/0!				
7.						0	#DIV/0!				
8.						0	#DIV/0!				
9.						0	#DIV/0!				
10.						0	#DIV/0!				
11.						0	#DIV/0!				
12.						0	#DIV/0!				
13.						0	#DIV/0!				
14.						0	#DIV/0!				
15.						0	#DIV/0!				
Sum erosion	n subtotals in	Column (7) for	each BEHI/NBS	combination	Total Erosion (ft ³ /yr)	12603					
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} (yds ³ /yr) 467											
Convert eros by 1.3}	sion in yds ³ /y	yr to tons/yr {mi	ultiply Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	607					
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.12											

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

Stream:	Rush Rive	r	S	Stream Type:	E6						
Location:	Rush Rive	r - 1 - 0.08		Valley Type:	Х						
Observers:	KP, AL			Date:	11/17/2010						
Enter Req	uired Infor	mation for Existing Co	ondition								
	D ₅₀	Riffle bed material D_{50} (mm)								
	D ₅₀	Bar sample D ₅₀ (mm)									
	D _{max}	Largest particle from ba	ır sample (ft)		(mm)	304.8 mm/ft					
	S	Existing bankfull water s	surface slope (ft/ft)								
	d	Existing bankfull mean	depth (ft)								
1.65	γ_{s}	Submerged specific wei	ight of sediment								
Select the	Appropria	te Equation and Calcu	ılate Critical Dimensio	onless She	ar Stress						
#DIV/0!	D ₅₀ /D [^] ₅₀	Range: 3-7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	τ* = 0.038	34 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless	Shear Stress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean	n depth (ft) $d = \frac{7}{2}$	$7*\gamma_s D_{max}$	(use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrad									
Calculate Sample	Bankfull W	ater Surface Slope Re	equired for Entrainme	nt of Large	st Particle	in Bar					
#DIV/0!	s	Required bankfull water	surface slope (ft/ft) \$	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrad	ing □ Degrading								
Sediment	Competen	ce Using Dimensional	Shear Stress								
0	Bankfull st	near stress τ = γdS (lbs/f	t ²) (substitute hydraulic ra	idius, R, with	mean depth,	, d)					
	$\gamma = 62.4, c$	d = existing depth, S = exis	sting slope								
	Predicted	largest moveable particle	size (mm) at bankfull she	ar stress τ (F	igure 3-11)						
	Predicted	shear stress required to in	nitiate movement of meas	ured D _{max} (m	m) (Figure 3	-11)					
#DIV/0!		Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope									
#DIV/0!	Predicted	slope required to initiate m	novement of measured D _r	_{max} (mm)	$S = \frac{\tau}{2 d}$, J					
L	τ = predic	ted shear stress, $\gamma = 62.4$,	, d = existing depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S					MATE	RIALS	SAMF	LE DA					_		ervers:	KP, A	L		I			
u b	Strea	ım:	Rush	River	1		11		Loca	tion:	Rush	River	- 1 - 0.0	80	1		1		Date: 1	1/17/	2010	
		⇒ (⇒ (⇒(⇒(⇒ (⇒(⇒ (→ (⇒ (
a a		h Pan	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve		Sieve		Sieve	SIZE				
m		CKET		mm		mm		mm		mm		mm		mm		mm		mm	CLIDEACE		RFACE	
p I	rare	weight	rare	weight	rare	weight	rare v	weight	Tare v	veight	Tare v	veignt	Tare v	veignt	Tare v	veight	rare v	weight			RIALS	
e s	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two		NTA est part	ticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net				
1																			N	lo. I	Dia.	WT.
2																			l —	1		
3																				2		
4																			Bucket +			
5 6																			materials weight			
7																			Description	_		
8																			Bucket tar weight	е		
9																			Materials			
10																			weight		0	
11																			Materials le	ss		
12																			than:			mm
13																					ure to a	
14																			//	weig	hts to g	
15	total	_		_		_				_		0		•				0		total		
Net wt	and total	0 #####		0 #####		0 #####		0 #####		0 #####		#####		0 #####		0 #####		#####	0	7		
-	1. % =<	#####		#####		#####		#####		#####		#####		#####		#####		100%		~~	D TO:	
7100011	1. 70 – 1	ппппп		ппппп		mmmm		ппппп		ппппп		ппппп		ппппп		ппппп		100 /0		3RAN	D TOT	AL
S	ample lo	cation n	otes				Sar	nple loc	ation ske	etch												
	1							,		-												
																						ا

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

Stream:	Rush River	Stream Type: E6					
Location:	Rush River - 1 - 0.08	Valley Type: X					
Observers:	KP, AL	Date: 11/17/2010					
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)					
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable					
	(E→C), (C→High W/d C)						
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable					
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable					

Worksheet 3-17. Lateral stability prediction summary.

Stream: Rush River			Stream Ty	_{/pe:} E6							
Location: Rush River - 1 - 0	0.08		Valley Ty	_{/pe:} X							
Observers: KP, AL			Da	ate: 11/17/2010							
Lateral stability criteria		Lateral Stability Categories									
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	Selected points (from each row)						
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2						
,	(2)	(4)	(6)	(8)							
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1						
	(1)	(2)	(3)	(4)							
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1						
	(1)		(3)								
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)							
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1						
(Worksheet 3-9)	(1)	(2)	(3)	(4)							
				Total points	9						
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Rush River			Stream Type:	E6						
Location: Rush River - 1	1 - 0.08		Valley Type:	X						
Observers: KP, AL			Date:	11/17/2010						
Vertical stability criteria	Vertical Stabi	Selected								
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	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)						
Sediment capacity (POWERSED)	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)						
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2					
	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheet 3- 16)	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)						
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1					
3-5)	(1)	(2)	(3)	(4)						
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1					
,	(1)	(2)	(3)	(4)						
	Total points									
	Vertical stal		int range for exces adation	ss deposition /						
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 3-19. Vertical stability prediction for channel incision or degradation.

Str	Stream: Rush River Stream Type: E6									
Lo	cation: Rush River -	1 - 0.08		Valley Type:	Х					
Ob	oservers: KP, AL			Date:	11/17/2010					
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected				
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)				
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2				
		(2)	(4)	(6)	(8)					
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2				
		(2)	(4)	(6)	(8)					
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8				
	(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)					
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4				
		(2)	(4)	(6)	(8)					
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1				
	3-9)	(1)	(2)	(3)	(4)					
					Total points	17				
Vertical stability category point range for channel incision / degradation										
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Stream: Rush River Stream Type: E6												
Location: Rush River - 1	- 0.08		Valley Type:	X								
Observers: KP, AL			Date:	11/17/2010								
Channel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected							
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)							
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2							
	(2)	(4)	(6)	(8)								
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2							
	(2)	(4)	(6)	(8)								
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2							
(Worksheet 3-18)	(2)	(4)	(6)	(8)								
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4							
(Worksheet o 15)	(2)	(4)	(6)	(8)								
				Total points	10							
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: Rush River Stream Type: E6											
Lo	cation: Rush River - 1 -	0.08		Valley Type:	X						
Ob	servers: KP, AL			Date:	11/17/2010						
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points						
		Stable		1							
1	Lateral stability	Mod. unstab	ole	2	1						
'	(Worksheet 3-17)	Unstable		3	1						
		Highly unsta	able	4							
	Vertical stability	No deposition	on	1							
2	excess deposition/	Mod. depos	ition	2	1						
-	aggradation	Excess dep	osition	3	1						
	(Worksheet 3-18)	Aggradation	1	4							
	Vertical stability	Not incised		1							
3	channel incision/	Slightly inci	sed	2	2						
l °	degradation	Mod. Incised	d	3	2						
	(Worksheet 3-19)	Degradation	1	4							
	Channal anlargement	No increase									
4	Channel enlargement prediction (Worksheet	Slight increa	2	1							
~	3-20)	Mod. increa	se	3	•						
	<i>3 23)</i>	Extensive		4							
	Pfankuch channel	Good: stable	e	1							
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	1						
١	10)				•						
	10)	Poor: unsta	ble	4							
	_			Total Points	6						
			Category p	oint range							
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □						

Worksheet 3-22. Summary of stability condition categories.

Stream:	Rush River			Location: Rus	sh River - 1 -	0.08		
Observers:	KP, AL	Date:	11/17/2010	Stream Ty	pe: E6	Valley	Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 3.25	Mean bankfull width (ft):	7.4 Cross-section area (ft ²):	111.1 Wic	of flood- ne area (ft):	11 66667 I	Intrenchment atio:	2.5
Channel Pattern	Mean: Range: MWR:	0.0 Lm/W _b		Rc/W _{bk}			Sinuosity:	0
	Check: Riffle/pool	☐ Step/pool ✓		Convergence/	divergence	☑ Dunes/a	ntidunes/smooth bed	t
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle		ool to Ratio		Slope	
Features	bankfull depth (ft): 5.2	(max/me	ean): 1.6	spa	oool acing:	Valley:	Average bankfull:	0.00043
	Nipanan	nt composition/density:	Potential composit	tion/density:	Remarks: Co	ondition, vigor	and/or usage of existing	reach:
	vegetation							
	Flow P1, 2, Strear regime: 9 and or	der:	Meander pattern(s):	patt	tern(s):	b	Debris/channel blockage(s):	D1
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.9 Degree of stability rat	ing:	nuisea (nui	dified Pfankuch meric and adjed	tive rating)	: G0	od
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	11.0 Width/deptl (W/d) / (W/	h ratio state ′d _{ref}):	1.1	W/d ration	Sta	ble
	Meander Width Ratio (MWR):	0.0 Reference MWR _{ref} :	0.0 Degree of o	confinement VR _{ref}):	1.0	MWR / N stability r	IIncor	nfined
Bank Erosion Summary	Length of reach studied (ft):	iyb ————	mbank erosion rate s/yr) 0.12 (ton		rve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	capacity	Remarks:			
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :	Exist	,	
Successional Stage Shift	→ -	→	→		Existing stream state (type):	E6	Potential stream state (type):	E6
Lateral Stability	▼ Stable □	Mod. unstable	Unstable	☐ Highly ur	nstable Rema	arks/causes:	None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggradat	Rema	arks/causes:	None	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degrada	tion	arks/causes:	None	
Channel Enlargement	✓ No increase	Slight increase	Mod. increase	☐ Extensive	e Rema	arks/causes:	None	
Sediment Supply (Channel Source)	□ Low ▽	Moderate	High 🔲 Very hi	gh Remarks/c	auses: None	e		

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

			Riparian Ve	getation
Stre	eam: Rush	River		Location: Rush River-2-6.15
Obs	servers: KP, A	L	Reference reach	Disturbed (impacted reach) X Date: 9/27/2011
spe	sting cies nposition:			Potential species composition:
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition Percent of total species composition
1. Overstory	Canopy layer	0%	0%	
	1			100%
2. Understory	Shrub layer		0%	
				100%
level	Herbaceous		94%	
3. Ground level	Leaf or needle litter		1%	Remarks: Condition, vigor and/or usage of existing reach:
	Bare ground		5%	
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%	

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

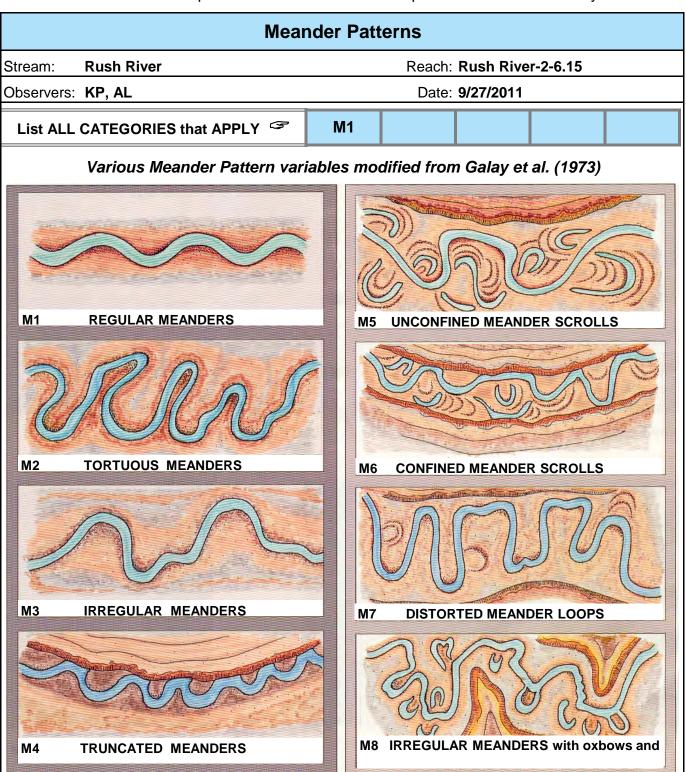
	FLOW REGIME													
Stream:	Rush River		Location:	Rush Riv	ver-2-6.15	5								
Observers:	<u> </u>						Date:	9/27/201	1					
	. COMBINATIONS that PLY	P1	P2	P9										
General	Category													
E	, , , , , , , , , , , , , , , , , , ,													
S		Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.												
I	associated with sporad	termittent stream channel: Surface water flows discontinuously along its length. Often ssociated with sporadic and/or seasonal flows and also with Karst (limestone) geology where sing/gaining reaches create flows that disappear then reappear farther downstream.												
Р	Perennial stream chann	Perennial stream channels: Surface water persists yearlong.												
Specific	Category													
1	Seasonal variation in st	treamflow	dominate	d primarily	/ by snow	melt runo	ff.							
2	Seasonal variation in st	treamflow	dominate	d primarily	/ by storm	nflow runc	off.							
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ndition, b	ackwater	, etc.						
4	Streamflow regulated b	y glacial ı	melt.											
5	Ice flows/ice torrents fro	om ice da	m breache	es.										
6	Alternating flow/backwa	ater due to	o tidal influ	ience.										
7	Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ring, 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 generate	ed runoff.												

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

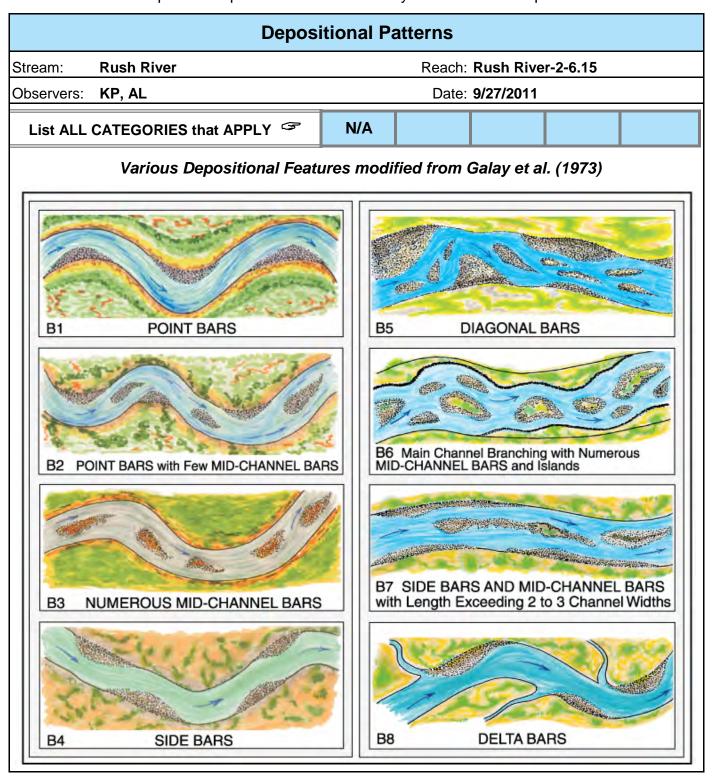
Stream Size and Order												
Stream:	Rush River											
Location:	Rush River-2-6	6.15										
Observers:	KP, AL											
Date:	9/27/2011											
Stream Size Category and Order S-4												
Category STREAM SIZE: Bankfull Check (✓) appropriate												
meters feet category												
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												
۸ ما ما م م م م ساد		f : f: f										

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

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



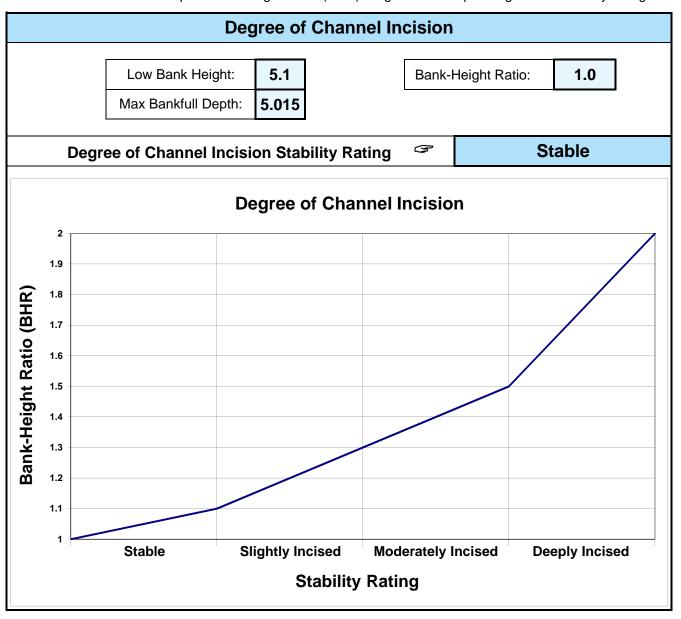
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



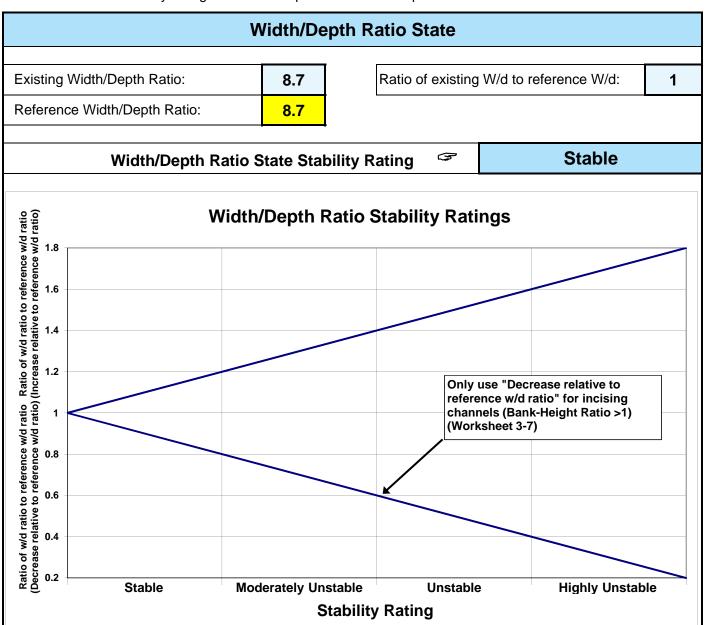
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strear	m: Rush River	Location: Rush River-2-6.15	
Obser	rvers: KP, AL	Date: 9/27/2011	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	>
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

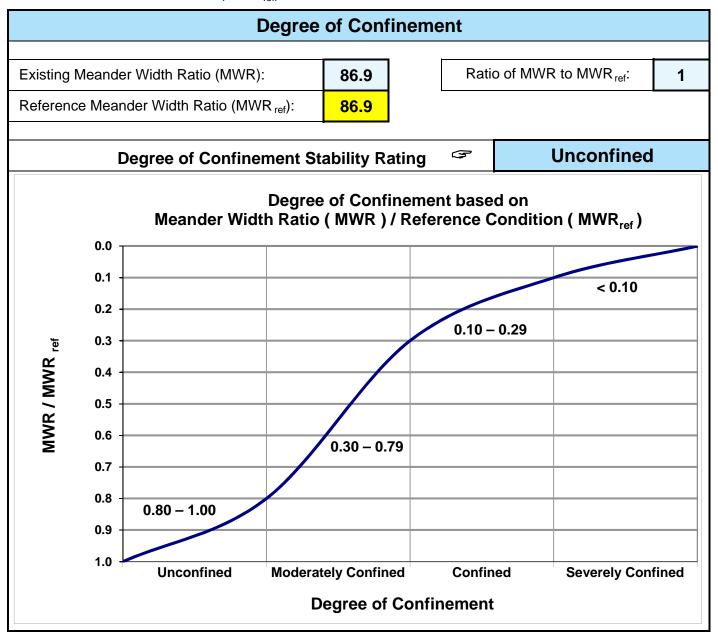
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



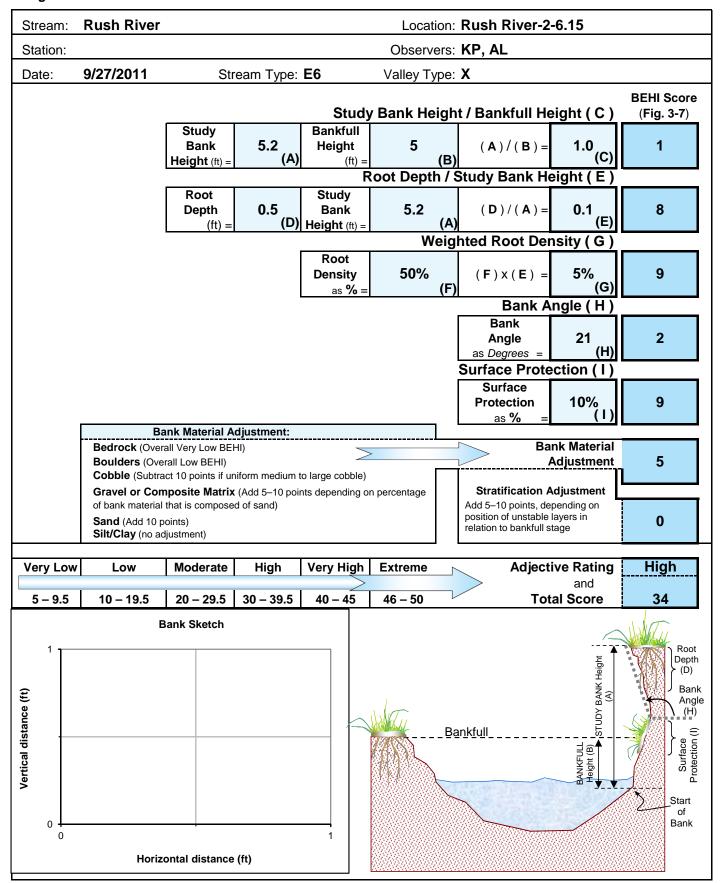
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Rusl	n River					Loc	ation:	Rush	River	-2-6.1	5		Valley	Type:	e: X Observers: KP, AL						Date: 9/27/2011				11
Loca-	Key	Caton	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Key	Catego	OI y			Descriptio	n		Rating		C	Description	n		Rating			Description	n		Rating			Descri	otion	Rating
0	1	Landform slope	l	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	lope gra	dient 40	⊢60%.		6	Bank slo	pe gradi	ent >	60%.	8
banks	2	Mass ero	sion	No eviderosion.		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg		sing sedi	iment	9				sing sediment near danger of same.	y 12
Upper	3	Debris jar potential		Essentia channel	•	ent from	immedi	ate	2	limbs.		ostly sma			4	larger s	sizes.	-	ounts, m	-	6	Moderate predomin	nantly la	rger si	zes.	8
n	4	Vegetativ bank protection			90% plant density. Vigor and variety ggest a deep, dense soil-binding of mass. 70–90% density. Fewer species or less vigor suggest less dense or deep of fewer species from a shallow, discontinuous root mass.							9		icating p	oor, d	er species and less iscontinuous and	12									
	5	Channel capacity	Bank heights sufficient to contain the bankfull stage is contained within banks. Channel stage. Width/depth ratio departure from capacity reference width/depth ratio = 1.0. Bank-Height 1 Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio								Bankfull stage is contained within banks. Width/depth ratio departure from reference			3	Bankfull sta common w	age is not of ith flows lea ture from re	ontaine ss than eference	d; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4. 3.	4							
nks	Bank rock content 12"+ common. 2 40–65%. Mostly boulders and small cobbles 6–12". 4 20–40%. Most in the 3–6" diamete class.							neter	6	or less.			of gravel sizes, 1–3	8												
ver ba	7 to flow Stable bed. 2 currents and minor pool filling. Obstructions fewer and less firm. 4 move with high flows causing bank cutting for deposition. Stable bed.							cause ba	ank erosi	on ye	and deflectors arlong. Sediment ation occurring.	8														
Low	8 Cutting Little or none. Infrequent raw banks 4 Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident solutions.						12		Almost continuous cuts, some high. Failure of overhangs freq			16														
	9	Depositio	n	Little or point ba		ırgemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Moderate depostion of new gravel and coarse sand on old and some new bars.				12	Extensive deposit of pr particles. Accelerated by			,	16	
	10	Rock angularity		Sharp e surfaces		nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	smooth.			ensions, surfaces	4
	11	Brightnes	is	General	lly not b					surface	3.	may hav		6 bright	2	mixture	range.		i.e., 35-		3	Predomi scoured	,	0 ,	• 65%, exposed or	4
E C	12	Consolidat particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4	appare	nt overla	ар.	nt with n		6	easily mo	oved.		ose assortment,	8
Bottom	13	Bottom si distributio		No size material	•	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ls 20–5	0%.	es. Stat		12	Marked of materials			ange. Stable	16
	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18	More tha flux or ch			oottom in a state of earlong.	24
	15	Aquatic vegetation			•	th moss- I. In swif						e forms i . Moss h			2	backwa	t but spo ater. Sea rocks sl	sonal a	stly in Igae gro	wth	3				or absent. Yellow- m may be present.	4
			•			Exc	ellent	total =	24				Good	total =	2				Fair	total =	15				Poor total	32
Stream ty	/pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stab			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		67-98		Grand total =	73
Fair (Mod. u	unstable	44-47	44-47 48+		96-132 133+		81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+						108-132		99-125		Existing stream type =	E 6
Stream ty	_		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6	- * *			*Potential	F^
Good (Stab	-		40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107						stream type =	E6
Fair (Mod. u	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				Modified cha	nnel
Poor (Unsta	able)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rati	ng =
																	*Ra	ting is a	djusted	to poten	tial strea	ım type, r	not existi	ng.	Fair	
																			-	-						

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)														
			Estim	ating Nea	r-Bank St	ress (NB:	S)							
Stream:	Rush F	River			Location:	Rush Rive	er-2-6.15							
Station:	0			S	tream Type:	E6	1	/alley Type:	X					
Observe	rs:	KP, AL						Date:	9/27/11					
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)							
(1) Chanı	nel pattern	, transverse ba	or split channe	el/central bar cr	eating NBS		Level I	Recona	issance					
(2) Ratio	of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction					
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p /S)	Level II	General prediction								
(4) Ratio	of pool slo	pe to riffle slope		Level II	General prediction									
(5) Ratio	of near-ba	nk maximum de	Level III	Detailed	prediction									
(6) Ratio	of near-ba	nk shear stress	Level III	Detailed	prediction									
(7) Veloc	ity profiles	/ Isovels / Velo		Level IV	Valid	lation								
=														
Levell	(1)													
Ľ			NL	BS = Extreme										
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank									
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)									
	Near-Bank													
= -	(2)	Pool Slope	Average		Dom	inant								
Level II	(3)	Sp	Slope S	Ratio S _p / S	(NBS)	Ī	Near-Bai	nk Stress						
_							Very	Low						
					Near-Bank	•			_					
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress									
	(- /	S _p	S _{rif}	S _{rif}	(NBS)									
		Nama Danis												
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress									
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)									
=														
Level III				Near-Bank			Bankfull							
Le		Near-Bank	Near Dook	Shear			Shear	D :: /	Near-Bank					
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Stress					
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)					
2		Velocity Grad	lient (ft / sec	Near-Bank Stress										
Level IV	(7)	/ f		(NBS)										
Le			,	Very Low										
					J	04	10) D. (
Noar-P	lank Ctr	Cor ess (NBS)	iverting Va	liues to a l	Near-Bank	Stress (NE ethod numb								
iveai-E	rating		(1)	(2)	(3)	etnoa numi (4)	(5)	(6)	(7)					
	Very Lo		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					
	Modera		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 Hi		(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					
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40					
					ear-Bank S				Low					

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Rush River	Rush River-	2-6.15								
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	3519.8		Date:	9/27/2011				
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E6				
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}				
1.	High	Very Low	0.165	3519.8	5.2	3020	0.04				
2.						0	#DIV/0!				
3.						0	#DIV/0!				
4.						0	#DIV/0!				
5.						0	#DIV/0!				
6.						0	#DIV/0!				
7.						0	#DIV/0!				
8.						0	#DIV/0!				
9.						0	#DIV/0!				
10.						0	#DIV/0!				
11.						0	#DIV/0!				
12.						0	#DIV/0!				
13.						0	#DIV/0!				
14.						0	#DIV/0!				
15.						0	#DIV/0!				
Sum erosior	n subtotals in Colo	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft³/yr)	3020					
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} Total Erosion (yds ³ /yr) 112											
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	145					
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.04					

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

Stream:	Rush Rive	r		Stream Type:	E6	
Location:	Rush Rive	r-2-6.15		Valley Type:		
Observers:	KP, AL			Date:	9/27/2011	
Enter Req	uired Infor	mation for Existing (Condition			
	D ₅₀	Riffle bed material D ₅₀	₀ (mm)			
	D ₅₀	Bar sample D ₅₀ (mm)				
0	D _{max}	Largest particle from I	bar sample (ft)		(mm)	304.8 mm/ft
	S	Existing bankfull wate	er surface slope (ft/ft)			
	d	Existing bankfull mean	n depth (ft)			
1.65	γ_s	Submerged specific w	veight of sediment			
Select the	Appropria	te Equation and Cald	culate Critical Dime	nsionless She	ar Stress	
#DIV/0!	D ₅₀ /D [^] ₅₀	Range: 3-7	Use EQUATION	1: $\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION	2: τ* = 0.03 8	34 (D _{max} /D ₅	₀) ^{-0.887}
#DIV/0!	$ au^*$	Bankfull Dimensionles	ss Shear Stress	EQUATION	ON USED:	#DIV/0!
Calculate	Bankfull Me	an Depth Required fo	or Entrainment of Lar	gest Particle in	n Bar Sampl	e
#DIV/0!	d	Required bankfull mea	an depth (ft) d :	$=\frac{\mathcal{T}*\gamma_s D_{max}}{S}$	(use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggra				
Calculate Sample	Bankfull W	ater Surface Slope F	Required for Entrain	ment of Large	est Particle	in Bar
#DIV/0!	s	Required bankfull wat	ter surface slope (ft/ft)	$S = \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggra	ading Degrading			
Sediment	Competen	ce Using Dimension	al Shear Stress			
0	Bankfull sl	hear stress τ = γdS (lbs	s/ft ²) (substitute hydraul	ic radius, R, with	mean depth	, d)
	$\gamma = 62.4, c$	d = existing depth, S = e	xisting slope			
	Predicted	largest moveable particl	e size (mm) at bankfull	shear stress $ au$ (I	Figure 3-11)	
	Predicted	shear stress required to	initiate movement of m	easured D _{max} (m	m) (Figure 3	-11)
#DIV/0!		mean depth required to ted shear stress, $\gamma = 62$.		easured D _{max} (m	$\mathbf{d} = \frac{7}{2}$	t vs
#DIV/0!	Predicted	slope required to initiate	movement of measure	d D _{max} (mm)	$S = \frac{\tau}{vd}$	
	τ = predic	ted shear stress, $\gamma = 62$.4, a = existing depth		γ d	

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	ATA: Size Distribution Analysis Observers: KP, AL													
u b	Strea	ım:	Rush	River					Loca	tion:	Rush	River-	2-6.15						Date: \$	9/27	/2011	
		→ (→ (⇒ (⇒ (→ (<u> </u>	⇒ (⇒ (→ (⇒ (
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve		Sieve	SIZE				
m p		veight	Tare	mm weight	Tare	mm weight	Tare \	mm veight	Tare v	mm veight	Tare	mm weight	Tare v	mm weight	Tare v	mm weight	Tare	mm weight			RFACE	
1	Luio			oigint	Turo (wolgin	Turo (roigin.	1010	voigin.	Taro	roigin	10101	roigin			1410	oigin			TERIAL DATA	S
e s	Sample		Sample		Sample		Sample weights Sample weights Sample weights Sample weights Sample weights Sample weights Sample weights									(Tw		gest par	ticles)			
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.
2																				1	Dia.	VVI.
3																				2		
4																			Bucket	+	<u> </u>	
5																			material weight			
7																						
8																				Bucket tare weight		
9																			Materia	ls		
10																			weight		()
11																			Materials I than:	less		
12																			trian.			mm
14																				se	e sure to a eparate m	aterial
15																					eights to g tal	grand
Net wt		0		0		0		0		0		0		0		0		0	0	\vdash		
-	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		\ <u></u>		
Accun	n. % =<	#####		#####		#####		#####		#####		#####		#####		#####		100%		GR/	AND TO	TAL
S	ample lo	cation no	otes				Sar	nple loca	ation ske	etch												
	<u> </u>																					

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

Stream:	Rush River	Stream Type: E6
Location:	Rush River-2-6.15	Valley Type: X
Observers:	KP, AL	Date: 9/27/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Rush River Stream Type: E6													
Location: Rush River-2-6.1	5		Valley Ty	_{'pe:} X									
Observers: KP, AL	Date: 9/27/2011 Lateral Stability Categories												
Lateral stability criteria		Selected											
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)								
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2								
,	(2)	(4)	(6)	(8)									
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1								
,	(1)	(2)	(3)	(4)									
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1								
,	(1)		(3)										
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)									
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1								
(Worksheet 3-9)	(1)	(2)	(3)	(4)									
				Total points	9								
	La	teral stability c	ategory point ra	nge									
Overall lateral stability category (use total points and check stability rating)	Stable 7 – 9 <mark>▽</mark>	Moderately unstable 10 − 12	Unstable 13 – 21 □	Highly unstable > 21 □									

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

Stream: Rush River			Stream Type:	E6	
Location: Rush River-2-	6.15		Valley Type:	X	
Observers: KP, AL			Date:	9/27/2011	
Vertical stability criteria	Vertical Stabi	lity Categories fo	Selected		
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	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)	
Sediment capacity (POWERSED)	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)	
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2
	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheet 3- 16)	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)	
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1
3-5)	(1)	(2)	(3)	(4)	
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1
	(1)	(2)	(3)	(4)	
				Total points	10
	Vertical stal		int range for exces adation	s deposition /	
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Rush River			Stream Type:	E6	
Location: Rush River-2	-6.15		Valley Type:	X	
Observers: KP , AL			Date:	9/27/2011	
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
	(2)	(4)	(6)	(8)	
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
	(2)	(4)	(6)	(8)	
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	2
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2
	(2)	(4)	(6)	(8)	
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1
3-9)	(1)	(2)	(3)	(4)	
				Total points	9
	Vertical stab	ility category poi degra	nt range for chan dation	nel incision /	
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 3-20. Channel enlargement prediction summary.

Str	eam: Rush River			Stream Type:	E6					
Lo	cation: Rush River-2-6	.15		Valley Type:	Х					
Ob	servers: KP, AL			Date:	9/27/2011					
	hannel enlargement	Char	Selected							
(c	rediction criteria choose one stability ategory for each criterion –4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)				
1	Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2				
		(2)	(4)	(6)	(8)					
2	Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2				
		(2)	(4)	(6)	(8)					
3	Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2				
	(Worksheet 3-18)	(2)	(4)	(6)	(8)					
4	Vertical stability incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2				
	(Worksheet o 10)	(2)	(4)	(6)	(8)					
			Total points							
			Category p	ooint range						
p p	Channel enlargement rediction (use total oints and check stability ating)	No increase 8 – 10 ✓	Slight increase 11 – 16	Moderate increase 17 – 24	Extensive > 24					

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

Str	eam: Rush River			Stream Type:	E6
Lo	cation: Rush River-2-6.1	15		Valley Type:	Х
Ob	servers: KP, AL			Date:	9/27/2011
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	1
'	(Worksheet 3-17)	Unstable		3	1
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. depos	ition	2	1
-	aggradation	Excess dep	osition	3	1
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci	sed	2	4
3	degradation	Mod. Incised	d	3	1
	(Worksheet 3-19)	Degradation	1	4	
	Channal anlargement	No increase		1	
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1
"	3-20)	Mod. increa	se	3	•
	3 20)	Extensive		4	
	Pfankuch channel	Good: stable	е	1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				_
	10)	Poor: unsta	ble	4	
				Total Points	6
			Category p	oint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15	Very High 16 – 20

Worksheet 3-22. Summary of stability condition categories.

Stream:	Rush River			Location:	Rush River-2	-6.15		
Observers:	KP, AL	Date:	9/27/2011	Stream	n Type: E6	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 3.1	Mean bankfull width (ft):	Cross-section area (ft ²):	n 84.43	Width of flood- prone area (ft):	79.25	Entrenchment ratio:	2.9
Channel Pattern	Mean: Range: MWR:	86.9 Lm/W _t	okf: 86.9	Rc/	/W _{bkf} :	8.7	Sinuosity:	1.43
	Check: Riffle/pool	Step/pool	Plane bed	Converge	nce/divergence	✓ Dunes.	/antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth	ratio Riffle	Pool	Pool to Rati	o	Slope	
Features	bankfull depth (ft): 5.0	(max/m	ean): 1.6		pool spacing:	Valley:	Averag bankful	บ บบบด/
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remarks	s: Condition, vig	gor and/or usage of existi	ng reach:
	vegetation							
	Flow P1, 2, Stream regime: 9 and o	N=4	Meander pattern(s):	M1	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.0 Degree of stability ra	-	table	Modified Pfank (numeric and a	•	•	Fair
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	8.7 Width/dep (W/d) / (W		te 1.0		itio state y rating:	table
	Meander Width Ratio (MWR):	86.9 Reference MWR _{ref} :	86.9 Degree of (MWR / M		nt 1.0		/ MWR _{ref} y rating: Unc	onfined
Bank Erosion Summary	Length of reach studied (ft):	020	mbank erosion ratens/yr) 0.04 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	pacity \square Excess	s capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ =	τ*=	Existing depth _{bkf} :	Required depth _{bkf} :		isting Required	uired _{bkf} :
Successional Stage Shift	→ -	→	→	→	Existing stre		Potential strear state (type):	n E6
Lateral Stability	▼ Stable □	Mod. unstable	Unstable	☐ High	ly unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	emarks/cause	es:	
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	Mod. incised	□ Degr	adation	emarks/cause	es:	
Channel Enlargement	▼ No increase □	Slight increase	Mod. increase	□ Exte	nsive	temarks/cause	es:	
Sediment Supply (Channel Source)	□ Low •	Moderate	High Very h	igh	ks/causes:			

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

			Riparian Ve	egetation							
Stre	eam: Shey e	enne River		Location: Sheyenne River-1-4.20							
	servers: KP, A		Reference reach	Disturbed (impacted reach) X Date: 10/6/2011	10/6/2011						
spe	sting cies nposition:			Potential species composition:							
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition Species composition							
1. Overstory	Canopy layer	20%	2%								
	ı			100%							
2. Understory	Shrub layer		10%								
				100%							
level	Herbaceous		22%								
3. Ground level	Leaf or needle litter		6%	Remarks: Condition, vigor and/or usage of existing reach:							
	Bare ground		60%								
	ed on crown closure. sed on basal area to	surface area.	Column total = 100%								

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

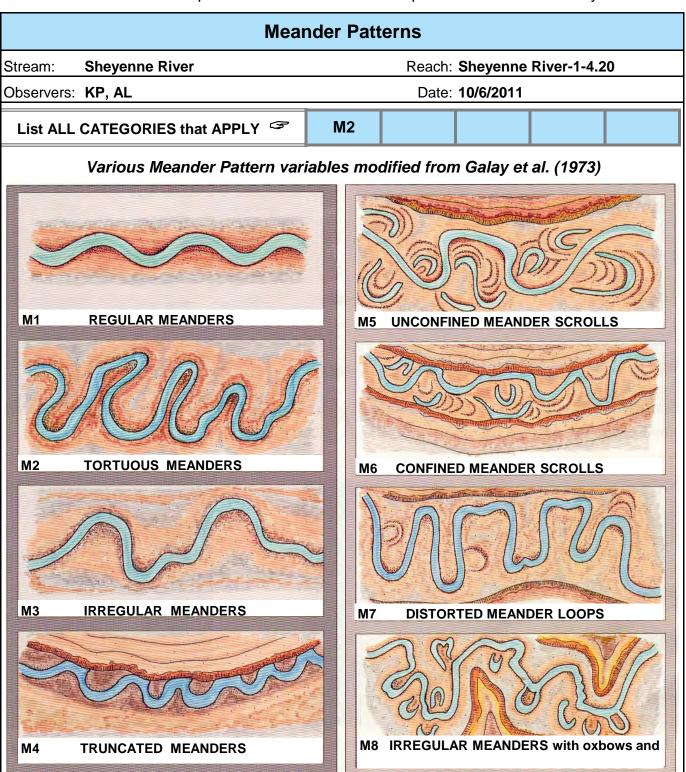
		F	LOW F	REGIMI	Ε									
Stream:	Sheyenne River		Location:	Sheyenr	ne River-1	1-4.20								
Observers:	KP, AL						Date:	10/6/201	1					
List ALL	COMBINATIONS that	P1	P2	P7	P9									
APF	PLY	F1	FZ	F7	ГЭ									
General Category														
E														
s	Subterranean stream c surface flow that follow			llel to and	l near the	surface fo	or various	seasons	- a sub-					
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal fl	ows and	also with	Karst (lim	estone) g	geology w	here					
Р	Perennial stream chan	nels: Surf	face water	persists y	/earlong.									
Specific (Category													
1	Seasonal variation in s	treamflow	dominated	d primarily	y by snow	melt runc	off.							
2	Seasonal variation in s	treamflow	dominated	d primarily	y by storm	nflow runc	off.							
3	Uniform stage and asso	ociated sti	reamflow c	lue to spr	ing-fed co	ondition, b	ackwater	, etc.						
4	Streamflow regulated b	y glacial r	melt.											
5	Ice flows/ice torrents fro	om ice da	m breache	s.										
6	Alternating flow/backwa	ater due to	o tidal influ	ence.										
7	Regulated streamflow	due to dive	ersions, da	ım releas	e, dewate	ering, etc.								
8	Altered due to develope conversions (forested t													
9	Rain-on-snow generate	ed runoff.												

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

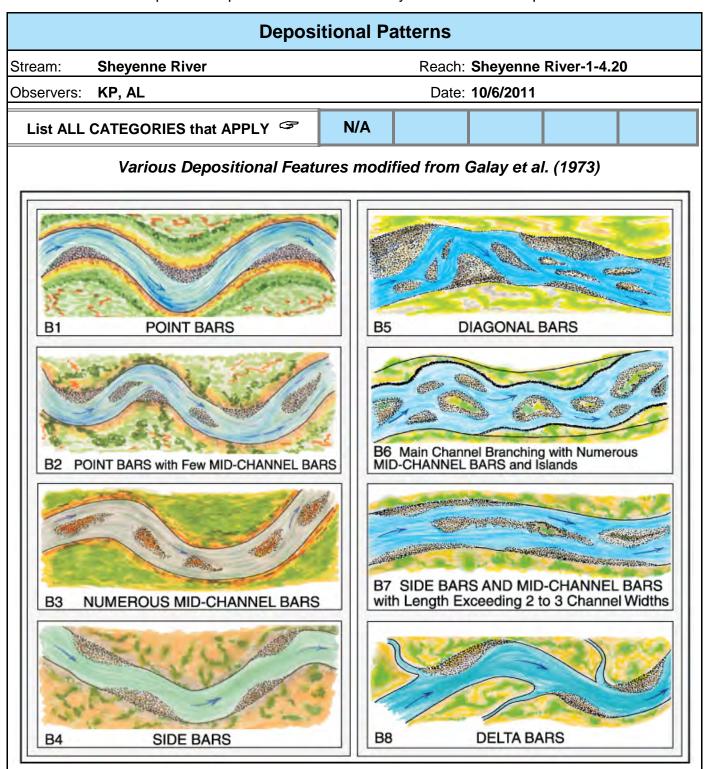
	Stream Siz	e and Orde	r								
Stream:	Sheyenne Rive	er									
Location:	Sheyenne Rive	er-1-4.20									
Observers: KP, AL											
Date:	10/6/2011										
Stream Size Category and Order S-7											
Category STREAM SIZE: Bankfull Check (✓) appropriate											
	meters	feet	category								
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									
	Strear	n Order									
A -1 -1411											

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

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



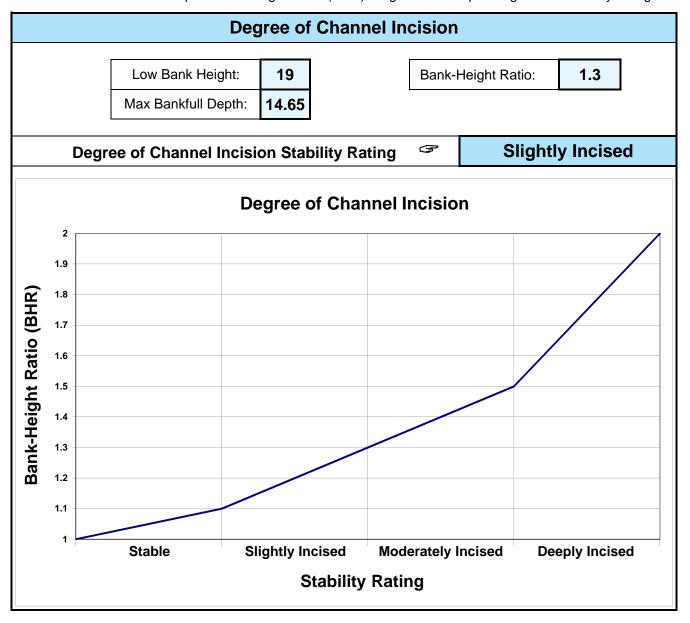
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



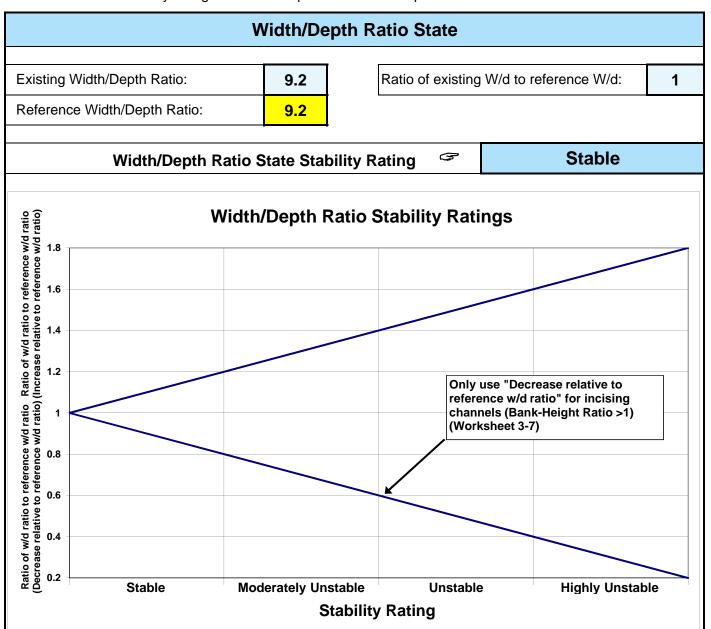
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strear	m: Sheyenne I	River Location: Sheyenne River-1-4.20	
Obser	rvers: KP, AL	Date: 10/6/2011	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	•
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

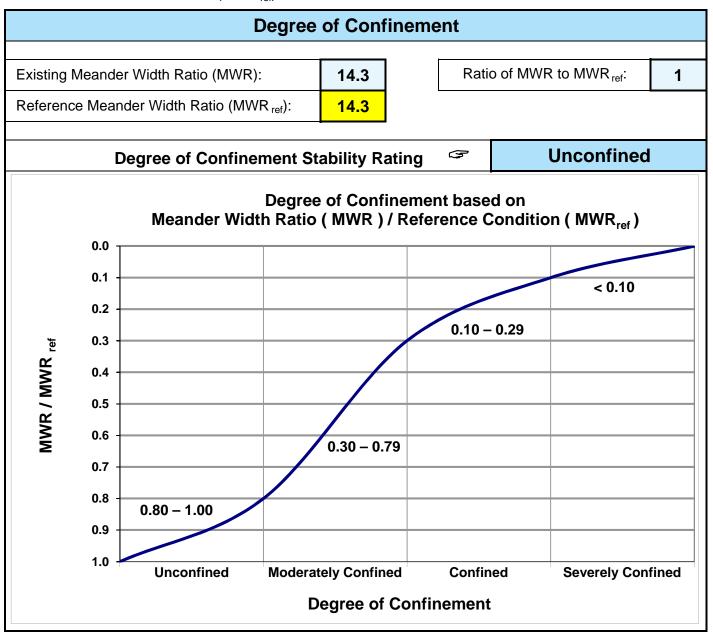
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



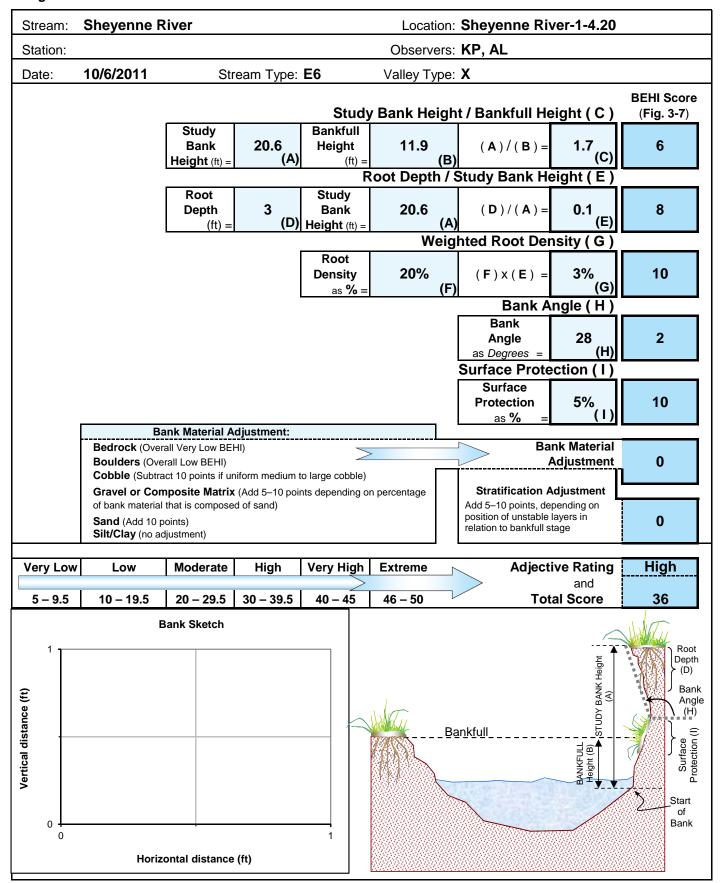
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Shey	enne l	River	•	Location: Sheyenne River-1-4.2(Valley Type: X Observers: KP, AL														Date: 10/6/2)11						
Loca-	Key	Cotoo	10 m/			Exce	llent					Go	od					F	air						Poor	
tion	Rey	Categ	JOI y		[Descriptio	n		Rating		D	Descriptio	n		Rating			Descriptio	n		Rating			Descri	ption	Rating
(0	1	Landform slope	n	Bank sl	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank slope gradient 40–60%.			6	Bank slo	pe grad	ient >	60%.	8		
Upper banks	2	Mass ero	osion	No evid erosion.		past or	future m	nass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg	large, causing sediment ong.		9				sing sediment nea danger of same.	12	
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.	Present, but mostly small twigs and mbs. 0–90% density. Fewer species or					Moderate to heavy amounts, mostly larger sizes.			6	Moderate to heavy am predominantly larger s			izes.	8		
ס	4	Vegetative bank protection			t a deep	nsity. Vi	_		3		or sugg	y. Fewer est less			6	fewer s	6 densit pecies f inuous r	rom a sl	hallow,	ınd	9	vigor inc		oor, d	er species and le discontinuous and	12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	ratio depa	stage is no arture from . Bank-He	reference	e width/dep	oth ratio	3	common w	vith flows le	ess than referenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1 .3.	1
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1-	3" 8
Lower banks	7	Obstructi to flow	ions		w/o cut	s firmly ir ting or de				currents fewer an	and mind d less firr		ing. Obs	tructions	4		ely frequ th high flo I filling.				6	cause b	ank eros	ion ye	and deflectors arlong. Sediment ration occurring.	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	U	ant. Cut erhangs		U		12		most continuous cuts, some over 24" gh. Failure of overhangs frequent.		16	
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	new bars.			12	particles. Accelerated b			xtensive deposit of predominantly fine articles. Accelerated bar development.			
	10	Rock angularity		Sharp e surface:		nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens	s and ed ions.	lges we	ll rounde	ed in 2	3	Well rou smooth.		all dim	nensions, surfaces	4
	11	Brightnes	ss	Surface Genera	,	dark or s right.	tained.		1	surface	3.	may hav		6 bright	2	Mixture dull and bright, i.e., 35–65% mixture range.			3	Predominantly bright, scoured surfaces.			ght, > 65%, exposed or			
E	12	Consolidate particles		Assorte overlap		tightly p	acked o	r	2	Modera overlap		ked with	some		4	Mostly loose assortment with no apparent overlap.			6	No packing evident. L easily moved.			oose assortment,	8		
Bottom	13	Bottom s distribution		No size materia	•	e evident 0%.	. Stable		4	50-80%	· .	it light. S		aterial	8	materia	ite chan	0%.			12		distribut s 0–20%		ange. Stable	16
_	14	Scouring depositio		<5% of depositi		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr	6 affecte ructions, Some fi	constri	ctions a		18				bottom in a state vearlong.	of 24
	15	Aquatic vegetatio			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellov m may be presen	4
						Exc	ellent	total =	19				Good	total =	4				Fair	total =	21				Poor tota	I = 40
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stab	le)	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		Grand total :	84
Fair (Mod. u	able)	48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110	91-110	106+	133+	108-132	108-132 133+	99-125 126+		Existing stream type	_ E6
Stream ty	-		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential	E6
Good (Stab			40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107				stream type				
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified c	
Poor (Unsta	able)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+ ting is a	121+ djusted	126+ to poter	121+ itial strea	ım type,	not exist	ing.	stability ra Fair	
																		J	•			21: -··			. un	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	rosion rate.								
			Estim	ating Nea	r-Bank St	ress (NB	S)		
Stream:	Sheyer	nne River			Location:	Sheyenne	River-1-4.	20	
Station:	0			S	tream Type:	E6	1	/alley Type:	Χ
Observe	rs:	KP, AL						Date:	10/6/11
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)		
(1) Chanr	nel pattern	, transverse ba	or split channe	el/central bar cr	eating NBS		Level I	Recona	issance
(2) Ratio	of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction
(3) Ratio	of pool slo	pe to average v		Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction
							Level IV	Valid	lation
=					or discontinuo				
Levell	(1)				-channel)				
ت				meander mig	ration, conver	ging flow		NI	35 = Extreme
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank				
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)				
		,	\ '7	5.0					
					Near-Bank				
= =	(2)	Pool Slope	Average		Stress		Dom	inant	
Level II	(3)	Sp	Slope S	Ratio S _p / S	(NBS)	Ī	Near-Bai	nk Stress	
_							Very	Low	
					Near-Bank	•			_
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress				
	(-)	S _p	S _{rif}	S _{rif}	(NBS)				
		Nama Danis							
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress				
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)				
=									
Level III				Near-Bank			Bankfull		
Le		Near-Bank	Near Dook	Shear			Shear	D :: /	Near-Bank
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ_{nb} /	Stress
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)
≥		Velocity Grad	lient (ft/sec	Near-Bank Stress					
Level IV	(7)	/ f		(NBS)					
Le			,	Very Low					
					J	04	10) D. (
Noar-D	ank Ct	Cor ess (NBS)	iverting Va	ilues to a l	Near-Bank	Stress (NE ethod numb			
iveai-b	rating		(1)	(2)	(3)	etnoa numi (4)	(5)	(6)	(7)
	Very Lo		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			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
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
-					ear-Bank S				Low

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne Rive	er		Location:	Sheyenne R	iver-1-4.20	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	6253.7		Date:	10/6/2011
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E6
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	High	Very Low	0.165	6253.7	20.6	21256	0.16
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosion subtotals in Column (7) for each BEHI/NBS combination Total Erosion (ft³/yr) 21256							
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} Total Erosion (yds ³ /yr) 787							
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	Total Erosion (tons/yr)	1023			
	osion per unit len total length of str			Erosion	Total Erosion (tons/yr/ft)	0.16	

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

Stream:	Sheyenne	River	S	tream Type:	E6		
Location:		River-1-4.20	\	/alley Type:	Χ		
Observers:	KP, AL			Date:	10/6/2011		
Enter Req	uired Infor	mation for Existing Condi	tion				
	D ₅₀	Riffle bed material D ₅₀ (mm))				
	D ₅₀	Bar sample D ₅₀ (mm)					
0	D _{max}	Largest particle from bar sa	mple (ft)		(mm)	304.8 mm/ft	
	s	Existing bankfull water surfa	ace slope (ft/ft)				
	d	Existing bankfull mean dept	h (ft)				
1.65	γ_{s}	Submerged specific weight	of sediment				
Select the	Appropria	te Equation and Calculate	Critical Dimensio	nless She	ar Stress		
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}	
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}	
#DIV/0!	τ*	Bankfull Dimensionless She	ear Stress	EQUATIO	ON USED:	#DIV/0!	
Calculate I	Bankfull Me	an Depth Required for Ent	rainment of Largest	Particle in	Bar Sampl	е	
#DIV/0!	d	Required bankfull mean dep	oth (ft) $d = \frac{\tau}{2}$	* γ_s D _{max}	(use	D _{max} in ft)	
	Check:	☐ Stable ☐ Aggrading					
Calculate Sample	Bankfull W	ater Surface Slope Requi	red for Entrainmer	nt of Large	st Particle	in Bar	
#DIV/0!	s	Required bankfull water sur	face slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)	
	Check:	☐ Stable ☐ Aggrading	□ Degrading	-			
Sediment	Competen	ce Using Dimensional Sh	ear Stress				
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (s	substitute hydraulic rad	dius, R, with	mean depth,	d)	
	$\gamma = 62.4, c$	d = existing depth, S = existing	slope				
	Predicted	largest moveable particle size	(mm) at bankfull shea	ır stress τ (F	igure 3-11)		
	Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)						
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{us}$						
#DIV/0!	Predicted	ted shear stress, γ = 62.4, S = slope required to initiate move	ment of measured D _m	_{ax} (mm)	$S = \frac{\tau}{\Omega d}$	· ·	
	τ = predic	ted shear stress, γ = 62.4, d =	existing depth		γd		

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, A	L		ī		
u b	Strea	ım:	Sheye	enne R	iver				Loca	tion:	Sheye	enne R	iver-1	-4.20	m		Т		Date: 10/	6/2011	
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒ (⇒ (
s a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve	SIZE	Sieve	SIZE	Sieve		Sieve				
m p		weight	Tare	mm weight	Tare	mm weight	Tare \	mm	Tare	mm veight	Tare	mm weight	Tare	mm weight	Tare v	mm	Tare	mm veight		URFACI	
ì	Tarev	Worgin	Tare	Weight	Taio	weight	Taro	voigiti	Taic	veignt	Tare	veignt	Taic	Weight	Tarev	veignt	Tare	veigni	MA	ATERIAL DATA	.S
e s	Sample v		Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two la	argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		T 5:	
2																			No.	Dia.	WT.
3																			2		
4																			Bucket +		
5																			materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials weight		_
11																			Materials less		0
12																			than:		mm
13																			J <i>I</i>	Be sure to	
14																				separate n veights to	naterial
15																				otal	grarra
Net wt		0		0		0		0		0		0		0		0		0	0	7_	
-	and total	##### #####		##### #####		##### #####		##### #####		##### #####	4	##### #####		##### #####	1 1 1	##### #####		##### 100%			
Accui	1. 70 = <	""""		""""		""""		*****		*****		""""		#####		#####		100 /6	GF GF	RAND TO	TAL
s	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											
	<u> </u>																				

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

Stream:	Sheyenne River	Stream Type: E6
Location:	Sheyenne River-1-4.20	Valley Type: X
Observers:	KP, AL	Date: 10/6/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E6				
Location: Sheyenne River-1-4.20 Valley Type: X								
Observers: KP, AL			Da	ate: 10/6/2011				
Lateral stability criteria		Selected						
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)			
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2			
,	(2)	(4)	(6)	(8)				
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	В3	B5, B6, B7	1			
,	(1)	(2)	(3)	(4)				
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3			
,	(1)		(3)					
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)				
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1			
(Worksheet 3-9)	(1)	(2)	(3)	(4)				
	Total points	11						
	La	teral stability c	ategory point ra	inge				
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream:	Sheyenne Riv	er		Stream Type:	E6			
Location: Sheyenne River-1-4.20 Valley Type: X								
Observers:	KP, AL			Date:	10/6/2011			
Vertical st	ability criteria	Vertical Stabi	Selected					
(choose on category fo criterion 1-	r each	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)		
Sedime 1 compete (Worksh		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)			
Sedimer 2 (POWER	nt capacity RSED)	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)			
W/d ratio state (Worksheet 3-8)		1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2		
		(2)	(4)	(6)	(8)			
	succession Worksheet 3-	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)			
	ional s (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1		
3-5)		(1)	(2)	(3)	(4)			
l h	blockages neet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1		
		(1)	(2)	(3)	(4)			
	Total points							
		int range for exces	s deposition /					
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne Ri	ver		Stream Type:	E6	
Location: Sheyenne Ri	ver-1-4.20		Valley Type:	X	
Observers: KP , AL			Date:	10/6/2011	
Vertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
	(2)	(4)	(6)	(8)	
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
	(2)	(4)	(6)	(8)	
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4
·	(2)	(4)	(6)	(8)	
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1
3-9)	(1)	(2)	(3)	(4)	
				Total points	13
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 3-20. Channel enlargement prediction summary.

Stream: Sheyenne River Stream Type: E6								
Location: Sheyenne River-1-4.20 Valley Type: X								
Observers: KP, AL			Date:	10/6/2011				
Channel enlargement	Char	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Worksheet 5-15)	(2)	(4)	(6)	(8)				
				Total points	12			
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	Stream: Sheyenne River Stream Type: E6										
Lo	cation: Sheyenne River-	-1-4.20		Valley Type:	Х						
Ob	servers: KP , AL			Date:	10/6/2011						
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points						
		Stable		1							
1	Lateral stability	Mod. unstab	ole	2	2						
Ι'	(Worksheet 3-17)	Unstable		3	2						
		Highly unsta	able	4							
	Vertical stability	No deposition	on	1							
2	excess deposition/	Mod. deposi	ition	2	1						
-	aggradation	Excess depo	osition	3	•						
	(Worksheet 3-18)	Aggradation	1	4							
	Vertical stability	Not incised		1							
3	channel incision/	Slightly inci		2	2						
ľ	degradation	Mod. Incised	d	3	2						
	(Worksheet 3-19)	Degradation	1	4							
	Channel enlargement	No increase		1							
4	prediction (Worksheet	Slight increa	ase	2	2						
	3-20)	Mod. increas	se	3	_						
	C = 0,	Extensive		4							
	Pfankuch channel	Good: stable		1							
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2						
ľ	10)				_						
	. • /	Poor: unsta	ble	4							
			Total Points	9							
		oint range									
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □						

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Ri	ver-1-4.20		
Observers:	KP, AL	Date:	10/6/2011	Stream	туре: Е6	Valle	y Type: X	
Channel Dimension	Mean bankfull 9.45	Mean bankfull width (ft):	.86 Cross-section area (ft²):	en 820.3	Width of flood- prone area (ft):	437.3333	Entrenchment ratio:	5.0
Channel Pattern	Mean: Range: MWR:	14.3 Lm/W _b	14.3	Rc/\	W _{bkf} :	3.3	Sinuosity:	2.79
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed		nce/divergence	✓ Dunes.	/antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	io	Slope	
Features	bankfull depth (ft):	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull	U UUUT /
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	gor and/or usage of existin	g reach:
	vegetation						I=	
	Flow P1, 2, Stream regime: 7, 9 and o	rder:	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.3 Degree of stability rat	ting:	ly iliciseu	Modified Pfank (numeric and a	djective ratin	g):	air
	Width/depth 9.2 ratio (W/d):	Reference W/d ratio (W/d _{ref}):	9.2 Width/dep (W/d) / (W	th ratio stat //d _{ref}):	te 1.0		itio state y rating:	able
	Meander Width Ratio (MWR):	14.3 Reference MWR _{ref} :	Degree of (MWR / M	confinemer WR _{ref}):	nt 1. 0	1	/ MWR _{ref} y rating: Unc o	onfined
Bank Erosion Summary	Length of reach studied (ft):	254	mbank erosion rate	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Exces	s capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ =	ο τ*= #####	Existing depth _{bkf} :	Require depth _{bkf}		isting Requ pe _{bkf} : slope	
Successional Stage Shift	→ -	→	→	→	Existing str state (type)		Potential stream state (type):) E6
Lateral Stability	☐ Stable N	Mod. unstable ☐	Unstable	☐ Highl	y unstable	Remarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	Remarks/cause	98:	
Vertical Stability (Degradation)	☐ Not incised ■	Slightly incised	Mod. incised	□ Degra	adation	Remarks/cause	es:	
Channel Enlargement	☐ No increase N	Slight increase	Mod. increase	☐ Exter	nsive	Remarks/cause	es:	
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very h	igh	ks/causes:			

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

		getation		
Stre	eam: Sheye	enne River		Location: Sheyenne River-2-11.56
Obs	servers: KP, A		Reference reach	Disturbed (impacted reach) X Date: 10/3/2011
spe	sting cies nposition:			Potential species composition:
R	•		Percent of site coverage**	Species composition Percent of total species composition
1. Overstory	Canopy layer	80%	2%	
	I			100%
2. Understory	Shrub layer		3%	
				100%
level	Herbaceous		10%	
3. Ground level	Leaf or needle litter		10%	Remarks: Condition, vigor and/or usage of existing reach:
Bare ground			75%	
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%	

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

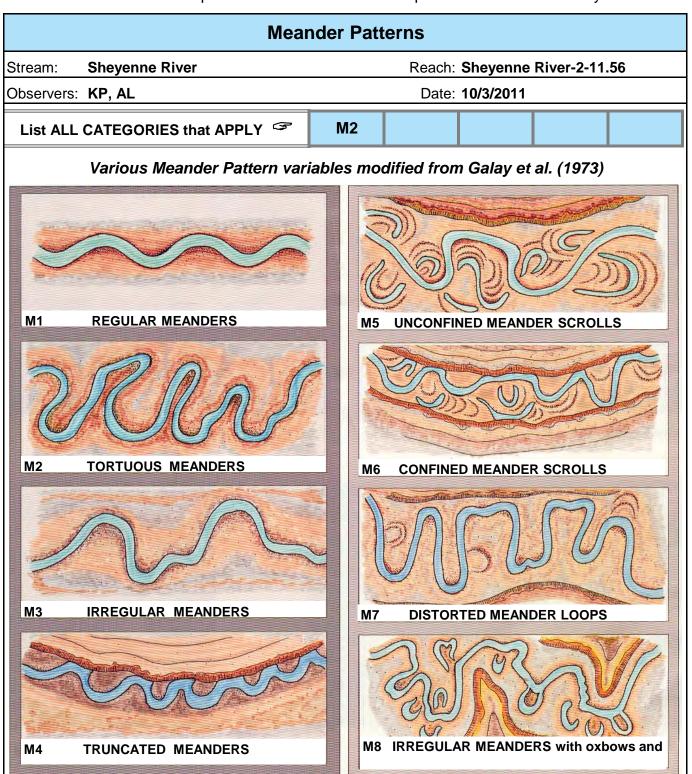
FLOW REGIME									
Stream:	Sheyenne River Location: Sheyenne River-2-11.56								
Observers:	bservers: KP, AL Date: 10/3/2011								1
List ALL COMBINATIONS that									
APF	APPLY								
General C	Category								
E	Ephemeral stream channels: Flows only in response to precipitation								
s	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface 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.								
Р	Perennial stream channels: Surface water persists yearlong.								
Specific Category									
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.								
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.								
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.								
4	Streamflow regulated by glacial melt.								
5	Ice flows/ice torrents from ice dam breaches.								
6	Alternating flow/backwater due to tidal influence.								
7	Regulated streamflow due to diversions, dam release, dewatering, etc.								
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.								
9	Rain-on-snow generated runoff.								

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

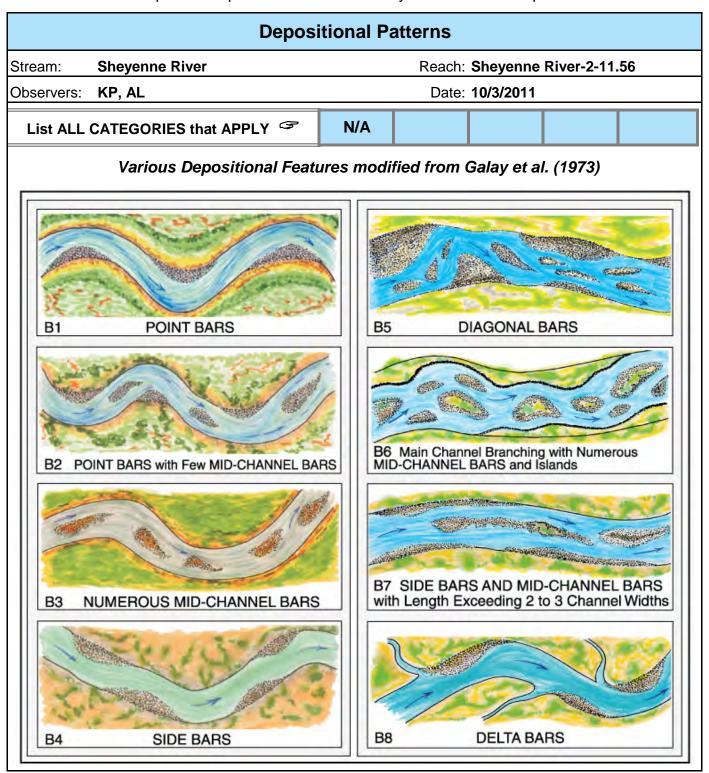
Stream Size and Order									
Stream: Sheyenne River									
Location: Sheyenne River-2-11.56									
Observers:	KP, AL								
Date:	10/3/2011								
Stream Size Category and Order S-8									
Category	STREAM SIZ	Check (✓) appropriate							
	meters	feet	category						
S-1	0.305	<1							
S-2	0.3 – 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							
	Strear	n Order							
Add categories in parenthesis for specific stream order of									

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

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



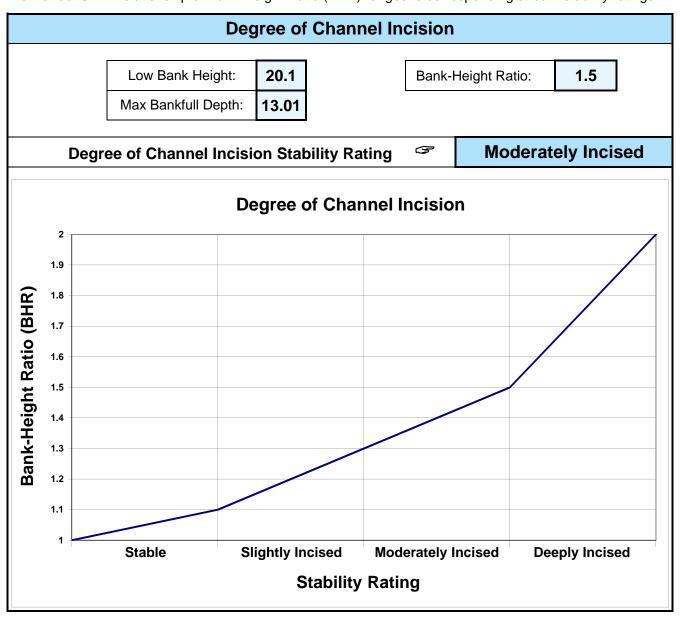
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



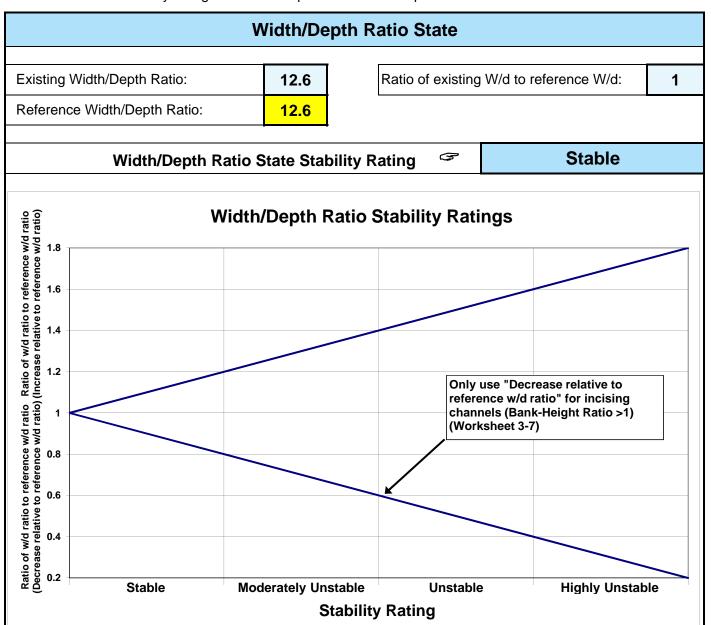
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages							
Stream: Sheyenne River Location: Sheyenne River-2-11.56							
Obsei	rvers: KP, AL	Date: 10/3/2011	Date: 10/3/2011				
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.					
D1	None	Minor amounts of small, floatable material.					
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.					
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	•				
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.					
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.					
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.					
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.					
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.					
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.					
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.					

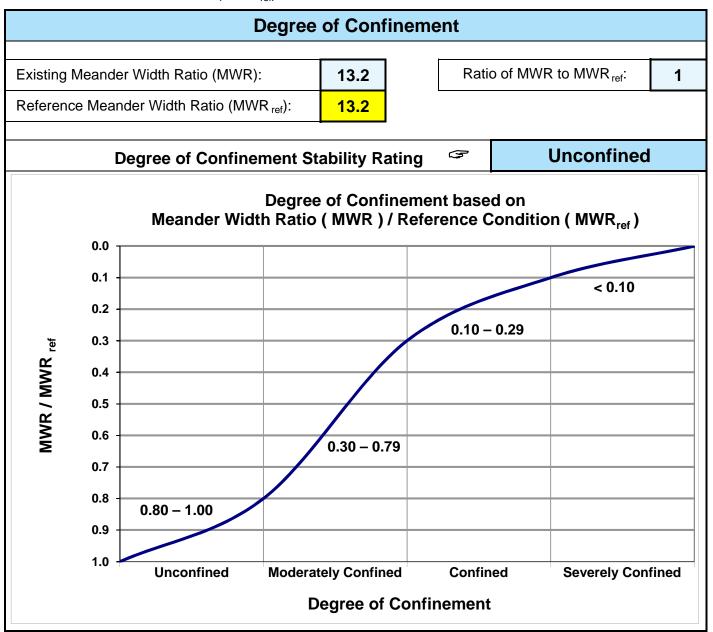
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



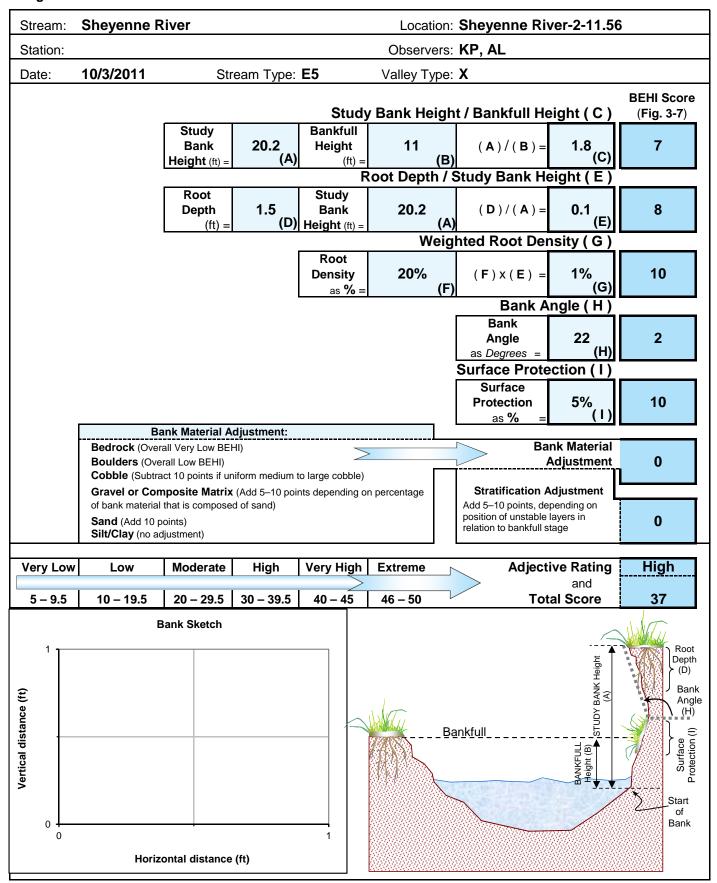
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Location Key Category 1 Landform slope 2 Mass erosion 3 Debris jam potential Vegetative bank protection 5 Channel capacity 8 Bank rock content	Excellent Description Bank slope gradient <30%. No evidence of past or future mass erosion. Essentially absent from immediate channel area. > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders. 12"+ common.	Rating 2 3 2 3 1	Bank slope of Infrequent. In future potent Present, but limbs. 70–90% den less vigor su root mass. Bankfull stage is Width/depth ratio	Description pradient 30 Mostly healial. mostly sm sity. Fewe ggest less contained wi	ed over. all twigs	and s or	6	Bank slop Frequent nearly ye Moderate larger siz 50–70% (pe gradi t or large earlong. e to hea	ient 40- e, caus	–60%. sing sedi	ostly	Rating 6 9	Frequent yearlong Moderate predomin	or large, ca OR imminer to heavy ar antly larger	using sediment nearly nt danger of same. mounts,	8 12 8		
1 Landform slope 2 Mass erosion 3 Debris jam potential Vegetative bank protection 5 Channel capacity	Bank slope gradient <30%. No evidence of past or future mass erosion. Essentially absent from immediate channel area. > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders.	2 3 2 3	Infrequent. No future potent future potent future potent future potent future potent future powers. To future futu	gradient 30 Mostly healial. mostly sm sity. Fewe ggest less	ed over. all twigs	and s or	4 6 4	Frequent nearly ye Moderate larger siz 50–70%	pe gradi t or large earlong. e to hea	ient 40 e, caus	–60%. sing sedi	ostly	6 9	Frequent yearlong Moderate predomin	or large, ca OR imminer to heavy ar antly larger	> 60%. using sediment nearly nt danger of same. mounts, sizes.	8 12		
1 slope 2 Mass erosion 3 Debris jam potential Vegetative bank protection 5 Channel capacity	No evidence of past or future mass erosion. Essentially absent from immediate channel area. > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders.	3 2 3	Infrequent. No future potent future potent future potent future potent future potent future powers. To future futu	Mostly healial. mostly sm sity. Fewe ggest less	ed over. all twigs r specie dense o	and s or	6	Frequent nearly ye Moderate larger siz 50–70%	t or large earlong. e to hea	e, caus	sing sedi	ostly	9	Frequent yearlong Moderate predomin	or large, ca OR imminer to heavy ar antly larger	using sediment nearly nt danger of same. mounts, sizes.	12		
4 bank protection Channel capacity	erosion. Essentially absent from immediate channel area. > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders.	2	Present, but limbs. 70–90% den less vigor su root mass. Bankfull stage is Width/depth ratio	mostly sm sity. Fewe ggest less	all twigs r specie dense d	and s or	4	nearly ye Moderate larger siz 50-70%	earlong. e to heares.	vy amo	ounts, m	ostly	9	yearlong Moderate predomin	OR imminer to heavy ar antly larger	nt danger of same. mounts, sizes.			
4 bank protection 5 Channel capacity	channel area. > 90% plant density. Vigor and variety suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders.	3	limbs. 70–90% den less vigor su root mass. Bankfull stage is Width/depth ratio	sity. Fewe ggest less	r specie dense d	s or	-	larger siz 50–70% (zes.		•	•	6	predomin	antly larger	sizes.	8		
4 bank protection 5 Channel capacity	suggest a deep, dense soil-binding root mass. 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. > 65% with large angular boulders.	3	less vigor su root mass. Bankfull stage is Width/depth ratio	ggest less contained wi	dense d				density.	1				~50% der	nsity plus fer	war enaciae and lace			
5 Channel capacity	stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0. > 65% with large angular boulders.	1	Width/depth ration				6	fewer spe discontinu	ecies fro	om a sł	nallow,	nd	9		cating poor,	discontinuous and	12		
Bank rock content	5 5		(BHR) = 1.0-1.1	= 1.0-1.2. B	om referer	nce	2	Bankfull star ratio departu = 1.2-1.4. B	age is not o	contained	d. Width/dep	oth ratio	3	common wit	h flows less tha	ned; over-bank flows are an bankfull. Width/depth nce width/depth ratio > 1.4. 1.3.	4		
<u> </u>		2	40–65%. Mo cobbles 6–1:		ers and s	small	4	20–40%. class.	Most in	the 3-	-6" diam	neter	6	or less.		s of gravel sizes, 1–3"	8		
6 content 7 Obstructions to flow 8 Cutting	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present currents and ne fewer and less	ninor pool fil			4	Moderately move with and pool fi	high flow				6	cause ba	nk erosion y	s and deflectors rearlong. Sediment gration occurring.	8		
8 Cutting	Little or none. Infrequent raw banks <6".	4	Some, internations to 12".	•			6	Significar mat overh			0		12			its, some over 24" angs frequent.	16		
9 Deposition	Little or no enlargement of channel or point bars.	4	Some new b coarse grave		e, mostly	y from	8	Moderate and coars new bars	se sand				12			Extensive deposit of predominantly fine particles. Accelerated bar development.			16
10 Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded cor Surfaces sm		•		2	Corners a	_	ges wel	l rounde	ed in 2	3	Well roun smooth.	ded in all di	mensions, surfaces	4		
11 Brightness	Surfaces dull, dark or stained. Generally not bright.	1	Mostly dull, t surfaces.			% bright	2	Mixture d mixture ra		bright,	i.e., 35-	-65%	3		Predominantly bright, > 65%, exposed or scoured surfaces.		4		
12 Consolidation of particles	f Assorted sizes tightly packed or overlapping.	2	Moderately poverlapping.	acked with	n some		4	Mostly local			nt with n	0	6	No packir easily mo	•	Loose assortment,	8		
particles Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution s			aterial	8	Moderate materials	20–509	%.			12	Marked d materials		hange. Stable	16		
14 Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affections steepen. Son	and where	e grades		12	30–50% at obstruction bends. Se	ctions, o	constric	ctions ar		18		n 50% of the ange nearly	e bottom in a state of yearlong.	24		
15 Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Al and pool are				2	Present b backwate makes ro	er. Seas	sonal al		wth	3			ce or absent. Yellow- om may be present.	4		
	Excellent total =	19			Good	total =	8				Fair	total =	27			Poor total =	24		
Stream type A1 A2	A3 A4 A5 A6 B1	B2	B3 B4	B5	В6	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 40-6	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98	Grand total =	78		
Fair (Mod. unstable 44-47 44-47 Poor (Unstable) 48+ 48+	130+ 133+ 143+ 111+ 59+	59+	61-78 65-8 79+ 85-	+ 89+	61-78 79+	51-61 62+	51-61 62+	106+	111+	91-110 111+	106+	133+	108-132 133+		9-125 126+	Existing stream type =	E5		
Stream type DA3 DA4 Good (Stable) 40-63 40-63		E6 40-63	F1 F2		F4 85-110	F5 90-115	F6 80-95		G2	G3 85-107	G4 85-107	G5 90-112	G6 85-107			*Potential stream type =	E5		
Fair (Mod. unstable 64-86 64-86			1	05 111-125									108-120			Modified char	nnel		
Poor (Unstable) 87+ 87+	87+ 87+ 87+ 97+ 97+	87+	106+ 106		126+	131+	111+		79+	121+	121+	126+	121+			stability ratin			
,			•	•	•		•		*Ratir	ng is a	djusted	to poten	tial strea	ım type, n	ot existing.	Fair			

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

01001011	rosion rate. Estimating Near-Bank Stress (NBS)									
			Estim	ating Nea	r-Bank St	ress (NB	S)			
Stream:	Sheyer	nne River					River-2-11	1.56		
Station:	0			S	tream Type:	E5	\	/alley Type:	X	
Observe	ers:	KP, AL						Date:	10/3/11	
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)			
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr	Level I	Reconaissance				
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General _I	prediction	
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General _I	prediction	
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General _I	prediction	
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction	
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction	
(7) Velocity profiles / Isovels / Velocity gradient							Level IV		lation	
)	443				or discontinuo					
Levell	(1)				channel)					
			Bankfull	meanuer mig	ration, conver	girig 110W		INE	טכ = EXITEITIE	
		Radius of Curvature	Width W _{bkf}	Ratio R _c /	Near-Bank Stress					
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)					
_					Near-Bank					
e e	(2)	Pool Slope	Average		Stress			inant		
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)		Near-Bar	nk Stress		
_							Very	Low		
					Near-Bank					
	(4) F	Pool Slope	Riffle Slope	Ratio S _p /	Stress					
	(-)	S _p	S _{rif}	S _{rif}	(NBS)					
		Na an Danie								
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress					
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)					
=										
Level III				Near-Bank			Bankfull			
Le		Near-Bank	Na an Danie	Shear			Shear		Near-Bank	
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ_{nb} /	Stress	
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)	
≥		Volosity C==	diant / ft /	Near-Bank						
Level IV	(7)	velocity Grad / f	dient (ft/sect)	Stress (NBS)						
Le		, .	,	Very Low]					
					J					
Non D	onk Ct-		nverting Va	llues to a l	Near-Bank					
near-B	sank Stro rating	ess (NBS) s	(1)	(2)	(3)	ethod numb (4)	per (5)	(6)	(7)	
	Very Lo		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	
	Modera		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	0.41 - 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00	
	Very Hi		(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 N	ear-Bank S	Strace (ND	S) rating	Vary	Low	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne Rive	er		Location:	Sheyenne R	River-2-11.56	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	5264.9		Date:	10/3/2011
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E5
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	High	Very Low	0.165	5264.9	20.2	17548	0.16
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosion	n subtotals in Col	umn (7) for eac	combination	Total Erosion (ft ³ /yr)	17548		
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	650		
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	845	
	osion per unit len total length of str	Total Erosion (tons/yr/ft)	0.16				

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

Stream:	Sheyenne	River	St	ream Type:	E5						
Location:	Sheyenne	River-2-11.56	\	/alley Type:	Х						
Observers:	KP, AL			Date:	10/3/2011						
Enter Req	uired Infor	mation for Existing Condition	on								
	D ₅₀	Riffle bed material D ₅₀ (mm)									
	D ₅₀	Bar sample D ₅₀ (mm)									
0	D _{max}	Largest particle from bar samp	le (ft)		(mm)	304.8 mm/ft					
	s	Existing bankfull water surface	slope (ft/ft)								
	d	Existing bankfull mean depth (ft)								
1.65 γ_s Submerged specific weight of sediment											
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress											
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 Us	se EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Us	se EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless Shear	Stress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean depth	(ft) $d = \frac{\tau}{\tau}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐									
Calculate Sample	Bankfull W	ater Surface Slope Required	d for Entrainmen	t of Large	st Particle	in Bar					
#DIV/0!	s	Required bankfull water surfac	e slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐	Degrading								
Sediment	Competen	ce Using Dimensional Shear	r Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (sub	stitute hydraulic rad	dius, R, with	mean depth,	d)					
	$\gamma = 62.4, c$	d = existing depth, S = existing sle	ope								
	Predicted	largest moveable particle size (m	m) at bankfull shea	r stress τ (F	igure 3-11)						
	Predicted	shear stress required to initiate m	novement of measu	red D _{max} (m	m) (Figure 3	-11)					
#DIV/0!		mean depth required to initiate m		red D _{max} (mr	$d = \frac{7}{1}$	<u>t</u> 'S					
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, $S = expression$	ent of measured D _m	_{ax} (mm)	$S = \frac{T}{2d}$	· •					
L	τ = predic	ted shear stress, γ = 62.4, d = ex	disting depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, A	L		_			
u b	Strea	m:	Sheye	enne R	iver				Loca	tion:	Sheye	nne R	iver-2-	11.56					Date:	10/3	3/2011	
		⇒ (⇒ (⇒(⇒ (⇒ (<u> </u>	⇒ (⇒ (→ (
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve		Sieve		Sieve	SIZE	Sieve	SIZE				
m p	Tare		Tare	mm weight	Tare	mm weight	Tare v	mm veight	Tare v	mm veight	Tare	mm weight	Tare v	mm veight	Tare	mm weight	Tare	mm weight		SURFACE		
1	14101	volgili		oigint	Turo (grit	Taio .	ioigi ii	10.0	voigin.	Taro	worgin	Taio (Taio	.roigin	Taio	oigin		MATERIALS DATA		S
e s	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample	_	Sample	l .	(Tv		rgest par	ticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.
2																				1 1	Dia.	VV I .
3																				2		
4																			Bucket	+		
5																			materia weigh			
6																						
7																			Bucket t weigh			
9																			Materia	als		
10																			weigh	ıt	()
11																			Materials			
12																			than:			mm
13																				se	e sure to a eparate m	aterial
15																					eights to g tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	7	
-	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####	4 –			
Accum	1. % =<	#####	\longrightarrow	#####		#####	\Longrightarrow	#####		#####	\longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	#####		100%	<u> </u>	GRA	AND TO	ΓAL
	amnla lo	cation no	ntas				San	nple loca	ation ska	atch												
	ипріс ю	cation ne	7.03				- Oai	TIPIC TOCK	ation six	J. (011												

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

Stream:	Sheyenne River	Stream Type: E5
Location:	Sheyenne River-2-11.56	Valley Type: X
Observers:	KP, AL	Date: 10/3/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E5	
Location: Sheyenne River-	2-11.56		Valley Ty	_{/pe:} X	
Observers: KP, AL			Da	ate: 10/3/2011	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne Riv	er		Stream Type:	E5					
Location: Sheyenne Riv	er-2-11.56		Valley Type:	X					
Observers: KP, AL			Date:	10/3/2011					
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected				
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	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)					
Sediment capacity (POWERSED)	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)					
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheet 3- 16)	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)					
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1				
3-5)	(1)	(2)	(3)	(4)					
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1				
	(1)	(2)	(3)	(4)					
Total points									
	Vertical stat		int range for exces adation	s deposition /					
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne River Stream Type: E5											
Lo	cation: Sheyenne Riv	ver-2-11.56		Valley Type:	X						
Ob	oservers: KP, AL			Date:	10/3/2011						
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected					
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
		(2)	(4)	(6)	(8)						
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
		(2)	(4)	(6)	(8)						
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	6					
	(WOIRSHEEL 3-1)	(2)	(4)	(6)	(8)						
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
		(2)	(4)	(6)	(8)						
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
	3-9)	(1)	(2)	(3)	(4)						
					Total points	15					
Vertical stability category point range for channel incision / degradation											
o p	/ertical stability for channel incision/ legradation (use total points and check stability rating)	Not incised 9 – 11	Slightly incised 12 – 18 ✓	Moderately incised 19 – 27 □	Degradation > 27 □						

Worksheet 3-20. Channel enlargement prediction summary.

Stream: Sheyenne Rive	r		Stream Type:	E5	
Location: Sheyenne Rive	r-2-11.56		Valley Type:	X	
Observers: KP, AL			Date:	10/3/2011	
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2
	(2)	(4)	(6)	(8)	
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4
	(2)	(4)	(6)	(8)	
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2
(Worksheet 3-18)	(2)	(4)	(6)	(8)	
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4
(Worksheet 5-15)	(2)	(4)	(6)	(8)	
				Total points	12
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Sheyenne River			Stream Type:	E5
Loc	cation: Sheyenne River-	-2-11.56		Valley Type:	Х
Ob	servers: KP, AL			Date:	10/3/2011
p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	2
! '	(Worksheet 3-17)	Unstable		3	2
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. depos	ition	2	1
-	aggradation	Excess dep	osition	3	•
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci	sed	2	2
٦	degradation	Mod. Incised	d	3	2
	(Worksheet 3-19)	Degradation	1	4	
	Channal anlargement	No increase		1	
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2
~	3-20)	Mod. increa	se	3	2
	0 2 0)	Extensive		4	
	Pfankuch channel	Good: stable	e	1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				2
	10)	Poor: unsta	ble	4	
				Total Points	9
			Category p	ooint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Ri	ver-2-11.56		
Observers:	KP, AL	Date:	10/3/2011	Stream	n Type: E5	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 8.84	Mean bankfull 11 width (ft):	1.5 Cross-section area (ft ²):	n 988.1	Width of flood- prone area (ft):	787.6667	Entrenchment ratio:	7.1
Channel Pattern	Mean: Range: MWR:	13.2 Lm/W _b	kf: 13.2	Rc/	W _{bkf} :	2.6	Sinuosity:	
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed		nce/divergence	Dunes	antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool Depth r	Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull depth (ft): 13.0	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull:	0.00016
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existing	reach:
	vegetation							
	Flow P1, 2, Strear regime: 7, 9 and or	3-0	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.5 Degree of stability rat		lerately cised	Modified Pfank (numeric and a	•		air
-	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12.6 Width/dep (W/d) / (W	th ratio stat //d _{ref}):	te 1.0		tio state y rating:	able
	Meander Width Ratio (MWR):	13.2 Reference MWR _{ref} :	Degree of (MWR / M	confineme WR _{ref}):	nt 1.0	I I	/ MWR _{ref} y rating: Unco	nfined
Bank Erosion Summary	Length of reach studied (ft):	(65	mbank erosion rate s/yr) 0.16 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ=	0 τ*= ####	Existing depth _{bkf} :	Require depth _{bkf} :		sting Requirements	
Successional Stage Shift	→ -	→	→	→	Existing stre		Potential stream state (type):	E5
Lateral Stability	☐ Stable 🔽	Mod. unstable Г	Unstable	☐ Highl	ly unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	emarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degr	adation	emarks/cause	es:	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exte	nsive	temarks/cause	es:	
Sediment Supply (Channel Source)	□ Low ▽	Moderate	High 🔲 Very h	igh	ks/causes:			

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

	Riparian Vegetation											
Stre	eam: Sheye	enne River		Location: Sheyenne River - 3 - 18.15								
Obs	servers: KD, JI		Reference reach	Disturbed (impacted reach)	Date: 11/17/2010							
spe	sting cies nposition: Trees	, grass		Potential species composition:	Tre	es, grass						
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species (Percent of total							
1. Overstory	Canopy layer	15% without leaves, 65% with leaves	1%	trees		100%						
						100%						
2. Understory	Shrub layer		0%									
						100%						
evel	Herbaceous		5%	tall grass		100%						
3. Ground level	Leaf or needle litter		0%	Remarks: Condition, vigo usage of existir								
	Bare ground		94%	None								
	ed on crown closure. sed on basal area to	surface area.	Column total = 100%									

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

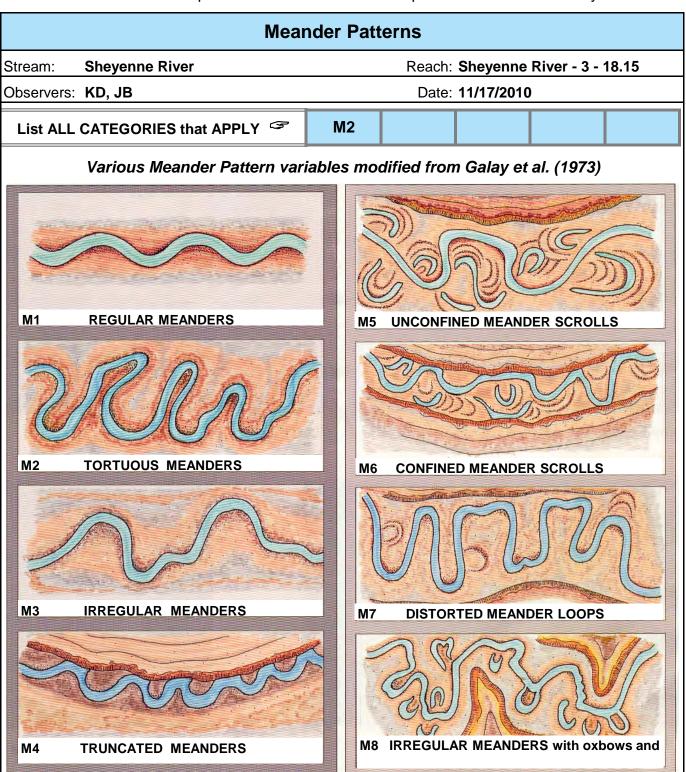
	'												
	FLOW REGIME												
Stream:	Sheyenne River		Location:	Sheyenr	e River -	3 - 18.15							
Observers:	KD, JB		11/17/20	10									
List ALL	COMBINATIONS that	P1	P2	P7	P9								
APPLY													
General Category													
E	Ephemeral stream channels: Flows only in response to precipitation												
S		Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.											
ı	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.												
Р	Perennial stream channels: Surface water persists yearlong.												
Specific Category													
1	Seasonal variation in s	treamflow	dominated	d primarily	y by snow	melt runo	ff.						
2	Seasonal variation in s	treamflow	dominated	d primarily	y by storn	nflow runc	off.						
3	Uniform stage and asso	ociated sti	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.					
4	Streamflow regulated b	y glacial r	melt.										
5	Ice flows/ice torrents fro	om ice da	m breache	:S.									
6	Alternating flow/backwa	ater due to	tidal influ	ence.									
7	Regulated streamflow	due to dive	ersions, da	ım releas	e, dewate	ering, 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 generate	ed runoff.											

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

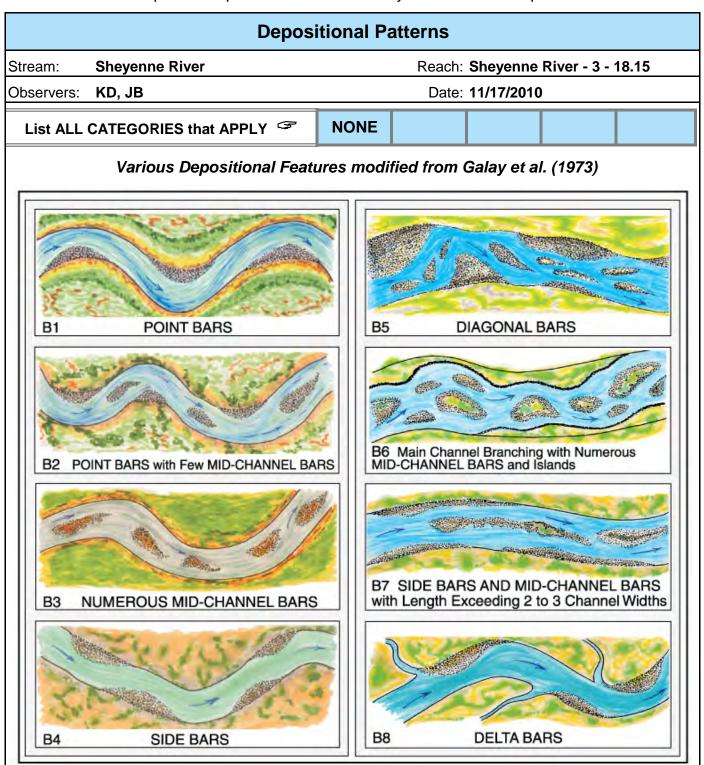
Stream Size and Order											
Stream:	Sheyenne Rive	er									
Location:	Sheyenne Rive	er - 3 - 18.15									
Observers:	KD, JB										
Date:	11/17/2010										
Stream Size Category and Order S-7											
Category	Check (✓) appropriate										
	meters	feet	category								
S-1	0.305	<1									
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 categorie	es in parenthesis	for specific strea	m order of								

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

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



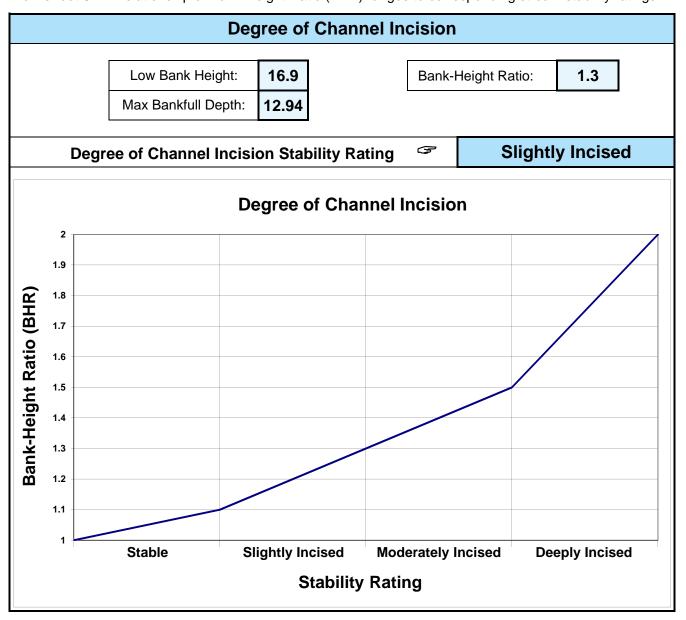
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



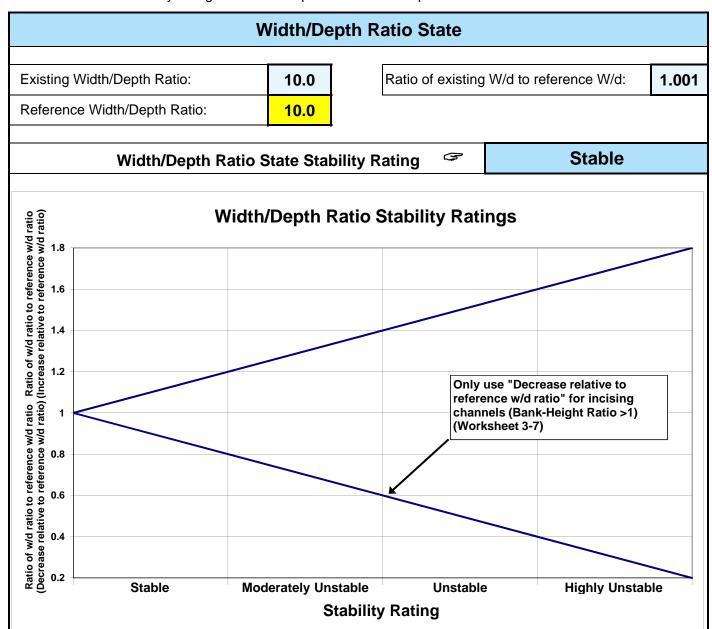
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strear	m: Sheyenne I	River Location: Sheyenne River - 3 - 18.15	
Obser	rvers: KD, JB	Date: 11/17/2010	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	•
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

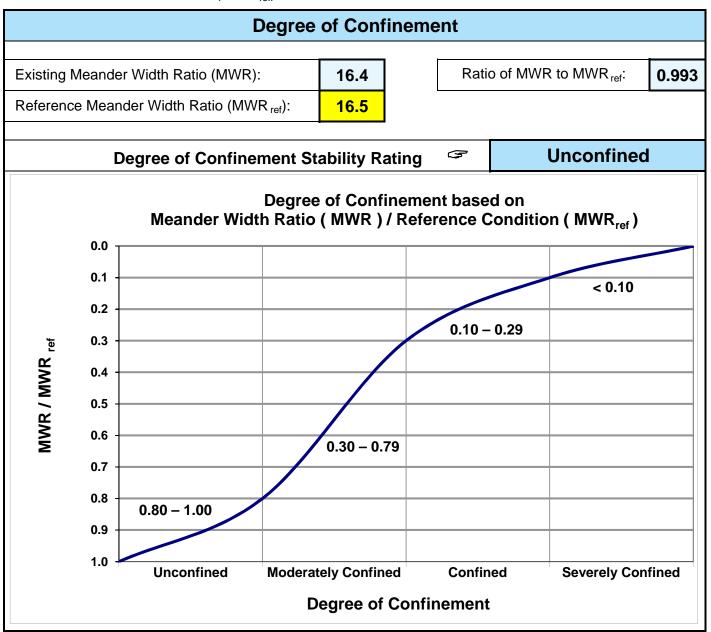
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



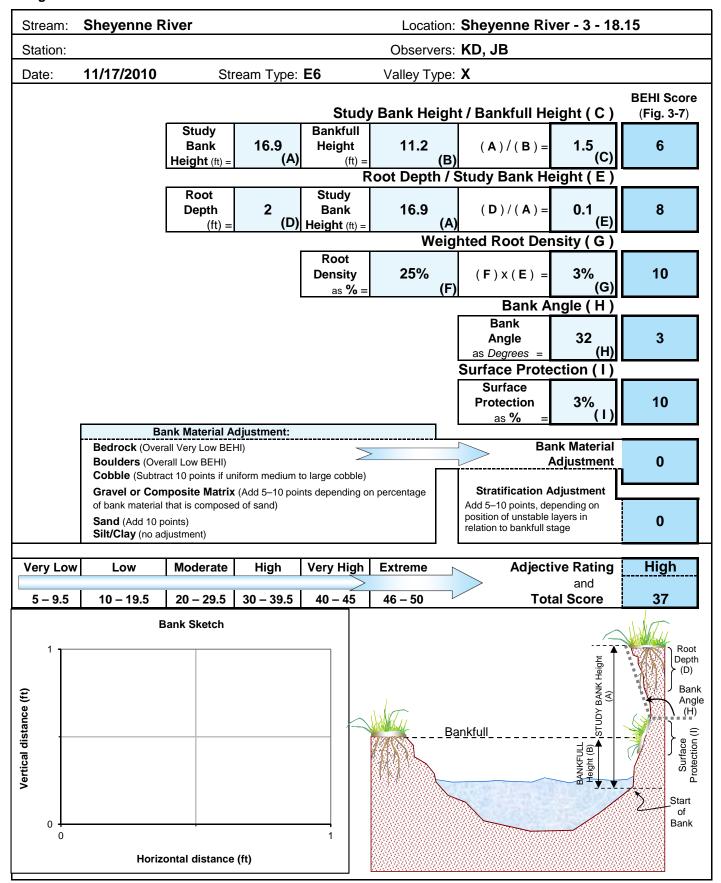
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Shey	enne F	River				Loc	ation:	Shey	enne	River	- 3 - 1		Valley	Туре:	Χ		Obse	ervers:	KD, J	В				Date: 11/17/2	010		
Loca-	Key	Categ	orv			Exce	llent					Go	od					F	air						Poor			
tion	itey	Categ	Ol y		[Descriptio	n		Rating		D	Description	n		Rating		[Description	n		Rating			Descri	ption	Rating		
9	1	Landform slope	1	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-4 0%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradi	ient >	60%.	8		
banks	2	Mass ero	sion	No eviderosion.		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg		ing sedi	ment	9	Frequent or large, causing sedime yearlong OR imminent danger of s			12			
Upper	3	Debris jai potential		channel	l area.	ent from			2	limbs.		ostly sma	_		4	larger s	sizes.	-	ounts, m	-	6	Moderate predomin	nantly la	rger s	izes.	8		
O	4	Vegetativ bank protection			t a deep	nsity. Vi , dense	_		3		or sugg	y. Fewer est less			6	fewer s	6 densit pecies f inuous r	rom a sl		nd	9		cating p	oor, d	er species and les liscontinuous and	12		
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull stage is not cor ratio departure from refe = 1.2–1.4. Bank-Height		t containe reference	d. Width/dep	th ratio	3	common w	th flows le ure from r	ss than eferenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4 .3.	. 4		
nks	6	Bank rocl content	k	12"+ co	mmon.	je angula			2	40–65%. Mostly boulders and small cobbles 6–12". 20–40%. Most in the class.				20–40%. Most in the 3–6" diameter class.		iameter 6		or less.			of gravel sizes, 1–3	8						
Lower banks	7	Obstruction to flow	ons		w/o cut	firmly in			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	cause ba	ınk eros	ion ye	and deflectors arlong. Sediment ration occurring.	8		
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	_			" high. F ughing e		12		Almost continuous cuts nigh. Failure of overhar		,	16		
	9	Depositio	on	Little or point ba		irgement	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	and coa	arse san	d on old	new gra I and so	me	12					Extensive deposit of predomir particles. Accelerated bar dev		16
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	l rounde	ed in 2	3	Well rounded in all dime smooth.			4			
	11	Brightnes	ss	General	lly not b					surface	3.	may hav		6 bright	2	mixture	range.		i.e., 35-		3	scoured surface			> 65%, exposed or	4		
E C	12	Consolidat particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4	appare	Mostly loose assortment with no apparent overlap. No packing evide easily moved.			oose assortment,	8							
Bottom	13	Bottom si distribution		No size material	•	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable	16		
	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18	More tha flux or ch			bottom in a state o rearlong.	24		
	15	Aquatic vegetatio			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				e or absent. Yellow m may be present.	/		
						Exc	ellent	total =	19				Good	total =	14				Fair	total =	6				Poor total	= 40		
Stream ty	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6		_			
Good (Stab			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		67-98		Grand total =	79		
Fair (Mod. u	ınstable		44-47 48+		96-132 133+		81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+						108-132		99-125 126+		Existing stream type =	E6		
		G6	1001	.201		*Potential																						
Good (Stab	-		40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107	90-112					stream type =	E6		
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120		113-125					Modified ch			
				126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rat											
,	,				1							ı			1		1		1	1	1	ım type, r	not exist	ing.	Fair			
*Rating is adjusted to potential stream type, not existing.																												

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion	Tale.								
			Estim	ating Nea	r-Bank St	ress (NB:	S)		
Stream:	Sheyer	nne River			Location:	Sheyenne	River - 3 -	18.15	
Station:	0			S	tream Type:	E6	\	/alley Type:	X
Observe	rs:	KD, JB						Date:	11/17/10
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)		
(1) Chanr	nel pattern	, transverse ba	r or split channe	el/central bar cr	Level I	Reconaissance			
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction
(7) Veloci	ty profiles	/ Isovels / Velo	city gradient				Level IV	Valid	dation
					or discontinuo				
Levell	(1)				-channel)				
د				meander mig	ration, conver	ging flow		Nt	35 = Extreme
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank				
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)				
		J ()	()	5.0					
					Near-Bank				
= 	(2)	Pool Slope	Average		Stress			inant	
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)	1	Near-Bai	nk Stress	
							Lo	w	
					Near-Bank				
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress				
	()	S _p	S _{rif}	S _{rif}	(NBS)	i			
		Near Peak							
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress				
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)				
=		12.9	9.4	1.37	Low				
Level III				Near-Bank			Bankfull		
Le		Near-Bank	Near-Bank	Shear			Shear	Datia - /	Near-Bank
	(6)	Max Depth	Slope S _{nb}	Stress τ _{nb} (Mean Depth		Stress τ _{bkf} (Ratio τ _{nb} /	Stress
		d _{nb} (ft)	Globe Gub	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)
				No. D.					
Level IV		Velocity Grad	dient (ft/sec	Near-Bank Stress					
eve	(7)	/ f		(NBS)					
Ľ		0.	03	Very Low					
		Cor	worting Va	dues to a N	Near-Bank	Strees (NE	RS) Pating		
Near-B	ank Str	ess (NBS)	iverting va	iiues io a l		ethod numb			
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Very Lo		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
	Modera	ate	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 Hi	gh	(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
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40
				Overall N	lear-Bank \$	Stress (NB	S) rating	Lo	ow

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne River - 3 - 18.15											
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	6608.7		Date:	11/17/2010					
Observers:	KD, JB		Valley Type:	Χ		Stream Type:	E6					
(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.	High	Low	0.165	6608.7	16.9	18428	0.13					
2.						0	#DIV/0!					
3.						0	#DIV/0!					
4.						0	#DIV/0!					
5.						0	#DIV/0!					
6.						0	#DIV/0!					
7.						0	#DIV/0!					
8.						0	#DIV/0!					
9.						0	#DIV/0!					
10.						0	#DIV/0!					
11.						0	#DIV/0!					
12.						0	#DIV/0!					
13.						0	#DIV/0!					
14.						0	#DIV/0!					
15.					Total	0	#DIV/0!					
Sum erosior	18428											
Convert eros	sion in ft ³ /yr to yd:	s ³ /yr {divide T	it ³ /yr) by 27}	Total Erosion (yds³/yr)	683							
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	887						
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.13						

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

Stream:	Sheyenne	River	St	ream Type:	E6							
Location:	Sheyenne	River - 3 - 18.15	\	/alley Type:	Х							
Observers:	KD, JB			Date:	11/17/2010							
Enter Req	uired Infor	mation for Existing Condition	on									
	D ₅₀	Riffle bed material D ₅₀ (mm)										
	D ₅₀	Bar sample D ₅₀ (mm)										
	D _{max}	Largest particle from bar samp	ole (ft)		(mm)	304.8 mm/ft						
	s	Existing bankfull water surface	e slope (ft/ft)									
	d	Existing bankfull mean depth ((ft)									
1.65	1.65 γ_s Submerged specific weight of sediment											
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress												
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 U	se EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}						
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 U	se EQUATION 2:	τ* = 0.038	4 (D _{max} /D ₅₀	0) -0.887						
#DIV/0!	τ*	Bankfull Dimensionless Shear	Stress	EQUATIO	ON USED:	#DIV/0!						
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample												
#DIV/0!	d	Required bankfull mean depth	(ft) $d = \frac{\tau}{}$	* γ _s D _{max}	use (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading ☐										
Calculate Sample	Bankfull W	ater Surface Slope Require	d for Entrainmen	t of Large	st Particle i	n Bar						
#DIV/0!	s	Required bankfull water surface	ce slope (ft/ft) S =	$= \frac{\tau * \gamma_s D}{d}$) _{max} (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading ☐	Degrading									
Sediment	Competen	ce Using Dimensional Shea	r Stress									
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (sub	ostitute hydraulic rad	lius, R, with	mean depth,	d)						
	$\gamma = 62.4, c$	d = existing depth, S = existing sl	ope									
	Predicted	largest moveable particle size (n	nm) at bankfull shea	r stress τ (F	igure 3-11)							
	Predicted	shear stress required to initiate r	novement of measu	red D _{max} (m	m) (Figure 3 -	-11)						
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\mathbf{d} = \frac{\mathbf{r}}{v\mathbf{S}}$											
#DIV/0!	Predicted	$τ$ = predicted shear stress, $γ$ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D_{max} (mm) $\mathbf{S} = \frac{\tau}{m}$										
	τ = predic	ted shear stress, γ = 62.4, d = ex	xisting depth		γ d							

Worksheet 3-15. Bar sample data collection and sieve analysis form.

s	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	A: Size Distribution Analysis Observers: KD, JB											
u b	Strea	ım:	Sheye	enne R	iver		•		Loca	tion:	Sheye	enne R	iver -	3 - 18.	15		1		Date: 11/	17/2010)
		⇒ (⇒ (⇒ (⇒ (⇒(⇒ (⇒(⇒(
a a		h Pan ICKET	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm			
m p		weight	Tare	weight	Tare	weight	Tare \			veight	Tare v	weight	Tare	weight	Tare v		Tare v	veight		SURFACE	
l e				J 3		3						J 7				- J			MATERIALS DATA		.S
s	Sample v		Sample	Ť	Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two la	argest pa	rticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No.	Dia.	WT.
2																			1	Dia.	****
3																			2		
4																			Bucket +		
5																			materials weight		
7																			Bucket tare		
8																			weight		
9																			Materials		
10																			weight		0
11																			Materials less than:		
13																				Be sure to	mm add
14																				separate n veights to	naterial
15																				otal	granu
Net wt		0		0		0		0		0		0		0		0		0	0	7_	
-	and total	##### #####		##### #####		##### #####		##### #####		##### #####		##### #####		##### #####		##### #####		##### 100%		ALID TO	-
rtodan	70 – 1	ппппп		ппппп		ппппп		mmmm		ппппп		ппппп		mmmm		ппппп		10070	J GF	RAND TO	IAL
S	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream:	Sheyenne River	Stream Type: E6
Location:	Sheyenne River - 3 - 18.15	Valley Type: X
Observers:	KD, JB	Date: 11/17/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E6					
Location: Sheyenne River	- 3 - 18.15		Valley Ty	_{/pe:} X					
Observers: KD, JB			Da	ate: 11/17/2010					
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected				
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)				
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2				
	(2)	(4)	(6)	(8)					
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1				
	(1)	(2)	(3)	(4)					
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3				
	(1)		(3)						
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)					
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1				
(Worksheet 3-9)	(1)	(2)	(3)	(4)					
				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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Riv	er - 3 - 18.15		Valley Type:	Χ						
Observers: KD, JB			Date:	11/17/2010						
Vertical stability criteria	Vertical Stabi	ity Categories fo	r Excess Deposition	on / Aggradation	Selected					
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	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)						
Sediment capacity (POWERSED)	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)						
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2					
	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheet 3- 16)	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)						
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1					
3-3)	(1)	(2)	(3)	(4)						
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1					
	(1)	(2)	(3)	(4)						
Total points										
	Vertical stat		int range for exces	s deposition /						
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne River Stream Type: E6						
Location: Sheyenne River - 3 - 18.15 Valley Type: X						
Observers: KD, JB Date: 11/17/2010						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected points (from each row)	
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation		
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
	(2)	(4)	(6)	(8)		
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
	(2)	(4)	(6)	(8)		
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4	
(worksneet 3-7)	(2)	(4)	(6)	(8)		
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4	
	(2)	(4)	(6)	(8)		
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1	
3-9)	(1)	(2)	(3)	(4)		
Total points						
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 3-20. Channel enlargement prediction summary.

Stream: Sheyenne River Stream Type: E6							
Location: Sheyenne River - 3 - 18.15 Valley Type: X							
Observers: KD, JB Date: 11/17/2010							
Channel enlargement	Char	Selected					
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)		
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2		
	(2)	(4)	(6)	(8)			
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4		
	(2)	(4)	(6)	(8)			
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition Exc		Aggradation	2		
(Worksheet 3-18)	(2)	(4)	(6)	(8)			
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4		
(Worksheet o 15)	(2)	(4) (6)		(8)			
Total points							
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: Sheyenne River Stream Type:					E6	
Lo	cation: Sheyenne River	Valley Type:	X			
Observers: KD, JB				Date:	11/17/2010	
Overall sediment supply prediction criteria (choose corresponding points for each criterion 1–5)		Stability Rating		Points	Selected Points	
		Stable		1	2	
1	Lateral stability	Mod. unstab	ole	2		
'	(Worksheet 3-17)	Unstable		3		
		Highly unsta	able	4		
	Vertical stability	No deposition	on	1	1	
2	excess deposition/	Mod. deposi	ition	2		
-	aggradation	Excess depo	osition	3		
	(Worksheet 3-18)	Aggradation	1	4		
	Vertical stability	Not incised		1	2	
3	channel incision/	Slightly incised		2		
ľ	degradation	Mod. Incised	d	3	2	
	(Worksheet 3-19)	Degradation	1	4		
	Channal anlargament	No increase		1	2	
4	Channel enlargement	Slight increa	ase	2		
4 prediction (Worksheet 3-20)		Mod. increas	se	3	2	
		Extensive		4		
	Pfankuch channel	Good: stable		1	2	
	stability (Worksheet 3-	Fair: mod unstable		2		
ľ	10)				2	
	10)	Poor: unsta	ble	4		
	9					
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □	

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location: SI	heyenne Riv	er - 3 - 18.1	15	
Observers:	KD, JB	Date:	11/17/2010	Stream T	ype: E6	Valle	у Туре: Х	
Channel Dimension	Mean bankfull 9.41	Mean bankfull 93 width (ft):	.82 Cross-section area (ft ²):	n 881.1 W pr	idth of flood- one area (ft):	534.6667	Entrenchment ratio:	5.7
Channel Pattern	Mean: Range: MWR:	16.4 Lm/W _b		Rc/W	bkf.	2.6	Sinuosity:	1.88
	Check: Riffle/pool	☐ Step/pool ✓	Plane bed		e/divergence	<u></u> Dunes/	antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Ratio		Slope	
Features	bankfull depth (ft): 12.9	(max/me	ean): 1.4		pool pacing:	Valley:	Average bankfull	: 0.00022
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remarks:	Condition, vig	or and/or usage of existin	g reach:
	vegetation	<u> </u>					I	
	Flow P1, 2, Stream regime: 7, 9 and o	rder:	Meander pattern(s):	pa	epositional attern(s):		Debris/channel blockage(s):	D3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.3 Degree of stability rat	ing:	(n	odified Pfanku umeric and ad	jective rating	g): '	air
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	10.0 Width/dep (W/d) / (W	th ratio state /d _{ref}):	1.0		tio state / rating:	able
	Meander Width Ratio (MWR):	16.4 Reference MWR _{ref} :	Degree of (MWR / M	confinement WR _{ref}):	1.0		MWR _{ref} Unco	onfined
Bank Erosion Summary	Length of reach studied (ft):	009 	mbank erosion rate s/yr) 0.13 (to	e: C	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remarks	:		
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ=	0 τ*= #####	Existing depth _{bkf} :	Required depth _{bkf} :		sting Requ pe _{bkf} : slope	
Successional Stage Shift	→ -	→	→	→	Existing streated state (type):	am E	Potential stream state (type):	¹ E6
Lateral Stability	☐ Stable •	Mod. unstable ☐	Unstable	☐ Highly (unstable Re	emarks/cause	S: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggrad	lation	emarks/cause	s: None	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degrad	lation	emarks/cause	s: None	
Channel Enlargement	☐ No increase №	Slight increase	Mod. increase	☐ Extensi	ive	emarks/cause	S: None	
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very h	igh Remarks	/causes: No	one		

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

			Riparian Ve	getation			
Stre	eam: Sheye	enne River		Location:	She	yenne Rive	r-4-22.27
	servers: KP, A		Reference reach	Disturbed (impacted reach)	x		10/1/2011
spe	sting cies nposition:			Potential species composition:			
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species	comp	oosition	Percent of total species composition
1. Overstory	Canopy layer	75%	3%				
							100%
2. Understory	Shrub layer		10%				
							100%
level	Herbaceous		7%				
3. Ground leve	Leaf or needle litter		20%	Remarks: Condition, vigo usage of existir			100%
	Bare ground		60%				
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%				

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

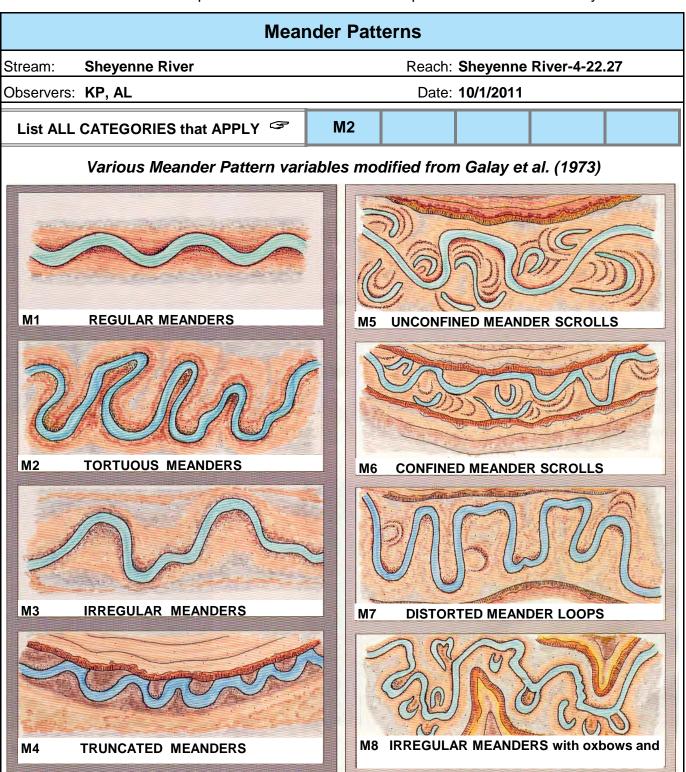
		F	LOW I	REGIMI	E								
Stream:	Sheyenne River		Location:	Sheyenr	ne River-4	-22.27							
Observers:	KP, AL						Date:	10/1/201	1				
List ALL	COMBINATIONS that	P1	P2	P7	P9								
APF	PLY												
General C	eral Category												
E													
s		Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.											
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology w	here				
Р	Perennial stream chanr	nels: Sur	face water	persists y	/earlong.								
Specific C	Category												
1	Seasonal variation in st	treamflow	dominate	d primarily	y by snow	melt runo	ff.						
2	Seasonal variation in st	treamflow	dominate	d primarily	y by storm	nflow runc	off.						
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ndition, b	ackwater	, etc.					
4	Streamflow regulated b	y glacial ı	melt.										
5	Ice flows/ice torrents fro	om ice da	m breache	es.									
6	Alternating flow/backwa	ater due to	o tidal influ	ence.									
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 generate	ed runoff.											

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

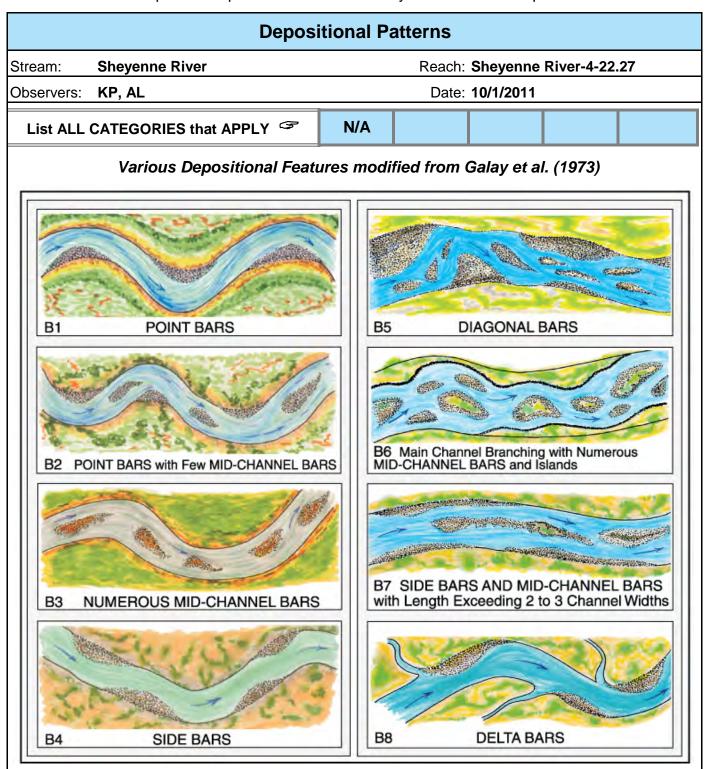
Stream Size and Order											
Sheyenne Rive	er										
Sheyenne Rive	er-4-22.27										
KP, AL											
10/1/2011											
Stream Size Category and Order S-4											
Category STREAM SIZE: Bankfull Check (1) appropriate											
meters feet category											
0.305	<1										
0.3 - 1.5	1 – 5										
1.5 – 4.6	5 – 15										
4.6 – 9	15 – 30	>									
9 – 15	30 – 50										
15 – 22.8	50 – 75										
22.8 - 30.5	75 – 100										
30.5 – 46	100 – 150										
46 – 76	150 – 250										
76 – 107	250 – 350										
107 – 150	350 – 500										
150 – 305	500 – 1000										
>305	>1000										
Stream Order											
	Sheyenne Rive Sheyenne Rive KP, AL 10/1/2011 e Category and STREAM SIZ wice meters 0.305 0.3 - 1.5 1.5 - 4.6 4.6 - 9 9 - 15 15 - 22.8 22.8 - 30.5 30.5 - 46 46 - 76 76 - 107 107 - 150 150 - 305 >305	Sheyenne River Sheyenne River-4-22.27 KP, AL 10/1/2011 e Category and Order STREAM SIZE: Bankfull width meters feet 0.305 <1									

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

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



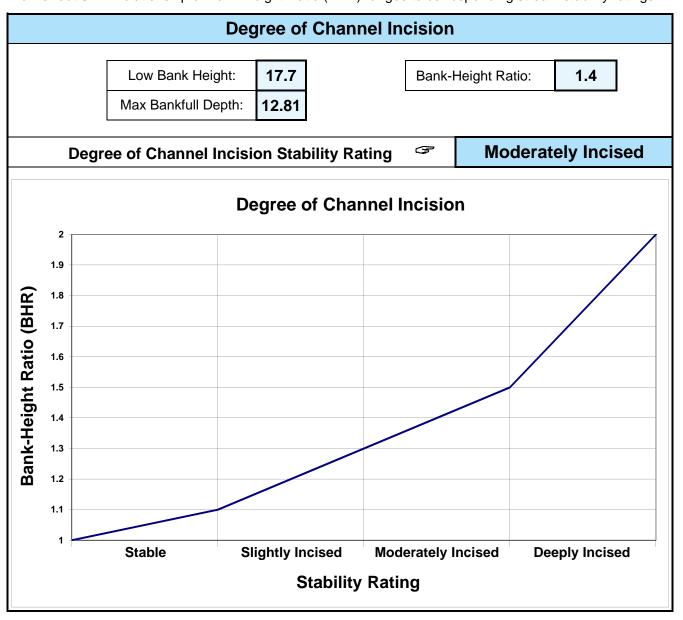
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



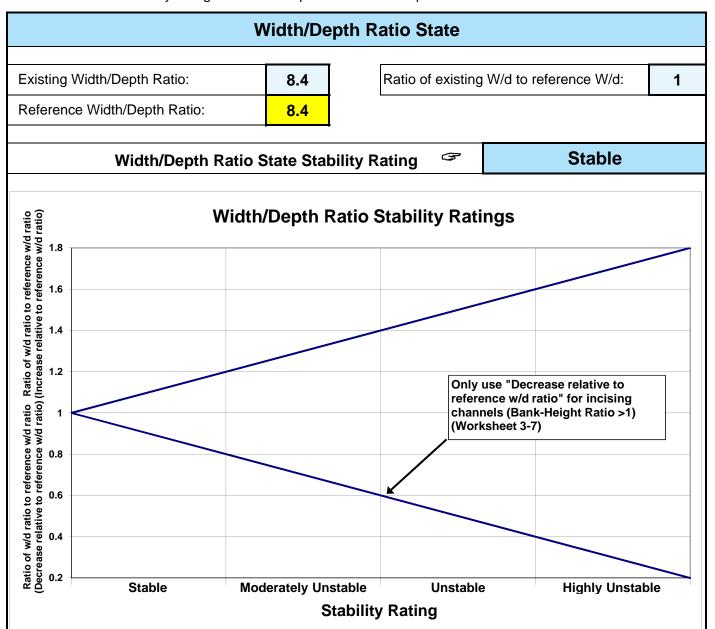
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strear	m: Sheyenne I	River Location: Sheyenne River-4-22.27	
Obser	rvers: KP, AL	Date: 10/1/2011	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	•
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

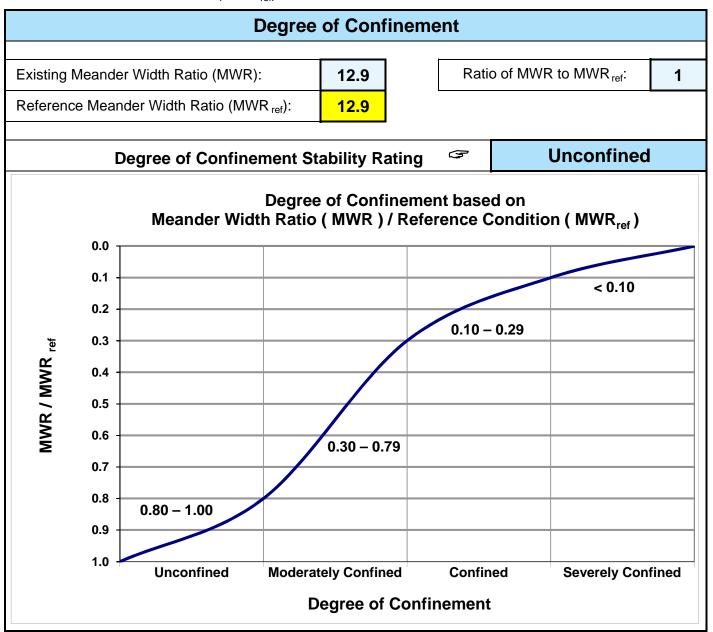
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



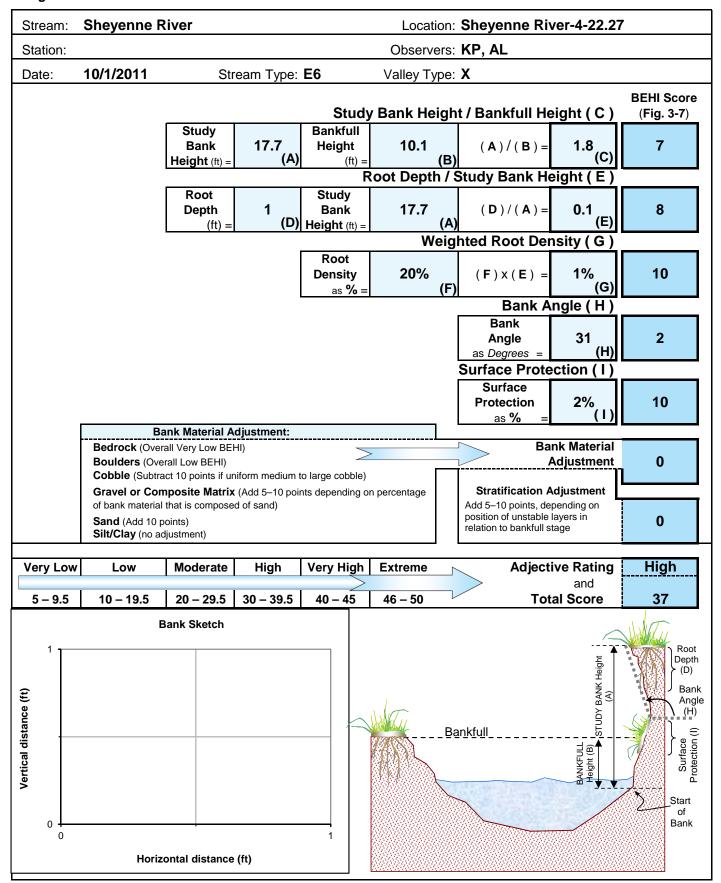
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream: Sheyenne River Location: Sheyenne River-4-22.2 Valley Type: X Observers: KP, AL										Date: 10/1/20	11															
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Ney	Calego	oi y			Descriptio	n		Rating			Description	n		Rating		[Description	n		Rating		[Descrip	otion	Rating
(0	1	Landform slope		Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradie	ent > (60%.	8
banks	2	Mass eros	sion I	No evide erosion.		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg	•	ing sedi	ment	9				sing sediment nea danger of same.	12
Upper	3	Debris jar potential		channel	l area.	ent from			2	Present, but mostly small twigs and limbs.		4 Moderate to heavy amounts, mostly larger sizes.		-			-				6	predomi	-	ger si	zes.	8
) 	4	Vegetative bank protection			t a deep	nsity. Vi , dense	_	-	3		or sugg	y. Fewer est less			6	fewer s		rom a sl		nd	9	vigor ind		oor, d	er species and les iscontinuous and	12
	5	Channel capacity		stage. Wic	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	rture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/dep width/dep (BHR) = 1	th ratio	3	common w ratio depar	th flows les	s than ference	d; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4 3.	. 4
nks	6	Bank rock content		12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	%. Most	in the 3-	-6" diam	eter	6	or less.			of gravel sizes, 1–3	8
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly ir ting or d			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	cause ba	nk erosi	on ye	and deflectors arlong. Sediment ation occurring.	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12". Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.		Significant. Cuts 12–24" high. Root		12				s, some over 24" ngs frequent.	16								
	9	Deposition	n	Little or point ba		irgemen	t of char	nnel or	4	Some r coarse		increase	, mostly	/ from	8	and coa	arse san	d on old	new gra I and so	me	12		nsive deposit of predominantly fine cles. Accelerated bar development.		16	
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e th and fla	U		2	Corners dimens		lges we	l rounde	rounded in 2		smooth.			ensions, surfaces	4
_	11	Brightnes	s	General	lly not b					surface	S.	may ha		6 bright	2	mixture	range.		i.e., 35-		3	scoured	surfaces		• 65%, exposed or	4
E	12	Consolidati particles		overlapp	ping.	tightly p			2	overlap	ping.	ked with			4	appare	nt overla	ар.	nt with n		6	easily moved.			8	
Bottom	13	Bottom siz distributio		No size material	_	e evident 0%.	t. Stable		4	50–80%	, o.	t light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12		distribution of the distri		ange. Stable	16
	14	Scouring deposition		<5% of deposition		affected	by scou	ır or	6	constric	tions ar	I. Scour Id where depositi	grades		12	at obstr		constri			18		n 50% of ange ne		oottom in a state o earlong.	f 24
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				or absent. Yellow m may be present.	
						Exc	cellent	total =	23				Good	total =	0				Fair	total =	6				Poor total	= 52
Stream typ	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	ſ		
Good (Stable			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		67-98		Grand total =	81
Fair (Mod. ur Poor (Unstat	nstable	44-47			96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+							2 108-132 99-125 133+ 126+			Existing stream type =	E6
Stream typ			DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6		- 1	ŀ	*Potential	
Good (Stable	-		10-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107	90-112					stream type =	E6
Fair (Mod. ur			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120								
Poor (Unstat			87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rat	
		'N							L.		<u> </u>			•	•	•	*Ra	ting is a	djusted t	to poten	tial strea	am type, i	not existir	ng.	Fair	-

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.												
			Estim	ating Nea	r-Bank St	ress (NB:	S)					
Stream:	Sheyer	nne River			Location:	Sheyenne	River-4-22	2.27				
Station:	0			S	tream Type:	E6	1	√alley Type:	X			
Observe	rs:	KP, AL						Date:	10/1/11			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr		Level I	Recona	aissance				
(2) Ratio	of radius o	of curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (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 predicti												
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	dation			
-					or discontinuo							
(1) Extensive deposition (continuous, cross-channel)												
			Bankfull	meander mig		ging now		INI	oo = Extreme			
		Radius of Curvature	Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)	ļ						
_					Near-Bank				•			
Level II	(3)	Pool Slope	Average	5 / 6 / 6	Stress			inant				
Le	(0)	S _p	Slope S	Ratio S _p / S	(NBS)	1		nk Stress				
							very	Low	L			
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank							
	(4)	S _p	S _{rif}	S _{rif}	Stress (NBS)							
		, e										
		Near-Bank			Near-Bank							
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress							
_	(3)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	1						
Level III				Mara Dani			DL4-II	1				
eve.		Near-Bank		Near-Bank Shear			Bankfull Shear					
_	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Near-Bank Stress			
	(0)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
>				Near-Bank								
Level IV	(7)	-	dient (ft/sec	Stress								
Lev	(- /	/ f	t)	(NBS)	l I							
_				Very Low	<u> </u>							
			nverting Va	lues to a l	Near-Bank	Stress (NE	3S) Rating					
Near-E		ess (NBS)				ethod numb			T			
	rating		(1)	(2)	(3)	(4) < 0.40	(5)	(6)	(7)			
	Very Lo		N/A	> 3.00	< 0.20	< 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 1.51 – 1.80	0.80 – 1.05	0.50 – 1.00			
	Modera		N/A See					1.06 – 1.14	1.01 – 1.60			
	High		(1)	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 Hi	_	(1) Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40			
	Extren	IC	ADOVE	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40			
				Overall N	lear-Bank S	otress (NB	S) rating	Very	Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne Rive	er	Sheyenne R	iver-4-22.27					
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	2881.7		Date:	10/1/2011		
Observers:	KP, AL		Valley Type:	Χ		Stream Type: E6			
(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.	High	Very Low	0.165	2881.7	17.7	8416	0.14		
2.						0	#DIV/0!		
3.						0	#DIV/0!		
4.						0	#DIV/0!		
5.						0	#DIV/0!		
6.						0	#DIV/0!		
7.						0	#DIV/0!		
8.						0	#DIV/0!		
9.						0	#DIV/0!		
10.						0	#DIV/0!		
11.						0	#DIV/0!		
12.						0	#DIV/0!		
13.						0	#DIV/0!		
14.						0	#DIV/0!		
15.						0	#DIV/0!		
Sum erosion	n subtotals in Col	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	8416			
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	312			
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	405			
	osion per unit len total length of str			Erosion	Total Erosion (tons/yr/ft)	0.14			

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

Stream:	Sheyenne	River	St	ream Type:	E6						
Location:	Sheyenne	River-4-22.27	V	'alley Type:	Х						
Observers:	KP, AL			Date:	10/1/2011						
Enter Req	uired Infor	mation for Existing Condition									
	D ₅₀	Riffle bed material D ₅₀ (mm)									
	D ₅₀	Bar sample D ₅₀ (mm)									
0	D _{max}	Largest particle from bar sample	(ft)		(mm)	304.8 mm/ft					
	s	Existing bankfull water surface s	lope (ft/ft)								
	d	Existing bankfull mean depth (ft)									
1.65	γ_s	Submerged specific weight of se	diment								
Select the	Appropria	te Equation and Calculate Cri	tical Dimensio	nless She	ar Stress						
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 Use	EQUATION 1:	τ* = 0.083	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use	EQUATION 2:	τ* = 0.038	4 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless Shear St	tress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean depth (fi	$d = \frac{\tau}{2}$	* $\gamma_s D_{max}$	- (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐									
Calculate Sample	Bankfull W	ater Surface Slope Required	for Entrainmen	t of Large	st Particle	in Bar					
#DIV/0!	s	Required bankfull water surface	slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$) _{max} (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐	Degrading								
Sediment	Competen	ce Using Dimensional Shear S	Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (subst	itute hydraulic rac	lius, R, with	mean depth,	d)					
	$\gamma = 62.4$, o	d = existing depth, S = existing slop	е								
	Predicted	largest moveable particle size (mm) at bankfull shea	r stress τ (F	igure 3-11)						
	Predicted	shear stress required to initiate mo	vement of measu	red D _{max} (m	m) (Figure 3	-11)					
#DIV/0!		mean depth required to initiate mov		ed D _{max} (mr	$d = \frac{7}{1}$	<u></u>					
#DIV/0!	Predicted	ted shear stress, γ = 62.4, S = exist slope required to initiate movement	of measured D _{ma}	_{ax} (mm)	$S = \frac{T}{2d}$	· •					
	τ = predic	ted shear stress, γ = 62.4, d = exis	ting depth		γd						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Side	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, A	L					
u b	Strea	m:	Sheye	enne R	iver				Loca	tion:	Sheye	nne R	iver-4-	22.27					Date: '	10/1	/2011	
		⇒ (⇒ (⇒(⇒ (⇒ (<u> </u>	⇒ (⇒ (→ (⇒ (
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve		Sieve		Sieve	SIZE	Sieve	SIZE				
m p		veight	Tare	mm weight	Tare	mm weight	Tare \	mm veight	Tare v	mm veight	Tare	mm weight	Tare v	mm veight	Tare	mm weight	Tare	mm weight			JRFACE	
1	14101	volgili	Taio	oigint	Turo (grit	Turo (ioigi ii	10.0	voigin.	Taro	worgin	Taio (Taio	.roigin	- 1410	oigint			TERIAL DATA	S
e s	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		(Tw		rgest par	ticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.
2																			-	1 1	Dia.	VV I .
3																				2		
4																			Bucket	+	<u> </u>	
5																			materia weight			
6																						
7																			Bucket ta weight			
9																			Materia	ls		
10																			weight	t	()
11																			Materials			
12																			than:			mm
13																				se	e sure to a eparate m	aterial
15																			<i></i>		eights to g tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	7	
-	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		<u> </u>		
Accum	1. % =<	#####	\longrightarrow	#####		#####		#####	\Longrightarrow	#####	\rightarrow	#####	\Longrightarrow	#####	\longrightarrow	#####		100%]	GRA	AND TO	TAL
	amnla lo	cation no	ntee				Sar	nple loca	ation sky	atch												
	ипріс ю	cation ne	7.03				- Oai	TIPIC TOCK	ation six	J. (011												

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

Stream:	Sheyenne River	Stream Type: E6
Location:	Sheyenne River-4-22.27	Valley Type: X
Observers:	KP, AL	Date: 10/1/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	✓ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	$(B \rightarrow G), (D \rightarrow G), (C \rightarrow G), (E \rightarrow G)$	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E6	
Location: Sheyenne River-	4-22.27		Valley Ty	_{/pe:} X	
Observers: KP, AL			Da	ate: 10/1/2011	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
,	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
,	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne Riv	er		Stream Type:	E6	
Location: Sheyenne Riv	er-4-22.27		Valley Type:	Х	
Observers: KP, AL			Date:	10/1/2011	
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	n / Aggradation	Selected
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	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)	
Sediment capacity (POWERSED)	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)	(6)	(8)	
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2
	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheet 3- 16)	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)	$(C \rightarrow D)$, $(F \rightarrow D)$	2
	(2)	(4)	(6)	(8)	
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1
3-5)	(1)	(2)	(3)	(4)	
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1
	(1)	(2)	(3)	(4)	
				Total points	14
	Vertical stal		int range for exces adation	s deposition /	
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne Ri	ver		Stream Type:	E6	
Location: Sheyenne Ri	ver-4-22.27		Valley Type:	X	
Observers: KP, AL			Date:	10/1/2011	
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
	(2)	(4)	(6)	(8)	
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
	(2)	(4)	(6)	(8)	
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	6
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4
·	(2)	(4)	(6)	(8)	
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1
3-9)	(1)	(2)	(3)	(4)	
				Total points	15
	Vertical stab	oility category poi degra	nt range for chan dation	nel incision /	
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 3-20. Channel enlargement prediction summary.

Stream: Sheyenne Rive	r		Stream Type:	E6								
Location: Sheyenne River-4-22.27 Valley Type: X Observers: KP AI Date: 10/1/2011												
Observers: KP, AL			Date:	10/1/2011								
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected							
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)							
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2							
	(2)	(4)	(6)	(8)								
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4							
	(2)	(4)	(6)	(8)								
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2							
(Worksheet 3-18)	(2)	(4)	(6)	(8)								
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4							
(Worksheet o 15)	(2)	(4)	(6)	(8)								
				Total points	12							
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Sheyenne River			Stream Type:	E 6
Loc	cation: Sheyenne River-	-4-22.27		Valley Type:	Х
Ob	servers: KP, AL			Date:	10/1/2011
p c	everall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	2
l '	(Worksheet 3-17)	Unstable		3	2
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. depos	ition	2	1
	aggradation	Excess dep	osition	3	•
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci	sed	2	2
3	degradation	Mod. Incised	d	3	2
	(Worksheet 3-19)	Degradation	1	4	
	Channal anlargament	No increase 1			
4	Channel enlargement prediction (Worksheet	Slight increase 2		2	
~	3-20)	Mod. increa	se	3	2
	3-20)	Extensive		4	
	Pfankuch channel	Good: stable	e	1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				2
	10)	Poor: unsta	ble	4	
				Total Points	9
			Category p	oint range	
ra	everall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Ri	ver-4-22.27		
Observers:	KP, AL	Date:	10/1/2011	Stream	n Type: E6	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 8.56	Mean bankfull 71 width (ft):	.48 Cross-section area (ft²):	n 571.8	Width of flood- prone area (ft):	535.6667	Entrenchment ratio:	7.5
Channel Pattern	Mean: Range: MWR:	12.9 Lm/W _b		Rc/	/W _{bkf} :	2.5	,	1.75
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed		nce/divergence	<u></u> Dunes/	/antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool Depth r	atio Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull depth (ft): 12.8	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull:	0.00033
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existing	reach:
	vegetation	<u> </u>					I=	
	Flow P1, 2, Strear regime: 7, 9 and or	rder:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.4 Degree of stability rat		lerately cised	Modified Pfank (numeric and a	•		air
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	8.4 Width/dep (W/d) / (W		te 1.0		tio state y rating:	able
	Meander Width Ratio (MWR):	12.9 Reference MWR _{ref} :	Degree of (MWR / M		nt 1.0	I I	/ MWR _{ref} y rating: Unco	nfined
Bank Erosion Summary	Length of reach studied (ft):	18Z	mbank erosion rates	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ=	0 τ*= #####	Existing depth _{bkf} :	Require depth _{bkf} :		isting Requi pe _{bkf} : slope _b	
Successional Stage Shift	→ -	→	→	→	Existing stre		Potential stream state (type):	E6
Lateral Stability	☐ Stable 	₹ Mod. unstable Γ	Unstable	☐ High	ly unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	emarks/cause	PS:	
Vertical Stability (Degradation)	□ Not incised	Slightly incised	Mod. incised	☐ Degr	adation	emarks/cause	98:	
Channel Enlargement	☐ No increase 🔽	Slight increase	Mod. increase	☐ Exte	nsive	temarks/cause	es:	
Sediment Supply (Channel Source)	□ Low ▼	Moderate	High 🔲 Very h	igh	ks/causes:			

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

			Riparian Ve	egetation
Stre	eam: Sheye	enne River		Location: Sheyenne River-5-26.47
	servers: KP, A		Reference reach	Disturbed (impacted x reach) Date: 10/5/2011
spe	sting cies nposition:			Potential species composition:
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition Species composition
1. Overstory	Canopy layer	80%	3%	
				100%
2. Understory	Shrub layer		40%	
				100%
level	Herbaceous		27%	
3. Ground level	Leaf or needle litter		10%	Remarks: Condition, vigor and/or usage of existing reach:
	Bare ground		20%	
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%	

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

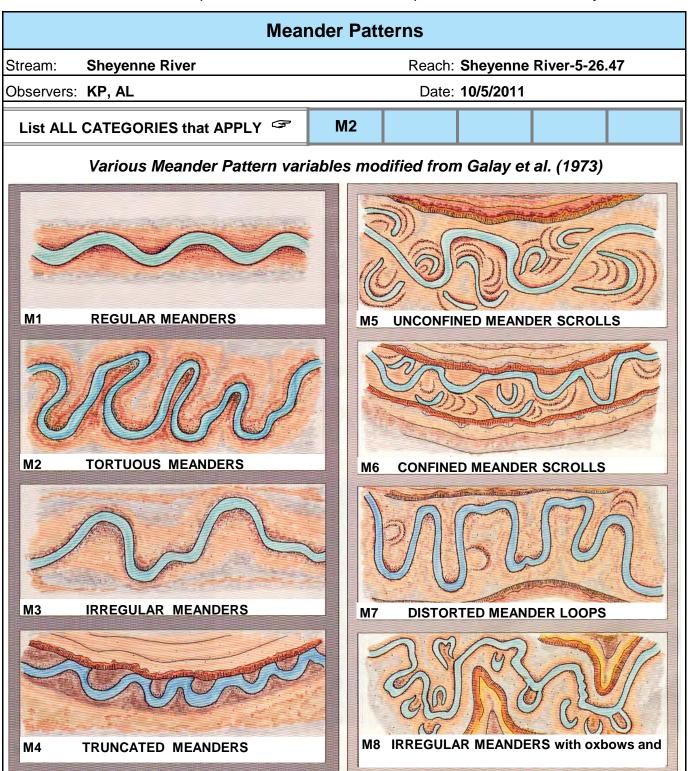
		F	LOW I	REGIM					
Stream:	Sheyenne River		Location:	Sheyenn	e River-5	5-26.47			
Observers:	KP, AL						Date:	10/5/201	1
	COMBINATIONS that	P1	P2	P 7	P8	P9			
APP	PLY	• •			. 0	. •			
General C	ategory								
E	Ephemeral stream char	nnels: Flo	ows only in	response	e to precip	oitation			
S	Subterranean stream consurface flow that follows:			llel to and	near the	surface fo	or various	seasons	- a sub-
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology wl	here
Р	Perennial stream chann	nels: Surf	face water	persists y	earlong.				
Specific C	Category								
1	Seasonal variation in st	reamflow	dominate	d primarily	/ by snow	melt runo	off.		
2	Seasonal variation in st	reamflow	dominate	d primarily	/ by storm	nflow runc	off.		
3	Uniform stage and asso	ociated st	reamflow o	lue to spr	ing-fed co	ndition, b	ackwater	, etc.	
4	Streamflow regulated b	y glacial r	melt.						
5	Ice flows/ice torrents fro	om ice da	m breache	s.					
6	Alternating flow/backwa	ater due to	o tidal influ	ence.					
7	Regulated streamflow of	due to div	ersions, da	ım releas	e, dewate	ring, etc.			
8	Altered due to develope conversions (forested to								
9	Rain-on-snow generate	d runoff.							

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

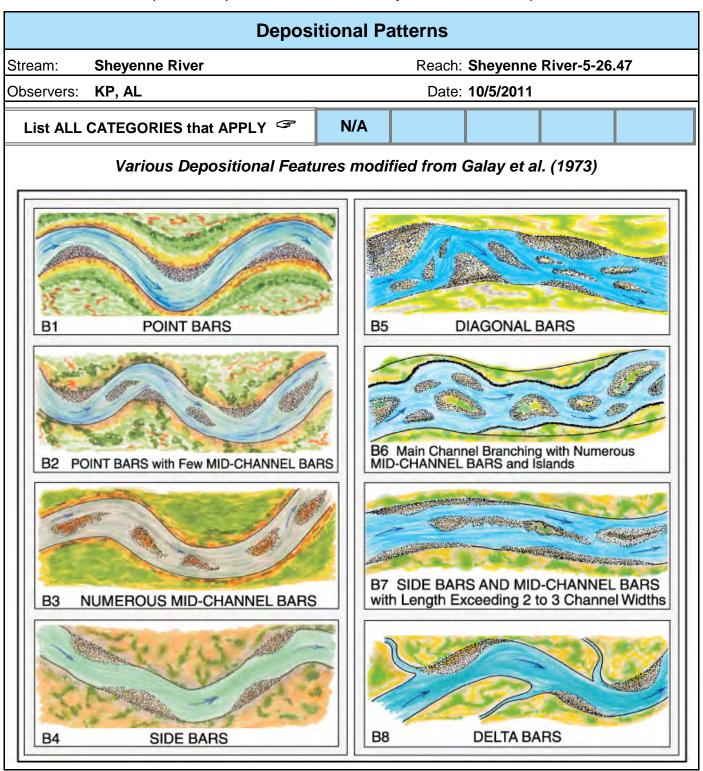
	Stream Siz	e and Orde	r							
Stream:	Sheyenne Rive	er								
Location: Sheyenne River-5-26.47										
Observers:	KP, AL									
Date:	10/5/2011									
Stream Siz	e Category and	l Order 🤝	S-6							
STREAM SIZE: Bankfull Check (✓) Category width check (✓)										
	meters	feet	category							
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								
	Strear	n Order								
A d d										

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

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



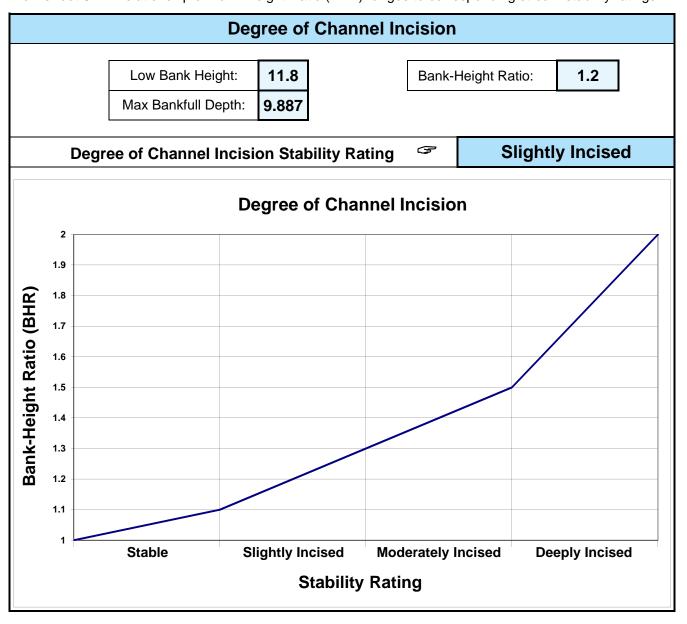
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



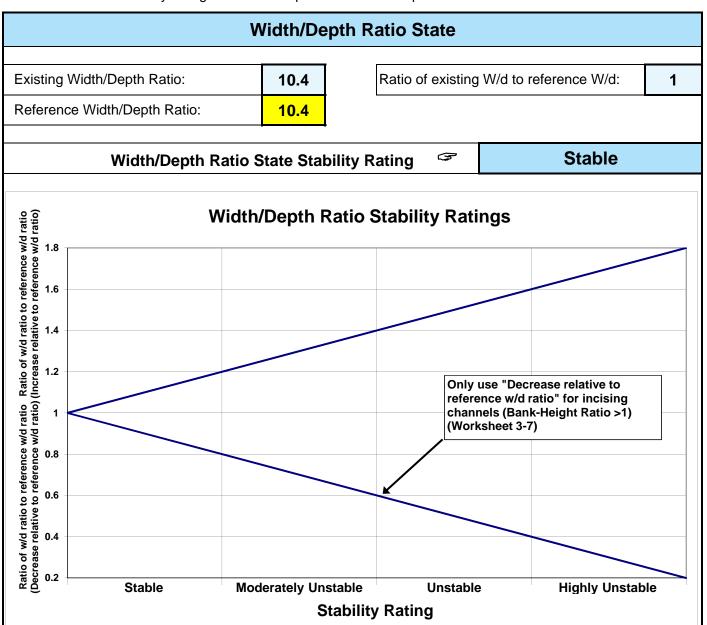
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages						
Strea	m: Sheyenne I	River Location: Sheyenne River-5-26.47						
Obsei	rvers: KP, AL	Date: 10/5/2011						
Desc	ription/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.						
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.	Y					
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.						
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.						
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.						
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.						
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.						
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.						

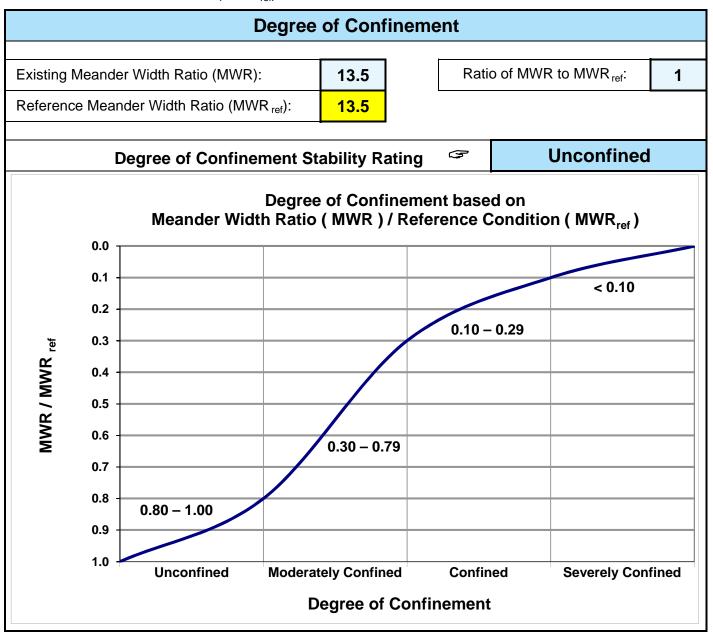
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



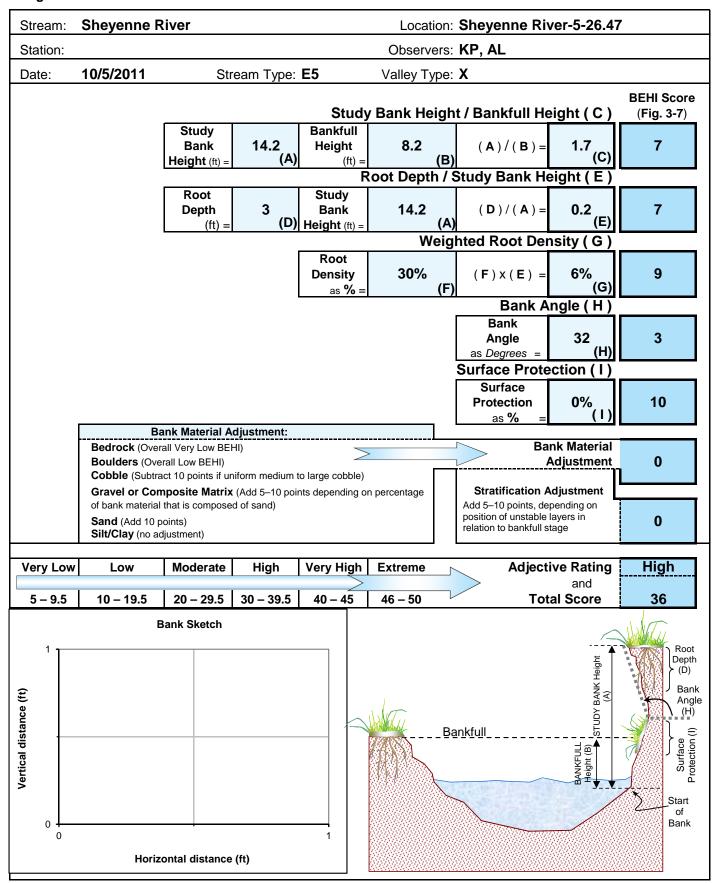
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Shey	enne l	River	•			Loc	ation:	Shey	enne l	River-	5-26.4		Valley	Type:	Χ		Obse	ervers:	KP, A	۸L				Date: 10/5/2)11	
Loca-	Key	Cotoo	10 m/			Exce	llent					Go	od					F	air						Poor		
tion	ney	Categ	jory		[Descriptio	n		Rating		D	Descriptio	n		Rating		[Descriptio	n		Rating		I	Descrip	otion	Rati	ng
(0	1	Landform slope	n	Bank slo	ope gra	dient <3	0%.		2	Bank slo	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradi	ent >	60%.	8	
Upper banks	2	Mass ero	osion	No evid erosion		past or	future m	ass	3	Infrequent. Mostly healed over. Low future potential.			6	Frequent or large, causing sediment nearly yearlong.		9				sing sediment nea danger of same.	arly 12	·					
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	izes.		ounts, m		6	Moderate to heavy amo predominantly larger siz			zes.	8	
ס	4	Vegetative bank protection			t a deep	nsity. Vi	_		3		or sugg	y. Fewer est less			6	fewer s		rom a sl		ınd	9	vigor ind		oor, d	er species and le iscontinuous and		<u>,</u>
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	tage is no arture from	t containe reference	d. Width/de width/dep (BHR) = 1	oth ratio	3	common w ratio depar	ith flows les	ss than eference	d; over-bank flows are bankfull. Width/depth e width/depth ratio > 1 3.	1	
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula			2	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1-	3" 8	
Lower banks	7	Obstructi to flow	ions		w/o cut	firmly ir ting or d					and mind	using ero: or pool fill m.			4		th high flo		able obst sing bank		6	cause ba	ank erosi	on ye	and deflectors arlong. Sediment ation occurring.	8	
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	Significa mat ove			-		12				s, some over 24" ngs frequent.	16	;
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n coarse (increase	, mostly	/ from	8			Extensive deposit of predominantly fine particles. Accelerated bar development.		16	j						
	10	Rock angularit		Sharp e surface:		nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimensi		lges we	ll rounde	ed in 2	3	Well rou smooth.	Well rounded in all dimensions, surfaces smooth.		4		
	11	Brightnes	ss	Surface Genera	,	dark or s right.	tained.		1	surfaces	3.	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predominantly bright, > 65%, exposed of scoured surfaces.		r 4			
E	12	Consolida particles		Assorte overlap		tightly p	acked o	r	2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	10	6	No packing evident. Loose assortment, easily moved.		8			
Bottom	13	Bottom s distribution		No size materia	•	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	zes. Stal		12		distributions 0–20%.		ange. Stable	16	j
_	14	Scouring deposition		<5% of depositi		affected	by scot	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18		an 50% o nange ne		oottom in a state earlong.	of 24	ļ
	15	Aquatic vegetatio			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				or absent. Yellov m may be presen	4	
						Exc	ellent	total =	18				Good	total =	6				Fair	total =	42				Poor tota	I = 12	2
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	J			
Good (Stab	le)	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		Grand total :	- 78	}
Fair (Mod. u Poor (Unsta	ble)	44-47 48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110 111+	91-110 111+	106+	133+	133+	133+ 126+ str		Existing stream type	_ E	5	
Stream ty Good (Stab	_		DA4 40-63	DA5 40-63	DA6 40-63	E3 40-63	E4 50-75	E5 50-75	E6 40-63	F1 60-85	F2 60-85	F3 85-110	F4 85-110	F5 90-115	F6 80-95	G1 40-60	G2 40-60	G3 85-107	G4 85-107	G5 90-112		*Potential 85-107 stream type :		_ E5	5		
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120			į	Modified c		
Poor (Unsta		87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability ra		
. 501 (011318	,	<i>-</i>	5, ,	0,,	0,,	011	07.1	07.1	0, ,	1001	1001	1201	1201	1 1017		, , , ,					1	ım type,	not existi	ng.	Fair		
																											_

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion	Tale.																		
			Estim	ating Nea	r-Bank St	ress (NB:	S)												
Stream:	Sheyer	nne River			Location:	Sheyenne	River-5-26	6.47											
Station:	0			S	tream Type:	E5	1	/alley Type:	Χ										
Observe	ers:	KP, AL						Date:	10/5/11										
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)												
(1) Chan	nel pattern	, transverse ba	r or split channe		Level I	Recona	aissance												
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction										
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction										
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction										
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction										
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction										
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	dation										
=					or discontinuo														
Levell	(1)				-channel)														
				meander mig	ration, conver	ging flow		NI	35 = Extreme										
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank														
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)														
		<u> </u>	()	5.0															
					Near-Bank														
Level II	(2)	Pool Slope	Average		Stress		Dom	inant	Ī										
ě	(3)	S _p	Slope S	Ratio S _p / S	(NBS)		Near-Bai	nk Stress											
_							Very	Low	l										
					Near-Bank				_										
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress														
	(. ,	S _p	S _{rif}	S _{rif}	(NBS)	1													
		N D 1				ļ													
		Near-Bank Max Depth	Mean Depth	<i>Ratio</i> d _{nb} /	Near-Bank Stress														
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)														
=																			
Level III				Near-Bank			Bankfull												
Fe		Near-Bank	Na an Danie	Shear			Shear		Near-Bank										
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	J	Stress τ _{bkf} (Ratio τ_{nb} /	Stress										
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)										
≥		Volocity Cro	diant / ft / aa-	Near-Bank															
Level IV	(7)	velocity Grad / f	dient (ft/sect)	Stress (NBS)															
Ľ		, .	,	Very Low	Ì														
					y 	01	10) D (
Noor E	Pank St		nverting Va	liues to a l	Near-Bank														
ivear-E	rating	ess (NBS) s	(1)	(2)	(3)	ethod numb (4)	per (5)	(6)	(7)										
	Very Lo		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												
	Modera		N/A	2.01 – 2.20	0.41 – 0.60	0.61 – 0.80	1.51 – 1.80	1.06 – 1.14	0.50 - 1.00 1.01 - 1.60										
	High		See	1.81 – 2.00	0.61 – 0.80 0.81 – 1.00		1.81 – 2.50												
	Very Hi		(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	1.61 – 2.00 2.01 – 2.40										
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40										
				, , , , , , , , , , , , , , , , , , , ,															
				Overall IV	cai-Dailk (20 632 (IAD	o, rating	v ei y	Overall Near-Bank Stress (NBS) rating Very Low										

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne Rive	r		Location:	Sheyenne R	iver-5-26.47	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4082		Date:	10/5/2011
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E5
(1)	(2)	(3) NBS rating	(4) Bank	(5)	(6) Study bank	(7)	(8) Erosion
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	(Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	height (ft)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1.	High	Very Low	0.165	4082	14.2	9564	0.11
2.						0	#DIV/0!
3.						0	#DIV/0!
4.						0	#DIV/0!
5.						0	#DIV/0!
6.						0	#DIV/0!
7.						0	#DIV/0!
8.						0	#DIV/0!
9.						0	#DIV/0!
10.						0	#DIV/0!
11.						0	#DIV/0!
12.						0	#DIV/0!
13.						0	#DIV/0!
14.						0	#DIV/0!
15.						0	#DIV/0!
Sum erosior	n subtotals in Col	umn (7) for ead	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	9564	
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	354	
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	460	
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.11	

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

Stream:	Sheyenne	River	St	ream Type:	E5					
Location:	Sheyenne	River-5-26.47	\	/alley Type:	Х					
Observers:	KP, AL			Date:	10/5/2011					
Enter Req	uired Infor	mation for Existing Condition	n							
	D ₅₀	Riffle bed material D ₅₀ (mm)								
	D ₅₀	Bar sample D ₅₀ (mm)								
0	D _{max}	Largest particle from bar sampl	e (ft)		(mm)	304.8 mm/ft				
	S Existing bankfull water surface slope (ft/ft)									
d Existing bankfull mean depth (ft)										
1.65	γ_s	Submerged specific weight of s	ediment							
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress										
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 Us	e EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Us	e EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless Shear	Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate	Bankfull Me	an Depth Required for Entrair	nment of Largest	Particle in	Bar Sampl	е				
#DIV/0!	d	Required bankfull mean depth ((ft) $d = \frac{\tau}{}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐								
Calculate Sample	Bankfull W	ater Surface Slope Required	I for Entrainmen	t of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water surface	e slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐	Degrading							
Sediment	Competen	ce Using Dimensional Shear	Stress							
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (subs	stitute hydraulic rad	dius, R, with	mean depth,	d)				
	$\gamma = 62.4$, o	d = existing depth, S = existing slo	рре							
	Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)									
	Predicted	shear stress required to initiate m	ovement of measu	red D _{max} (m	m) (Figure 3	-11)				
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{u^2}$									
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, $S = ex$ slope required to initiate movement	nt of measured D _m	_{ax} (mm)	$S = \frac{T}{2d}$					
	τ = predic	ted shear stress, $\gamma = 62.4$, d = exi	isting depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, A	L		ī		
u b	Strea	am:	Sheye	enne R	iver		ı		Loca	tion:	Sheye	enne R	iver-5	-26.47	m		П		Date: 10/	5/2011	
				→ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒ (⇒ (
s a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm			
m p		weight	Tare	weight	Tare	weight	Tare \		Tare	veight	Tare	weight	Tare	weight	Tare v		Tare v	veight		URFACE	
ì																			M.A	ATERIAL DATA	.S
e s	Sample	_	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two la	argest pa	rticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No.	Dia.	WT.
2																			1 1	Dia.	VV 1.
3																			2		
4																			Bucket +		
5																			materials weight		
6 7																					
8																	-		Bucket tare weight		
9																			Materials		
10																			weight		0
11																			Materials less than:		
12																					mm
14																				Be sure to separate n	naterial
15																				veights to	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	7	
-		#####		#####		#####		#####		#####		#####		#####	1 1 1	#####		#####		~	
Accun	1. % =<	#####		#####	\Longrightarrow	#####		#####		#####		#####	\longrightarrow	#####		#####		100%	GF	RAND TO	TAL
	ample le	cation n	otoe				Sar	nple loca	ation ek	otch											
	апріс ю	cation	7.63				Jai	TIPIE IOC	ation ski	JUII											

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

Stream:	Sheyenne River	Stream Type: E5
Location:	Sheyenne River-5-26.47	Valley Type: X
Observers:	KP, AL	Date: 10/5/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River Stream Type: E5									
Location: Sheyenne River-	5-26.47		Valley Ty	_{/pe:} X					
Observers: KP, AL			Da	ate: 10/5/2011					
Lateral stability criteria		Lateral Stabilit	y Categories		Selected				
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)				
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2				
	(2)	(4)	(6)	(8)					
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	В3	B5, B6, B7	1				
	(1)	(2)	(3)	(4)					
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3				
	(1)		(3)						
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)					
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1				
(Worksheet 3-9)	(1)	(2)	(3)	(4)					
Total points									
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne Riv	er		Stream Type:	E5				
Location: Sheyenne Riv	er-5-26.47		Valley Type:	Х				
Observers: KP, AL			Date:	10/5/2011				
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	n / Aggradation	Selected			
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	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)				
Sediment capacity (POWERSED)	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)				
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheet 3- 16)	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)				
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1			
3-5)	(1)	(2)	(3)	(4)				
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	2			
	(1)	(2)	(3)	(4)				
Total points								
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne Ri	ver		Stream Type:	E5				
Location: Sheyenne Ri	ver-5-26.47		Valley Type:	X				
Observers: KP , AL			Date:	10/5/2011				
Vertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected			
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2			
	(2)	(4)	(6)	(8)				
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2			
	(2)	(4)	(6)	(8)				
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4			
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4			
	(2)	(4)	(6)	(8)				
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1			
3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-20. Channel enlargement prediction summary.

Str	ream: Sheyenne Rive	r		Stream Type:	E5			
Lo	cation: Sheyenne Rive	r-5-26.47		Valley Type:	X			
Ob	oservers: KP, AL			Date:	10/5/2011			
	Channel enlargement	Char	Selected					
(c	orediction criteria choose one stability category for each criterion -4)	No increase Slight increase		Moderate increase	Extensive	points (from each row)		
Successional stage shift (Worksheet 3-16)		Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2		
		(2)	(4)	(6)	(8)			
2	Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4		
		(2)	(4)	(6)	(8)			
3	Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2		
	(Worksheet 3-18)	(2)	(4)	(6)	(8)			
4	Vertical stability incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4		
	(Workshoet 6 15)	(2)	(4)	(6)	(8)			
	Total points 12							
p p	Channel enlargement prediction (use total points and check stability ating)	No increase 8 – 10	Slight increase 11 – 16 ✓	Moderate increase 17 – 24 □	Extensive > 24 □			

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

Str	eam: Sheyenne River			Stream Type:	E5					
Lo	cation: Sheyenne River-	5-26.47		Valley Type:	X					
Ob	servers: KP , AL			Date:	10/5/2011					
p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points					
		Stable		1						
1	Lateral stability	Mod. unstab	ole	2	2					
! '	(Worksheet 3-17)	Unstable		3	2					
		Highly unsta	able	4						
	Vertical stability	No deposition	on	1						
2	excess deposition/	Mod. deposi	ition	2	1					
-	aggradation	Excess depo	osition	3	1					
	(Worksheet 3-18)	Aggradation	1	4						
	Vertical stability	Not incised		1						
3	channel incision/	Slightly inci	sed	2	2					
ľ	degradation	Mod. Incised	d	3	2					
	(Worksheet 3-19)	Degradation	1	4						
	Channal anlargement	No increase								
4	Channel enlargement prediction (Worksheet	Slight increa	Slight increase 2		2					
~	3-20)	Mod. increas	se	3	2					
	3-20)	Extensive		4						
	Pfankuch channel	Good: stable	е	1						
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2					
ľ	10)				2					
	10)	Poor: unsta	ble	4						
	Total Points 9									
	Category point range									
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □					

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Ri	ver-5-26.47		
Observers:	KP, AL	Date:	10/5/2011	Stream	Туре: Е5	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 6.06	Mean bankfull 62 width (ft):	.74 Cross-section area (ft ²):	n 379.3	Width of flood- prone area (ft):	376.6667	Entrenchment ratio:	6.0
Channel Pattern	Mean: Range: MWR:	13.5 Lm/W _b	kf: 13.5	Rc/\	W _{bkf} :	3.1	Sinuosity:	1.7
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Convergen	ce/divergence	✓ Dunes.	/antidunes/smooth b	ed
River Profile and Bed	Max Riffle	Pool Depth r	Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull 9.9 depth (ft):	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull	ti tititi /
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existin	g reach:
	vegetation							
	Flow P1, 2, Strear regime: 7, 8, 9 and or		Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D4
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.2 Degree of stability rat	ing:	ly iliciseu	Modified Pfank (numeric and a	djective ratin	g):	air
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	10.4 Width/dep (W/d) / (W	th ratio state //d _{ref}):	e 1.0		tio state y rating:	able
	Meander Width Ratio (MWR):	13.5 Reference MWR _{ref} :	Degree of (MWR / M	confinemen WR _{ref}):	^{nt} 1.0		/ MWR _{ref} y rating: Unc o	onfined
Bank Erosion Summary	Length of reach studied (ft):	182	mbank erosion rate s/yr) 0.11 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ=	0 τ*= ####	Existing depth _{bkf} :	Require depth _{bkf} :		isting Requ pe _{bkf} : slope	
Successional Stage Shift	→ -	→	→	→	Existing stre state (type)		Potential stream state (type):	E5
Lateral Stability	☐ Stable 🔽	Mod. unstable Г	Unstable	☐ Highly	y unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	emarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degra	adation	emarks/cause	PS:	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exten	nsive	temarks/cause	PS:	
Sediment Supply (Channel Source)	□ Low ▽	Moderate	High 🔲 Very h	igh	ks/causes:			

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

			Riparian Ve	getation			
Stre	eam: Sheye	enne River		Location:	She	eyenne River	· - 6 - 35.82
	servers: KP, A		Reference reach	Disturbed (impacted reach)	X		11/21/2010
spe	sting cies nposition:			Potential species composition:			
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species	comp	oosition	Percent of total species composition
1. Overstory	Canopy layer						
							100%
2. Understory	Shrub layer						
		XIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII					100%
level	Herbaceous						
3. Ground leve	Leaf or needle litter			Remarks: Condition, vigo usage of existir			100%
	Bare ground			None			
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%				

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

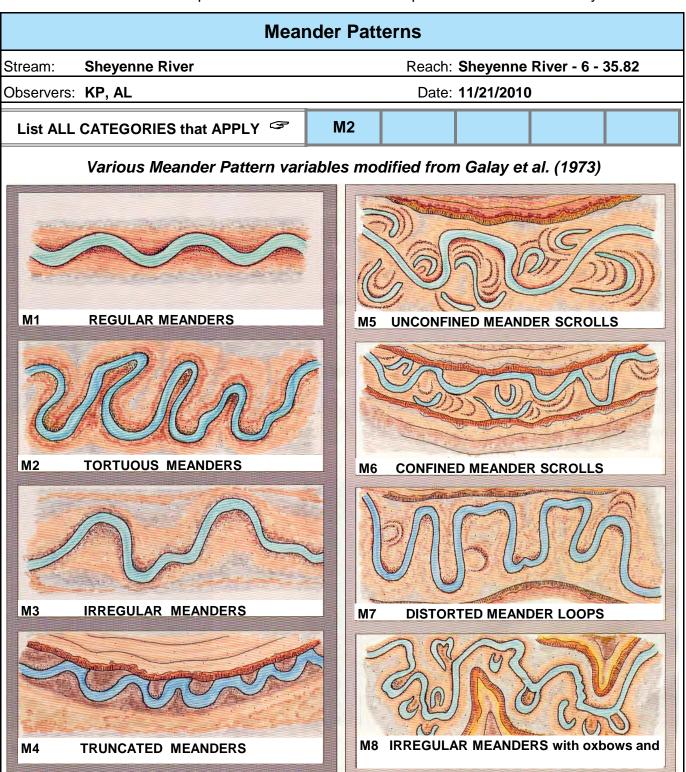
FLOW REGIME											
Stream:	Sheyenne River		Location:	Sheyenr	e River -	6 - 35.82					
Observers: KP, AL Date: 11/21/2010											
List ALL COMBINATIONS that											
APPLY											
General C	General Category										
E	Ephemeral stream cha	nnels: Flo	ows only in	respons	e to precip	pitation					
s	Subterranean stream c surface flow that follow			llel to and	l near the	surface fo	or various	seasons	- a sub-		
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.										
Р	Perennial stream chan	nels: Surf	face water	persists y	/earlong.						
Specific (Category										
1	Seasonal variation in s	treamflow	dominated	d primarily	y by snow	melt runo	ff.				
2	Seasonal variation in s	treamflow	dominated	d primarily	y by storn	nflow runc	off.				
3	Uniform stage and asso	ociated sti	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.			
4	Streamflow regulated b	y glacial r	melt.								
5	Ice flows/ice torrents fro	om ice da	m breache	:S.							
6	Alternating flow/backwa	ater due to	tidal influ	ence.							
7	7 Regulated streamflow due to diversions, dam release, dewatering, etc.										
8	Altered due to develope conversions (forested t										
9	Rain-on-snow generate	ed runoff.									

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

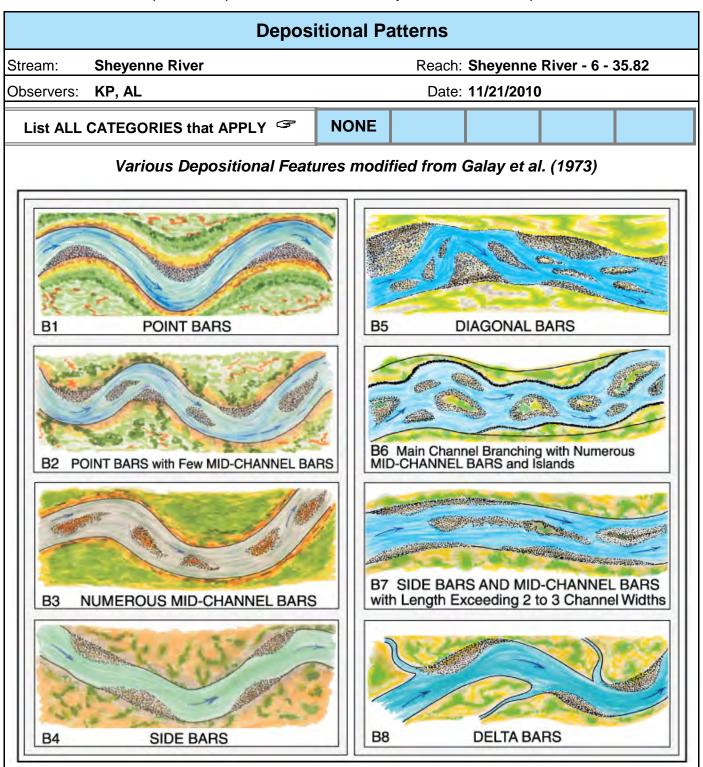
Stream Size and Order									
Stream:	Stream: Sheyenne River								
Location:	Sheyenne Rive	er - 6 - 35.82							
Observers:	KP, AL								
Date:	11/21/2010								
Stream Size Category and Order S-6									
Category		ZE: Bankfull dth	Check (✓) appropriate						
	meters	feet	category						
S-1	0.305	<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 \square									
	Strear	n Order							
Add categori	as in naranthasis	for enacific etras	m order of						

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

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



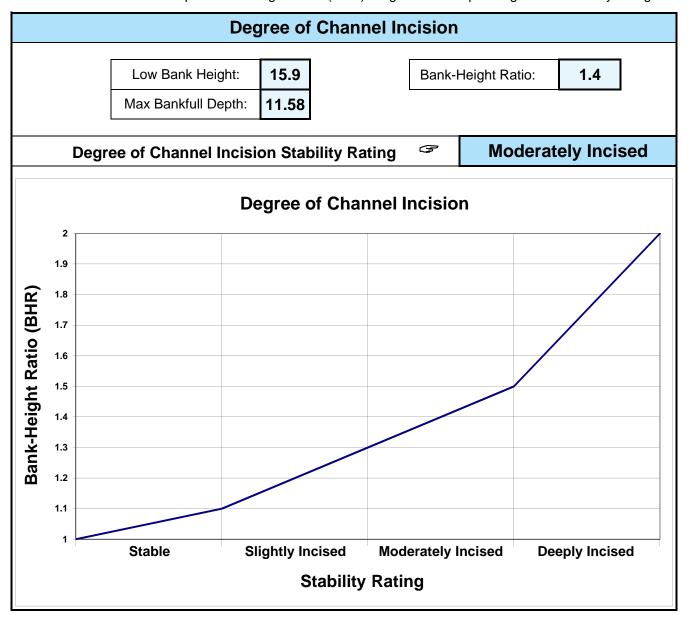
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



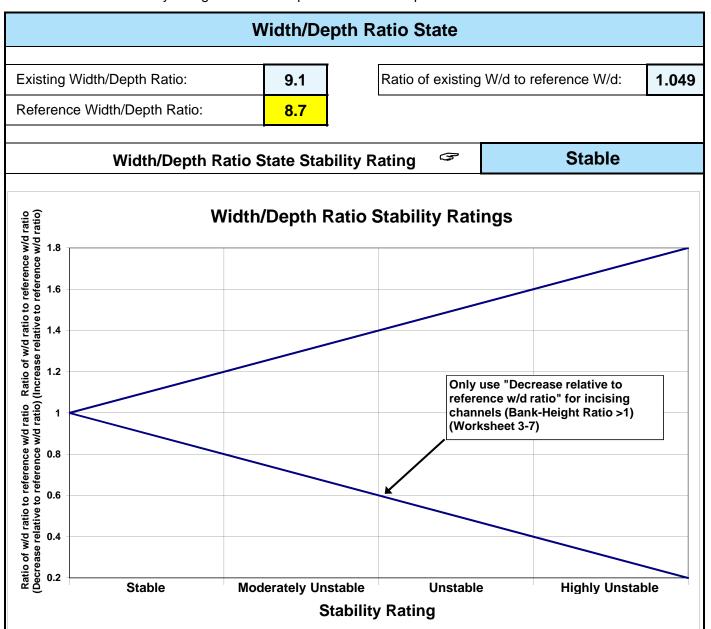
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages								
Strear	m: Sheyenne I	River Location: Sheyenne River - 6 - 35.82							
Obser	rvers: KP, AL	Date: 11/21/2010							
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply						
D1	None	Minor amounts of small, floatable material.							
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	•						
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.							
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.							
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.							
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.							
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.							
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.							
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.							
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.							

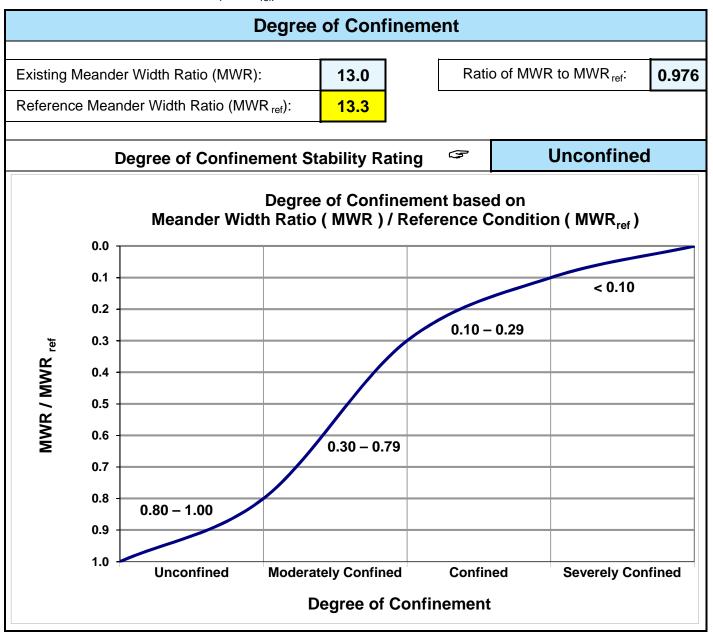
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



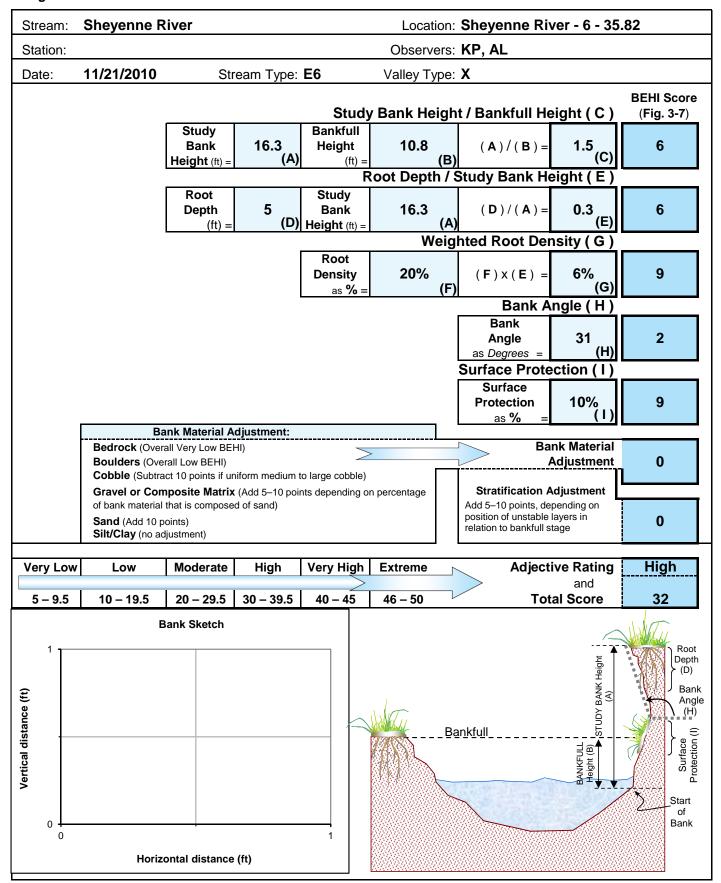
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Shey	enne R	River				Loc	ation:	Shey	enne	River	- 6 - 3		Valley	Туре:	Χ		Obse	ervers:	KP, A	۱L				Date: 11/2	/201	0																
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor																		
tion	Ney	Calego	ог у			Descriptio	n		Rating			Descriptio	n		Rating		[Description	n		Rating			Descri	ption		Rating																
"	1	Landform slope		Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradi	ent >	60%.		8																
banks	2	Mass eros	sion I	No evide erosion.		past or	future m	ass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg	•	ing sedi	ment	9	Frequent or large, car yearlong OR imminer					12																
Upper	3	Debris jan potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	sizes.	-	ounts, m	-	6	Moderat predomi	nantly la	rger s	izes.		8																
ס	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		icating p	oor, d	er species and liscontinuous a		12																								
	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio departure from reference width/depth ratio = 1.0-1.2. Bank-Height Ratio (BHR) = 1.0-1.1. Bank rock content Solution Sol		th ratio	3	common w	ith flows le ture from re	ss than eferenc	ed; over-bank flows bankfull. Width/dep e width/depth ratio .3.	th	4																																	
nks				2			y boulde	rs and	small	4		6. Most	in the 3-	-6" diam	eter	6	or less.			of gravel sizes,	1–3"	8																					
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in			2	currents fewer an	and mind d less fire	or pool fill m.	ing. Obs	tructions	4	* * *		move with high flows causing bank cutting				move with high flows causing bank cutting		move with high flows causing bank cutting				Frequent obst cause bank er		ion ye	and deflectors arlong. Sedime ration occurring		8										
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at aw bank			6				" high. F ughing e		12																			Almost continuous cuts high. Failure of overhan		!"	16
	9	Deposition	n	Little or point ba		irgement	t of char	nnel or	4	Some r coarse		increase	, mostly	/ from	8		arse san		new gra I and so		12			Extensive deposit of predominantly fine particles. Accelerated bar development.			16																
_	10	Rock angularity		Sharp edges and corners. Plane surfaces rough.			е	1			rs and e	0		2	Corners dimens		lges we	l rounde	ed in 2	3	smooth.			nensions, surfac		4																	
_	11	Brightness	s	General	lly not b					surface	s.	may ha		6 bright	2	mixture	range.		i.e., 35-		3	Predominantly bright, > scoured surfaces.		, ,		4																	
E	12	Consolidati particles		overlapp	ping.	tightly pa			2	overlap	ping.	ked with			4	appare	nt overla	ар.	nt with n		6	easily moved.		•		t,	8																
Bottom	13	Bottom siz distributio		No size material	_	e evident 0%.	. Stable		4	50-80%	6.	t light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable		16																
_	14	Scouring a deposition		<5% of deposition		affected	by scou	ır or	6	constric	tions an	d. Scour nd where deposit	grades		12	at obstr		constri	ctions ar		18	More that			bottom in a stat rearlong.	e of	24																
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			city Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.		ater. Seasonal algae growth		ckwater. Seasonal algae growth		0 0		nostly in			sonal algae growth		asonal algae growth		3				e or absent. Yel m may be pres		4							
						Exc	ellent	total =	23				Good	total =	0				Fair	total =	30				Poor to	tal =	20																
Stream ty	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			ı																	
Good (Stable			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		67-98		Grand tota	I =	73																
Fair (Mod. ui Poor (Unstal	nstable	44-47 4			96-132 133+		81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+						108-132 133+		99-125		Existing stream typ	e =	E 6																
Stream ty	_		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential																		
Good (Stable	-		10-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107	90-112					stream typ	e =	E6																
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified		nel																
Poor (Unstal			87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability																		
			J.						LI CONTRACTOR OF THE PROPERTY					•			*Ra	ting is a	djusted t	to poten	tial strea	ım type, ı	not exist	ing.	Fa																		

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

CIOSIOII	iale.	rosion rate.								
			Estim	ating Nea	r-Bank St	ress (NB:	S)			
Stream:	Sheyer	nne River			Location:	Sheyenne	River - 6 -	35.82		
Station:	0			S	tream Type:	E6	1	/alley Type:	X	
Observe	rs:	KP, AL						Date:	11/21/10	
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)			
(1) Chanr	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Reconaissance		
(2) Ratio	of radius o	of curvature to b	ankfull width (I	R _c / W _{bkf})	Level II	General prediction				
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction	
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction	
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	d _{nb} / d _{bkf})		Level III	Detailed	prediction	
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction	
(7) Veloci	ty profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation	
_										
Levell	(1)									
			Bankfull	meanuer mig		girig now		INE	o = Extreme	
		Radius of Curvature	Width W _{bkf}	Ratio R _c /	Near-Bank Stress					
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)					
_					Near-Bank	•			•	
Level II	(3)	Pool Slope	Average	5 / 6 / 6	Stress			inant		
Le	(0)	S _p	Slope S	Ratio S _p / S	(NBS)	1		nk Stress		
							very	Low	ļ	
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank					
	(4)	S _p	S _{rif}	S _{rif}	Stress (NBS)					
		P								
		Near-Bank			Near-Bank	l				
	(5)	Max Depth	Mean Depth	<i>Ratio</i> d _{nb} /	Stress					
_	(3)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	1				
Level III				Mara Dani			David 4 ill		1	
eve.		Near-Bank		Near-Bank Shear			Bankfull Shear			
_	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank Stress	
	(0)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)	
>				Near-Bank						
Level IV	(7)	-	dient (ft/sec	Stress						
Lev	(- /	/ f	t)	(NBS)]					
				Very Low]					
			nverting Va	lues to a l	Near-Bank	Stress (NE	SS) Rating			
Near-B		ess (NBS)				ethod numb			1	
	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
	Very Lo		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	
	Modera		N/A See	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)	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 Hi	_	(1) Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40	
	Extren	IC	ADOVE	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40	
				Overall N	ear-Bank S	otress (NB	S) rating	Very	Low	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream: Sheyenne River - 6 - 35.82								
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	4858.9		Date:	11/21/2010	
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E6	
(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.	High	Very Low	0.165	4858.9	16.3	13068	0.13	
2.						0	#DIV/0!	
3.						0	#DIV/0!	
4.						0	#DIV/0!	
5.						0	#DIV/0!	
6.						0	#DIV/0!	
7.						0	#DIV/0!	
8.						0	#DIV/0!	
9.						0	#DIV/0!	
10.						0	#DIV/0!	
11.						0	#DIV/0!	
12.						0	#DIV/0!	
13.						0	#DIV/0!	
14.						0	#DIV/0!	
15.						0	#DIV/0!	
Sum erosior	n subtotals in Colu	umn (7) for ead	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	13068		
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	it ³ /yr) by 27}	Total Erosion (yds³/yr)	484			
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	629		
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.13		

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

Stream:	Sheyenne	River	St	ream Type:	E6			
Location:		River - 6 - 35.82	\	/alley Type:	Χ			
Observers:	KP, AL			Date:	11/21/2010			
Enter Req	uired Infor	mation for Existing Condition	1					
	D ₅₀	Riffle bed material D ₅₀ (mm)						
	D ₅₀	Bar sample D ₅₀ (mm)						
	D _{max}	Largest particle from bar sample	e (ft)		(mm)	304.8 mm/ft		
	s	Existing bankfull water surface s	slope (ft/ft)					
	d	Existing bankfull mean depth (ft))					
1.65	γ_{s}	Submerged specific weight of se	ediment					
Select the	Appropria	te Equation and Calculate Cr	itical Dimensio	nless She	ar Stress			
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7 Use	EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}		
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use	EQUATION 2:	$\tau^* = 0.038$	4 (D _{max} /D ₅	₀) ^{-0.887}		
#DIV/0!	τ*	Bankfull Dimensionless Shear S	tress	EQUATIO	ON USED:	#DIV/0!		
Calculate	Bankfull Me	an Depth Required for Entrain	ment of Largest	Particle in	Bar Sampl	е		
#DIV/0!	d	Required bankfull mean depth (f	$d = \frac{\tau}{\tau}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)		
	Check:	☐ Stable ☐ Aggrading ☐						
Calculate Sample	Bankfull W	ater Surface Slope Required	for Entrainmen	t of Large	st Particle	in Bar		
#DIV/0!	s	Required bankfull water surface	slope (ft/ft) S =	$= \frac{\tau * \gamma_s D}{d}$) _{max} (use	D _{max} in ft)		
	Check:	☐ Stable ☐ Aggrading ☐	Degrading					
Sediment	Competen	ce Using Dimensional Shear	Stress					
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (subs	titute hydraulic rad	lius, R, with	mean depth,	d)		
	$\gamma = 62.4, c$	d = existing depth, S = existing slop	oe					
	Predicted	largest moveable particle size (mm	n) at bankfull shea	r stress τ (F	igure 3-11)			
	Predicted	shear stress required to initiate mo	ovement of measu	red D _{max} (m	m) (Figure 3	-11)		
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{vs}$							
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, S = exist slope required to initiate movement	t of measured D _m	_{ax} (mm)	$S = \frac{T}{2d}$	· •		
	τ = predic	ted shear stress, γ = 62.4, d = exis	sting depth		γ d			

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S u	Strea	m:	Sheye	nne R	iver				Location: Sheyenne River - 6 - 35.82							KP, A			Date: 11/21/2010		
b		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow		\Rightarrow			
s a m		h Pan CKET	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm			
p I	Tare v	veight	Tare	veight	Tare	weight	Tare	weight	Tare v	weight	Tare v	veight	Tare v	veight	Tare v	weight	Tare v	weight		SURFAC ATERIA	
e s	Sample	_	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two	DATA largest pa	articles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No	. Dia.	WT.
2																			1	+	1
3																			2		
4																			Bucket +		
5																			materials weight		
6																					
7 8																			Bucket tare weight		
9																			Materials		
10																			weight		0
11																			Materials les than:	S	
13																				5	mm
14																				Be sure to separate	material
15																				weights to total	grand
Net wt.	total	0		0		0		0		0		0		0		0		0	0	_	
% Gra	nd total	#####		#####		#####		#####		#####		#####		#####		#####		#####		V	
Accum	. % =<	#####		#####	\Rightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####		#####	\Longrightarrow	#####		100%	G	RAND TO	OTAL
				I							ı										
Sa	ample lo	cation no	otes				Sar	nple loc	ation ske	etch											

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

Stream:	Sheyenne River	Stream Type: E6
Location:	Sheyenne River - 6 - 35.82	Valley Type: X
Observers:	KP, AL	Date: 11/21/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E6	
Location: Sheyenne River	- 6 - 35.82		Valley Ty	_{/pe:} X	
Observers: KP, AL			D	ate: 11/21/2010	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
,	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Riv	ver - 6 - 35.82		Valley Type:	Х						
Observers: KP, AL			Date:	11/21/2010						
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected					
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	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)						
Sediment capacity (POWERSED)	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)						
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2					
	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheet 3- 16)	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)						
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1					
3-5)	(1)	(2)	(3)	(4)						
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1					
	(1)	(2)	(3)	(4)						
				Total points	10					
	Vertical stal		int range for exces adation	ss deposition /						
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 3-19. Vertical stability prediction for channel incision or degradation.

Str	Stream: Sheyenne River Stream Type: E6									
Lo	cation: Sheyenne Riv	ver - 6 - 35.82		Valley Type:	X					
Ob	oservers: KP, AL			Date:	11/21/2010					
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected				
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)				
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2				
		(2)	(4)	(6)	(8)					
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2				
		(2)	(4)	(6)	(8)					
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	6				
	(WOIRSHEEL 3-1)	(2)	(4)	(6)	(8)					
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4				
		(2)	(4)	(6)	(8)					
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1				
	3-9)	(1)	(2)	(3)	(4)					
					Total points	15				
		Vertical stab		nt range for char dation	nel incision /					
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Rive	r - 6 - 35.82		Valley Type:	X						
Observers: KP, AL			Date:	11/21/2010						
Channel enlargement	Char	Channel Enlargement Prediction Categories								
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	Selected points (from each row)					
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2					
	(2)	(4)	(6)	(8)						
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4					
	(2)	(4)	(6)	(8)						
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2					
(Worksheet 3-18)	(2)	(4)	(6)	(8)						
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4					
(Worksheet o 15)	(2)	(4)	(6)	(8)						
	Total points									
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Sheyenne River			Stream Type:	E6			
Lo	cation: Sheyenne River	- 6 - 35.82		Valley Type:	X			
Ob	servers: KP, AL			Date:	11/21/2010			
p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points			
		Stable		1				
1	Lateral stability	Mod. unstab	ole	2	2			
'	(Worksheet 3-17)	Unstable		3	Z			
		Highly unsta	able	4				
	Vertical stability	No deposition	on	1				
2	excess deposition/	Mod. deposi	ition	2	1			
-	aggradation	Excess depo	osition	3	1			
	(Worksheet 3-18)	Aggradation	1	4				
	Vertical stability	Not incised		1				
3	channel incision/	Slightly inci	sed	2	2			
ľ	degradation	Mod. Incised	d	3	2			
	(Worksheet 3-19)	Degradation	1	4				
	Channal anlargament	No increase		1				
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2			
~	3-20)	Mod. increas	se	3	2			
	3-20)	Extensive		4				
	Pfankuch channel	Good: stable	e	1				
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2			
ľ	10)				_			
	10)	Poor: unsta	ble	4				
				Total Points	9			
Category point range								
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □			

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Riv	ver - 6 - 35.8	32
Observers:	KP, AL	Date:	11/21/2010	Stream	Туре: Е6	Valle	y Type: X
Channel Dimension	Mean bankfull 7.9	Mean bankfull 72 width (ft):	.02 Cross-section area (ft²):	n 568.9	Width of flood- prone area (ft):	810.75	Entrenchment ratio: 11.3
Channel Pattern	Mean: Range: MWR:	13.0 Lm/W _b		Rc/\	W _{bkf} :	3.1	Sinuosity: 1.78
	Check: Riffle/pool		Plane bed	Convergen	nce/divergence	✓ Dunes/	antidunes/smooth bed
River Profile and Bed Features	Max Riffle	Pool Depth r	Riffle	Pool	Pool to Rati	o	Slope
	bankfull depth (ft): 11.6	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull: 0.000
	Tapanan	nt composition/density:	Potential compos	ition/density:	Remarks	s: Condition, vig	or and/or usage of existing reach:
	vegetation						
	Flow P1, 2, Stream regime: 7, 9 and on	3-n	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.4 Degree of stability rat			Modified Pfank (numeric and a	•	ĕ ⊨air
	Width/depth 9.1 ratio (W/d):	Reference W/d ratio (W/d _{ref}):	8.7 Width/dep (W/d) / (W	th ratio state /d _{ref}):	^e 1.0		tio state y rating: Stable
	Meander Width Ratio (MWR):	13.0 Reference MWR _{ref} :	Degree of (MWR / M	confinemen WR _{ref}):	^{nt} 1.0		MWR _{ref} Unconfined varing:
Bank Erosion Summary	Length of reach studied (ft):	359 	mbank erosion rate s/yr) 0.13 (to	ns/yr/ft)	Curve used: Fig 3-9	Remarks:	
Sediment Capacity (POWERSED)	☐ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	s:	
Entrainment/ Competence	Largest particle from bar sample (mm):	0 τ= 0	ο τ*= ####	Existing depth _{bkf} :	Required depth _{bkf} :		sting Required pe _{bkf} : slope _{bkf} :
Successional Stage Shift	→ –	→	→	→	Existing stre		Potential stream state (type):
Lateral Stability	☐ Stable 	Mod. unstable ☐	Unstable	☐ Highly	y unstable	temarks/cause	S: None
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	emarks/cause	s: None
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degra	adation	emarks/cause	s: None
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exten	nsive	temarks/cause	S: None
Sediment Supply (Channel Source)	□ Low □	Moderate	High Very h	igh	ks/causes:	lone	

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

Riparian Vegetation								
Stre	eam: Sheye	enne River		Location: Sheyenne River - 7 - 43.27				
Observers: KD, JB		Reference reach	Disturbed (impacted reach) X Date:	11/20/2010				
spe	Existing species trees, small shrubs, cocklebur composition: bushes, grass			Potential species trees, small shrubs, cocklebur composition: bushes, grass				
•			Percent of site coverage**	Species composition	Percent of total species composition			
1. Overstory	Canopy layer	5% without leaves, 70% with leaves	1%	trees	100%			
					100%			
2. Understory Shrup layer		5%	small shrubs cockleburs	95% 5%				
					100%			
level	Herbaceous		2%	grass	100%			
3. Ground level	Leaf or needle litter		1%	Remarks: Condition, vigor and/or usage of existing reach:				
	Bare ground		91%	None				
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%					

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

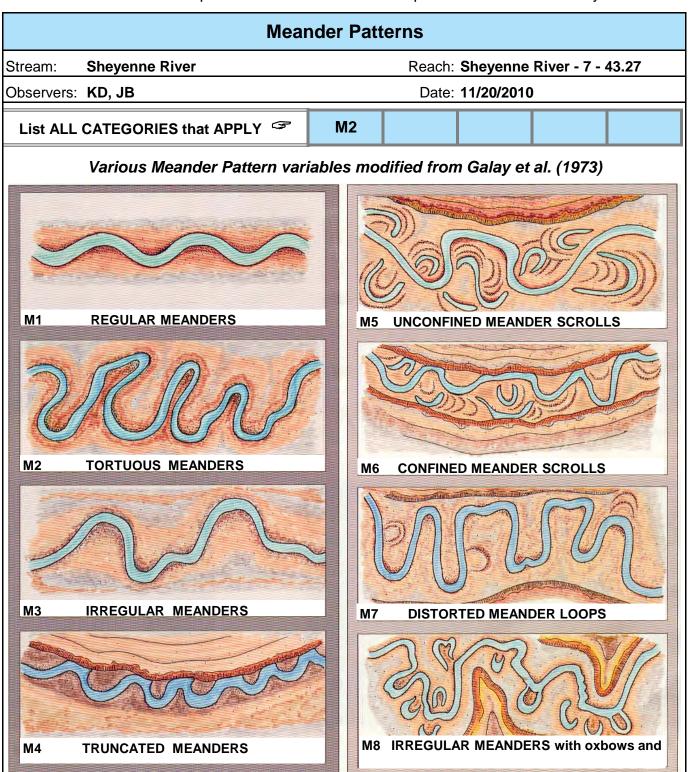
nological interpretations.									
FLOW REGIME									
Stream:	Sheyenne River - 7 - 43.27								
Observers:	Date: 11/20/2010								10
	List ALL COMBINATIONS that P1 P2 P7 P9								
APF	APPLYG								
General C	General Category								
E	Ephemeral stream channels: Flows only in response to precipitation								
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface 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.								
Р	Perennial stream channels: Surface water persists yearlong.								
Specific Category									
1	Seasonal variation in streamflow dominated primarily by snowmelt runoff.								
2	Seasonal variation in streamflow dominated primarily by stormflow runoff.								
3	Uniform stage and associated streamflow due to spring-fed condition, backwater, etc.								
4	Streamflow regulated by glacial melt.								
5	Ice flows/ice torrents from ice dam breaches.								
6	Alternating flow/backwater due to tidal influence.								
7	Regulated streamflow due to diversions, dam release, dewatering, etc.								
8	Altered due to development, such as urban streams, cut-over watersheds or vegetation conversions (forested to grassland) that change flow response to precipitation events.								
9	Rain-on-snow generated runoff.								

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

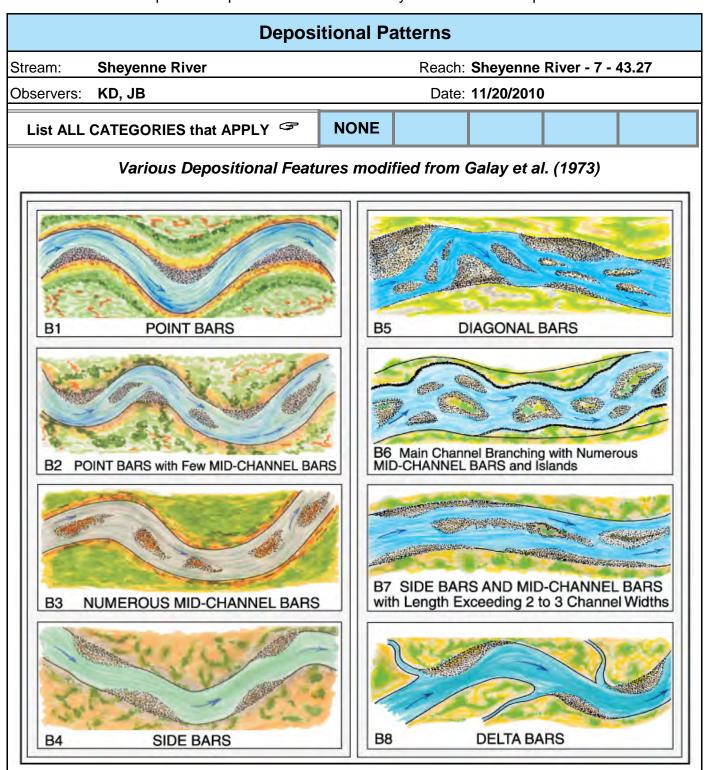
Stream Size and Order							
Stream: Sheyenne River							
Location: Sheyenne River - 7 - 43.27							
Observers: KD, JB							
Date:	11/20/2010						
Stream Size Category and Order S-7							
Category	STREAM SIZE: Bankfull width		Check (✓) appropriate				
	meters	feet	category				
S-1	0.305	<1					
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							

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

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



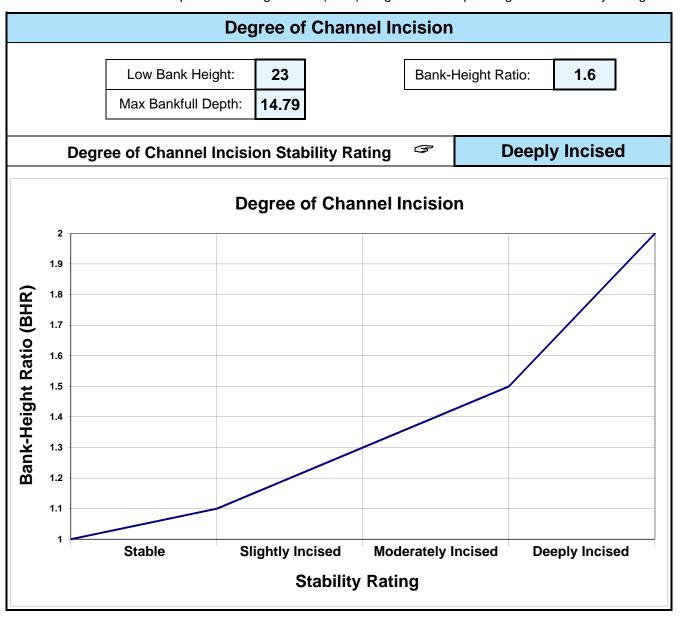
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



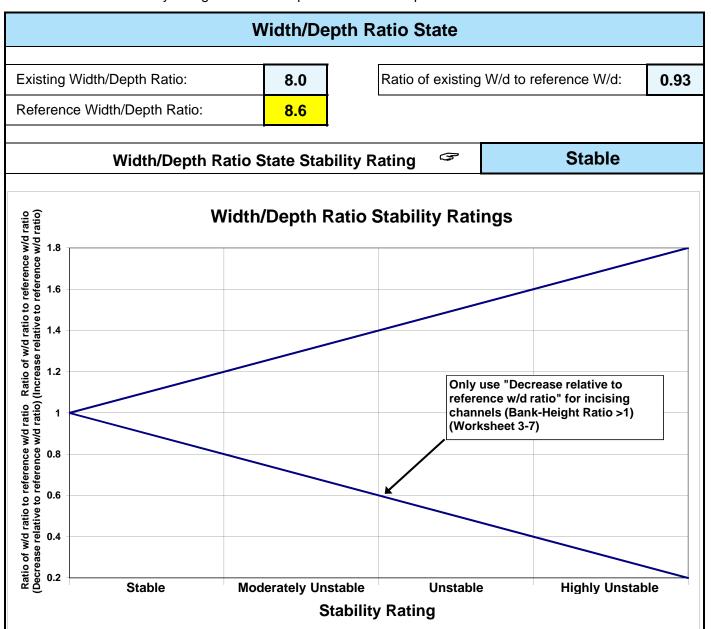
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages								
Stream	m: Sheyenne I	River Location: Sheyenne River - 7 - 43.27							
Obse	rvers: KD, JB	Date: 11/20/2010							
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply						
D1	None	Minor amounts of small, floatable material.							
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	~						
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.							
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.							
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.							
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.							
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.							
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.							
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.							
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.							

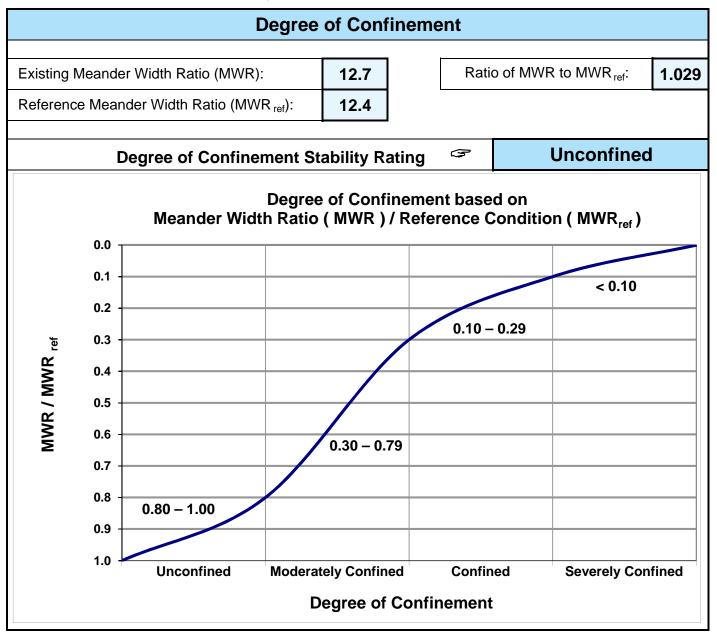
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



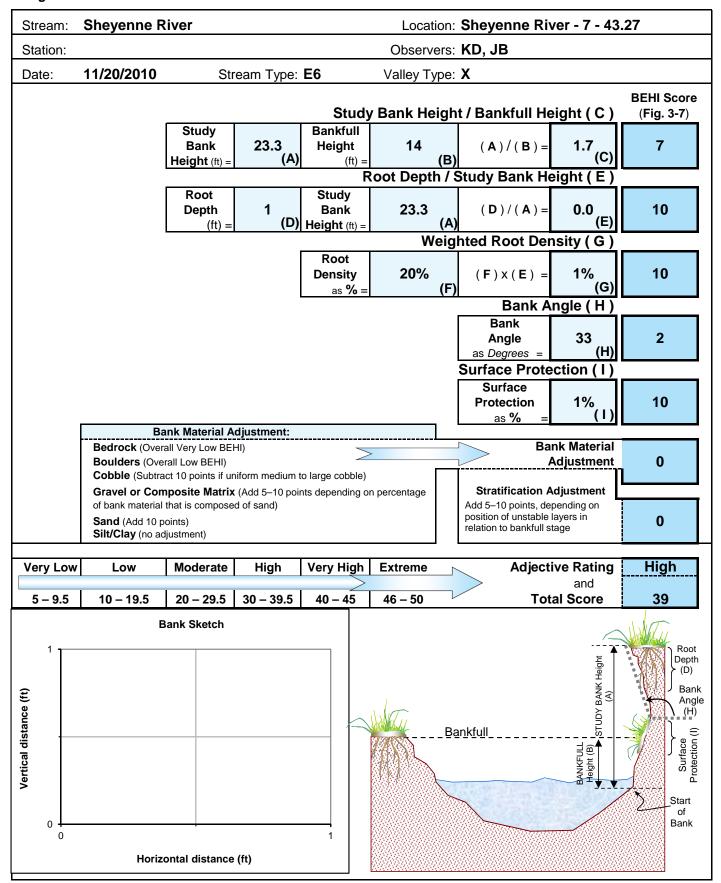
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Shey	enne l	River	,			Loc	ation:	Shey	enne l	River	- 7 - 4		Valley	Type:	Χ		Obse	ervers:	KD,	JB				Date: 11/20	2010	,		
Loca-	Key	Categ	lorv.			Exce	llent					Go	od					Fa	air						Poor				
tion	Rey	Caleg	JOI y			Descriptio	n		Rating		D	Description	n		Rating		[Description	on		Rating			Descri	ption	R	Rating		
"	1	Landform slope	n	Bank sle	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slope gradient >		60%.		8			
Upper banks	2	Mass ero	osion	No evid erosion		past or	future m	nass	3	Infreque future p		stly heale	ed over.	Low	6		nt or lar	-	sing sed	iment	9				sing sediment ne t danger of same		12		
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	izes.		ounts, m		6	predominantly larger size		izes.		8			
)	4	Vegetative bank protection			t a deep	nsity. Vi			3		or sugge	y. Fewer est less			6	fewer s		rom a sl		ınd	9		dicating	poor, c	er species and le discontinuous and		12		
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/de width/dep (BHR) = 1	oth ratio	3	common w	vith flows I rture from	ess than reference	ed; over-bank flows a bankfull. Width/depth e width/depth ratio > 1.3.		4		
nks	6	Bank rock content 12"+ common. 2 40–65%. Mostly boulders and small cobbles 6–12". 4 20–40%. Most in the 3–6" diameter class. Rocks and logs firmly imbedded. Flow Some present causing erosive cross Moderately frequent, unstable obstructions		6	or less.			of gravel sizes, 1	-3"	8																			
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly ir ting or d					and mind	or pool fill			4		th high flo		able obst sing bank		6	cause b	ank eros	sion ye	and deflectors earlong. Sediment ration occurring.	t	8		
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4	-		ently at o aw bank			6	U			l" high. I ughing (12				s, some over 24" ings frequent.		16		
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba	arse san		new gra		12			Extensive deposit of predominantly fine particles. Accelerated bar development.					16
	10	Rock angularity		Sharp e surface:		nd corne	rs. Plan	е	1			rs and e th and fla	-		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.		all dim	nensions, surface	s	4		
	11	Brightnes	ss	Surface Genera	,	dark or s right.	tained.		1	surface	3.	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predom scoured	,	0 ,	> 65%, exposed	or	4		
E	12	Consolidate particles		Assorte overlap		tightly p	acked o	r	2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	10	6	No packing evident. Loose easily moved.		oose assortment,		8			
Bottom	13	Bottom s distribution		No size materia	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable		16		
_	14	Scouring depositio		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr		constri			18				bottom in a state earlong.	of	24		
	15	Aquatic vegetatio			•	th moss I. In swif			1			e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yello m may be prese		4		
						Exc	ellent	total =	19				Good	total =	14				Fair	total =	27				Poor tot	al =	12		
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	В5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6						
Good (Stabl	le)	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		Grand total	=	72		
Fair (Mod. u Poor (Unsta	ble)	48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110	91-110	106+	133+	108-132	108-132 133+	99-125 126+		Existing stream type	=	E6		
Stream ty	_		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential		E6		
Good (Stabl			40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107							stream type		ol.		
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified o				
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+ ting is a	121+ diusted	126+ to poter	121+ itial strea	ım type	not exis	sting	stability r Fai		-		
																	ita	y 15 d	ajastou	to poter	11141 31160	type,	TIOL CAIS	ıg.	Га				

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	erosion rate.												
				Estim	ating Nea	r-Bank St	ress (NB	S)					
Stı	ream:	Sheye	nne River			Location:	Sheyenne	River - 7 -	43.27				
Sta	ation:	0			S	tream Type:	E6	\	/alley Type:	Χ			
Ob	serve	rs:	KD, JB						Date:	11/20/10			
				Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1)	Chanr	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Reconaissance				
(2)	Ratio	of radius c	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General prediction				
(3)	Ratio	of pool slo	pe to average v	water surface sl	ope (S _p / S)			Level II	General	orediction			
(4)	Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	orediction			
(5)	Ratio	of near-ba	nk maximum d	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6)	Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	τ _{bkf})		Level III	Detailed	prediction			
(7)	Veloci	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation			
	=								-				
	Level	(1)				,							
					meander mig		ging flow		NE	35 = Extreme			
			Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
		(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)							
				` '									
	_					Near-Bank							
	<u>e</u>	(3)	Pool Slope	Average		Stress			inant				
	Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)		Near-Bank Stress					
	_							Very	Low				
			D 101	D.(1)	D-#- 0 /	Near-Bank							
		(4)	Pool Slope S _p	Riffle Slope S _{rif}	Ratio S _p / S _{rif}	Stress (NBS)							
		. ,	O _p	O _{rif}	O _{rif}	(NDS)							
			Near-Bank			Near-Bank							
		(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress							
		(5)	d _{nb} (ft)	d _{bkf} (ft)	d_{bkf}	(NBS)							
	=												
	Level III				Near-Bank Shear			Bankfull Shear					
	Ľ	(C)	Near-Bank Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	A.,	Stress τ _{bkf} (Ratio τ _{nb} /	Near-Bank			
		(6)	d _{nb} (ft)	Slope S _{nb}	Ib/ft ²)	d _{bkf} (ft)	Average Slope S	Ib/ft ²)	$\tau_{\rm bkf}$	Stress (NBS)			
			- 110 (-7)	· III	15/10	DKI (**)	0.000	15/10	- DKI	(11,50)			
					Near-Bank								
	Level IV	/ 7 \	Velocity Grad	dient (ft/sec	Stress								
	ě	(7)	/ f	t)	(NBS)	1							
	_				Very Low]							
			Cor	nverting Va	lues to a l	lear-Bank	Stress (NE	SS) Rating					
N	lear-B		ess (NBS)			Me	ethod numb	er					
		rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)			
_		Very Lo		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			
\vdash		Modera		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 Hi	gn	(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			
\vdash		Even-	20	Abovo	. 4 = 0	. 4 ^^	. 4 00		. 4 00	. 0.40			
		Extren	ne	Above	< 1.50	> 1.00 ear-Bank \$	> 1.20	> 3.00	> 1.60	> 2.40 Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne Rive	r		Location:	ocation: Sheyenne River - 7 - 43.27					
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	7463		Date:	11/20/2010			
Observers:	KD, JB		Valley Type:			Stream Type:				
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	7463	23.3	28692	0.2			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosion	n subtotals in Colu	ımn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	28692				
Convert eros	sion in ft ³ /yr to yd:	s ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	1063					
Convert eros by 1.3}	sion in yds ³ /yr to t	ons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	1381				
	osion per unit leng total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.2				

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

Stream:	Sheyenne	River	Stream ⁻	Туре: Е6				
Location:	Sheyenne	River - 7 - 43.27	Valley ⁻	Туре: Х				
Observers:	KD, JB			Date: 11/20/201	0			
Enter Req	uired Infor	mation for Existing Condition						
	D ₅₀	Riffle bed material D ₅₀ (mm)						
	D ₅₀	Bar sample D ₅₀ (mm)						
	D _{max}	Largest particle from bar sample (ft)		(mm)	304.8 mm/ft			
	S	Existing bankfull water surface slope	e (ft/ft)					
	d	Existing bankfull mean depth (ft)						
1.65	γ_s	Submerged specific weight of sedim	ent					
Select the	Appropria	te Equation and Calculate Critica	al Dimensionless	Shear Stress				
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 Use EC	UATION 1: $\tau^* = 0$).0834 (D ₅₀ /C) ^) ^{-0.872}			
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use EQ	UATION 2: $\tau^* = 0$	0.0384 (D _{max} /D	₅₀) ^{-0.887}			
#DIV/0!	τ*	Bankfull Dimensionless Shear Stres	s EQI	JATION USED:	#DIV/0!			
Calculate	Bankfull Me	an Depth Required for Entrainmer	nt of Largest Parti	cle in Bar Samp	le			
#DIV/0!	d	Required bankfull mean depth (ft)	$d = \frac{\tau * \gamma_s r}{s}$	D max (use	e D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading ☐ De						
Calculate Sample	Bankfull W	ater Surface Slope Required for	Entrainment of L	argest Particle	in Bar			
#DIV/0!	s	Required bankfull water surface slop	be (ft/ft) $S = \frac{\tau^*}{}$	$\frac{\gamma_s \mathbf{D}_{max}}{\mathbf{d}}$ (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading ☐ De	grading	<u> </u>				
Sediment	Competen	ce Using Dimensional Shear Stre	ess					
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (substitute	e hydraulic radius, R	, with mean depth	n, d)			
	$\gamma = 62.4$, o	d = existing depth, S = existing slope						
	Predicted	largest moveable particle size (mm) at	bankfull shear stres	s τ (Figure 3-11)				
Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)								
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{vS}$							
#DIV/0!	$τ$ = predicted shear stress, $γ$ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{τ}{m}$							
	$\tau = \text{predic}$	ted shear stress, γ = 62.4, d = existing	depth	γd				

Worksheet 3-15. Bar sample data collection and sieve analysis form.

Su	Strea	ım:	Sheye	nne R	iver				Loca	tion:	Sheye	nne R	River -		ervers:				Date: 11/20/2010		
b		⇒(⇒(⇒(⇒(\Rightarrow		⇒(⇒(⇒(⇒(
s a m		h Pan CKET	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm			
p I	Tare	weight	Tare	weight	Tare	weight	Tare v	weight	Tare v	weight	Tare v	veight	Tare	veight	Tare v	weight	Tare	weight		SURFAC ATERIA	
e s	Sample		Sample		Sample	_	Sample		Sample		Sample		Sample		Sample		Sample		(Two	DATA largest pa	articles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No	. Dia.	WT.
2																			1	_	****
3																			2	_	
4																			Bucket +		
5																			materials		
6																			weight		
7 8																			Bucket tare weight		
9																			Materials		
10																			weight		0
11 12																			Materials les than:	S	
13																				Be sure to	mm
14																				separate i	material
15																				weights to total	grana
Net wt.	. total	0		0		0		0		0		0		0		0		0	0	_	
	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		~	
Accum	1. % =<	#####	\Longrightarrow	#####	\Rightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####	\Longrightarrow	#####	\Longrightarrow	100%	G	RAND TO	OTAL
											l .										
Sa	ample lo	cation no	otes				Sar	nple loca	ation ske	etch											

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

Stream:	Sheyenne River	Stream Type: E6
Location:	Sheyenne River - 7 - 43.27	Valley Type: X
Observers:	KD, JB	Date: 11/20/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E6	
Location: Sheyenne River	- 7 - 43.27		Valley Ty	_{/pe:} X	
Observers: KD, JB			D	ate: 11/20/2010	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
,	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
,	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Riv	er - 7 - 43.27		Valley Type:	X						
Observers: KD, JB			Date:	11/20/2010						
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected					
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	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)						
Sediment capacity (POWERSED)	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)						
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2					
	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheet 3- 16)	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)						
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1					
3-5)	(1)	(2)	(3)	(4)						
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1					
	(1)	(2)	(3)	(4)						
				Total points	10					
	Vertical stat		int range for exces	s deposition /						
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Ri	ver - 7 - 43.27		Valley Type:	X						
Observers: KD, JB			Date:	11/20/2010						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected					
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
	(2)	(4)	(6)	(8)						
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
	(2)	(4)	(6)	(8)						
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8					
(WOIKSHEEL 3-1)	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
·	(2)	(4)	(6)	(8)						
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
3-9)	(1)	(2)	(3)	(4)						
				Total points	17					
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 3-20. Channel enlargement prediction summary.

Stream: Sheyenne River Stream Type: E6										
Location: Sheyenne Rive	r - 7 - 43.27		Valley Type:	X						
Observers: KD, JB			Date:	11/20/2010						
Channel enlargement	Char	Selected								
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)					
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2					
	(2)	(4)	(6)	(8)						
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4					
	(2)	(4)	(6)	(8)						
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2					
(Worksheet 3-18)	(2)	(4)	(6)	(8)						
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4					
(Worksheet 3-13)	(2)	(4)	(6)	(8)						
				Total points	12					
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Sheyenne River			Stream Type:	E6
Lo	cation: Sheyenne River	- 7 - 43.27		Valley Type:	Х
Ob	servers: KD, JB			Date:	11/20/2010
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	2
Ι'	(Worksheet 3-17)	Unstable		3	2
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. deposi		2	1
-	aggradation	Excess depo	osition	3	•
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci		2	2
ľ	degradation	Mod. Incised	d	3	2
	(Worksheet 3-19)	Degradation	1	4	
	Channel enlargement	No increase		1	
4	prediction (Worksheet	Slight increa	ase	2	2
	3-20)	Mod. increas	se	3	_
	C = 0,	Extensive		4	
	Pfankuch channel	Good: stable		1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				_
	. • /	Poor: unsta	ble	4	
				Total Points	9
			Category p	ooint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	Sheyenne Riv	ver - 7 - 43.2	27	
Observers:	KD, JB	Date:	11/20/2010	Stream	n Type: E6	Valle	у Туре: X	
Channel Dimension	Mean bankfull depth (ft):	Mean bankfull width (ft):	Cross-section area (ft ²):	n 819.7	Width of flood- prone area (ft):	903.6667	Entrenchment 11.	.2
Channel Pattern	Mean: Range: MWR:	12.7 Lm/W _b		Rc/	/W _{bkf} :	2.7	Sinuosity: 1.82	
	Check: Riffle/pool		Plane bed		nce/divergence	✓ Dunes/	antidunes/smooth bed	
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	io	Slope	
Features	bankfull depth (ft):	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull:	0015
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existing reach	า:
	vegetation							
	Flow P1, 2, Streat regime: 7, 9 and o	rder:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	2
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.6 Degree of stability rat	ting:	y Incised	Modified Pfank (numeric and a	djective rating	g):	
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	8.6 Width/dep (W/d) / (W	th ratio sta /d _{ref}):	te 0. 9		tio state y rating: Stable	
	Meander Width Ratio (MWR):	12.7 Reference MWR _{ref} :	Degree of (MWR / M	confineme WR _{ref}):	nt 1.0		MWR _{ref} Unconfine y rating:	ed
Bank Erosion Summary	Length of reach 54 studied (ft):	463	mbank erosion rate	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	√ □ Insufficient cap	acity \square Excess	s capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		sting Required slope _{bkf} : slope _{bkf} :	
Successional Stage Shift	→ -	→	→	→	Existing stre state (type)		Potential stream state (type):	E 6
Lateral Stability	☐ Stable ■	✓ Mod. unstable 「	Unstable	☐ High	ly unstable	Remarks/cause	S: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	demarks/cause	s: None	
Vertical Stability (Degradation)	☐ Not incised ■	Slightly incised	Mod. incised	□ Degr	adation	demarks/cause	s: None	
Channel Enlargement	☐ No increase ■	Slight increase	☐ Mod. increase	□ Exte	nsive	temarks/cause	S: None	
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very h	igh	ks/causes:	lone		

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

	Riparian Vegetation											
Stre	eam: Sheye	enne River		Location:	She	yenne Rive	r-8-55.75					
	servers: KP, A		Reference reach	Disturbed (impacted reach)	x		10/2/2011					
spe	sting cies nposition:			Potential species composition:								
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species	comp	osition	Percent of total species composition					
1. Overstory	Canopy layer	25%	3%									
							100%					
2. Understory	Shrub layer		38%									
		Annum					100%					
level	Herbaceous		7%									
3. Ground leve	Leaf or needle litter		2%	Remarks: Condition, vigo usage of existir			100%					
	Bare ground		50%									
	ed on crown closure. sed on basal area to	surface area.	Column total = 100%									

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

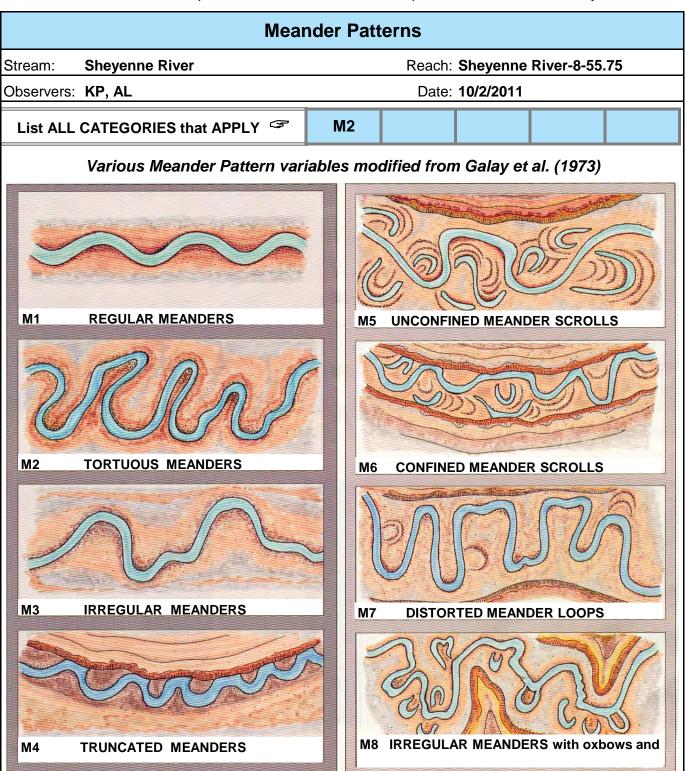
	FLOW REGIME												
Stream:	Sheyenne River		Location:	Sheyenr	e River-8	3-55.75							
Observers:	KP, AL						Date:	10/2/201	1				
List ALL	COMBINATIONS that	P1	P2	P7	P9								
APF	APPLY												
General C	eneral Category												
E	E Ephemeral stream channels: Flows only in response to precipitation												
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.												
I	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	geology wl	here				
Р	Perennial stream channels: Surface water persists yearlong.												
Specific C	Category												
1	Seasonal variation in st	treamflow	dominate	d primarily	y by snow	melt runo	ff.						
2	Seasonal variation in st	treamflow	dominate	d primarily	y by storm	nflow runc	off.						
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ndition, b	ackwater	, etc.					
4	Streamflow regulated b	y glacial ı	melt.										
5	Ice flows/ice torrents fro	om ice da	m breache	es.									
6	Alternating flow/backwa	ater due to	o tidal influ	ence.									
7	Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ring, 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 generate	ed runoff.											

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

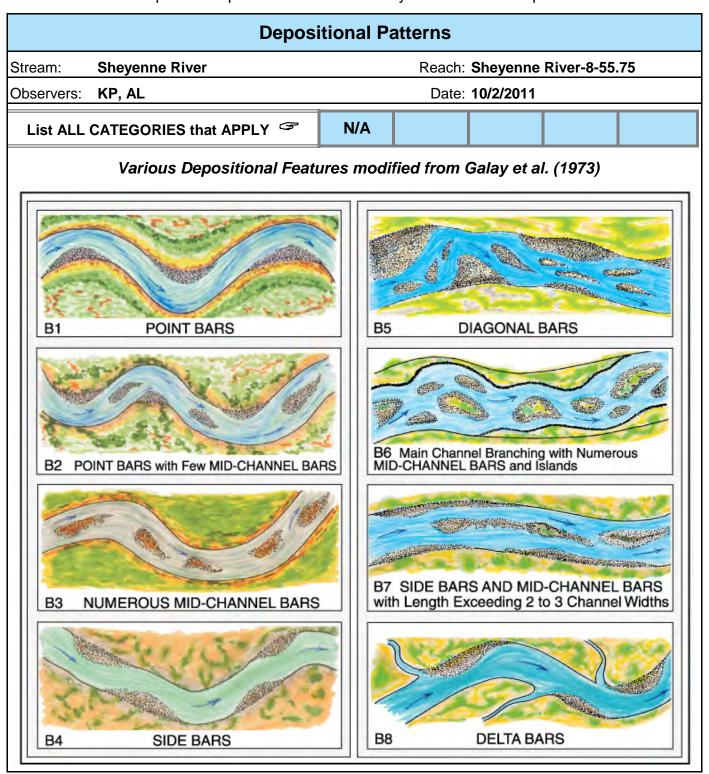
Stream Size and Order										
Stream:	Sheyenne Rive	er								
Location:	Sheyenne Rive	er-8-55.75								
Observers:	KP, AL									
Date:	10/2/2011									
Stream Size Category and Order 🤝 S-6										
Category STREAM SIZE: Bankfull Check (✓) width appropriate										
	meters	feet	category							
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 categoria	as in naranthasis	for enacific etras	m order of							

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

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



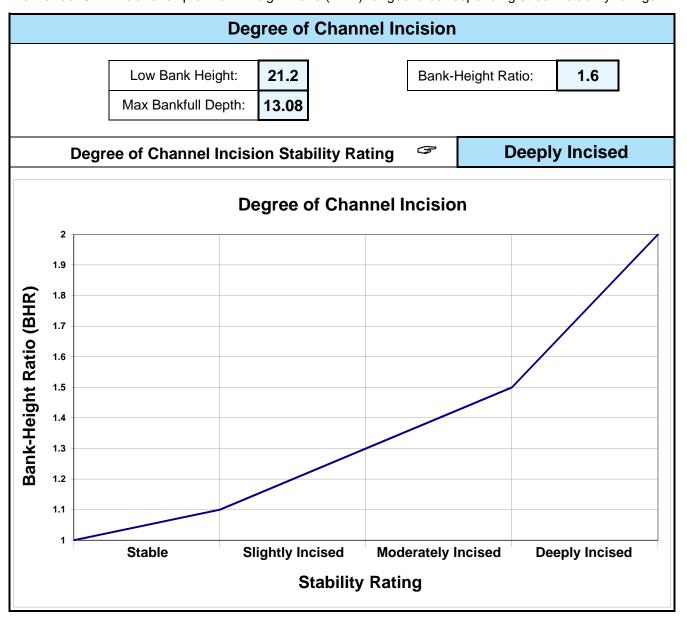
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



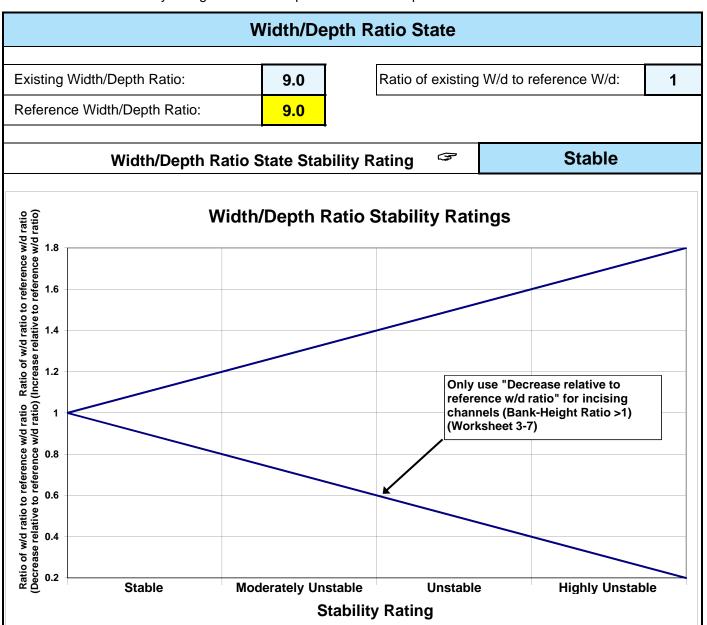
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strea	m: Sheyenne I	River Location: Sheyenne River-8-55.75	
Obsei	rvers: KP, AL	Date: 10/2/2011	
Desc	ription/extent	Materials that upon placement into the active channel or flood- prone area may cause adjustments in channel dimensions or conditions due to influences on the existing flow regime.	Check (√) all that apply
D1	None	Minor amounts of small, floatable material.	
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	~
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

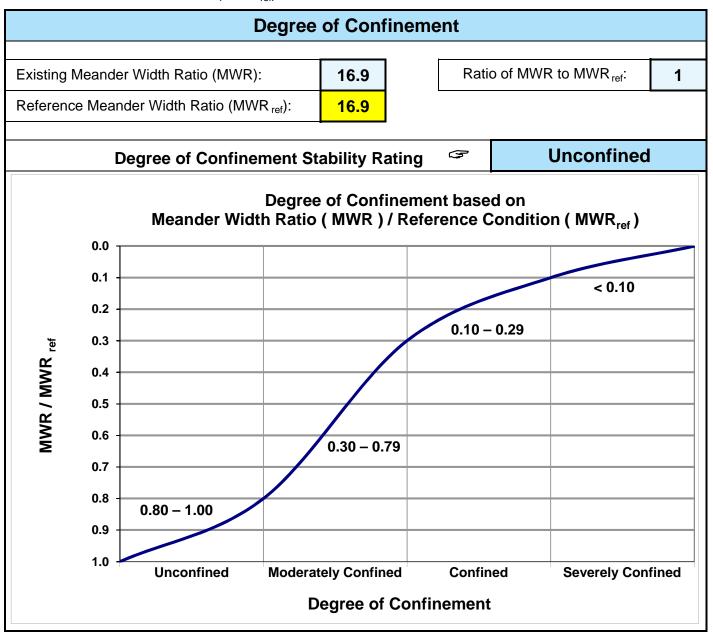
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



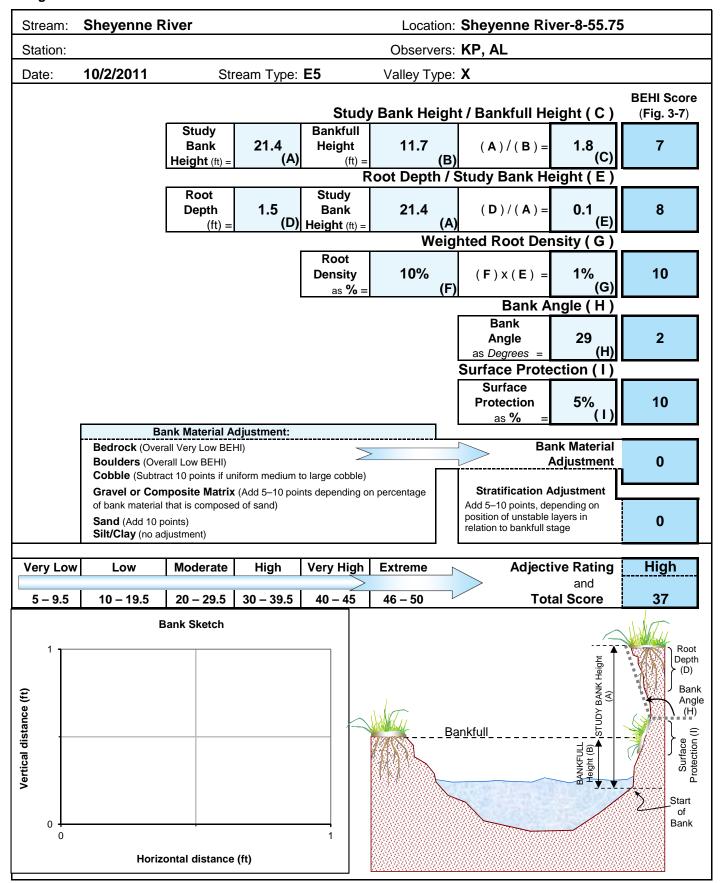
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream: Sheyenne River Location: Sheyenne River-8-55.7 Valley Type: X Observers: KP, AL								۸L				Date: 10/2/20	11													
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air		_				Poor	
tion	Rey	Calego	Ory			Descriptio	n		Rating		D	Description	n		Rating		[Description	n		Rating			Descri	ption	Rating
6	1	Landform slope	l	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradi	ient >	60%.	8
banks	2	Mass eros	SION	No evide erosion.		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg	•	ing sedi	iment	9				sing sediment nea danger of same.	rly 12
Upper	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	sizes.	-	ounts, m	-	6	Moderate predomin	nantly la	rger s	izes.	8
O	4	Vegetative bank protection			a deep	nsity. Vi , dense			3		or sugg	y. Fewer est less			6	fewer s		rom a sl		nd	9		icating p	oor, c	er species and les liscontinuous and	12
	5	Channel capacity		stage. Wic	dth/depth i width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/dep width/dep (BHR) = 1	oth ratio	3	common w	th flows le ure from re	ss than eferenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4 .3.	ı. 4
nks	6	Bank rock content		12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	all 4		6. Most	in the 3-	-6" diam	neter	6	<20% rock fragments or less.				8" 8
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly in			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	Frequent obstructions a cause bank erosion yea traps full, channel migra			arlong. Sediment	8
Low	8	Cutting		Little or <6".	none. Ii	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	_			" high. F ughing e		12				s, some over 24" ngs frequent.	16
	9	Depositio	n	Little or point ba		irgement	t of char	nel or	4	Some n		increase	, mostly	/ from	8	and coa	arse san	d on old	new gra I and so	me	12				redominantly fine bar development.	16
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e	U		2	Corners dimens		lges we	l rounde	ed in 2	3	Well roui smooth.	nded in a	all dim	nensions, surfaces	4
	11	Brightnes		Surface General		lark or st right.	tained.		1	Mostly of surface		may hav	ve <35%	6 bright	2	Mixture mixture		d bright,	i.e., 35-	35–65% 3		Predomi scoured			> 65%, exposed or	4
E	12	Consolidati particles		overlapp	ping.	tightly pa			2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	0	6	No packing evident. Loo easily moved.		oose assortment,	8	
Bottom	13	Bottom si: distributio		No size material	•	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable	16
	14	Scouring deposition		<5% of deposition		affected	by scou	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18	More tha flux or ch			bottom in a state o	f 24
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				e or absent. Yellow m may be present	/
	•		•			Exc	ellent	total =	19				Good	total =	8				Fair	total =	12				Poor total	= 52
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	В5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stabl			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		67-98		Grand total =	91
Fair (Mod. u	ınstable	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		Existing	E5
Poor (Unsta			48+ DA4	130+ DA5	133+ DA6	143+ E3	111+ E4	59+ E5	59+ E6	79+ F1	85+ F2	89+ F3	79+ F4	62+ F5	62+ F6	106+ G1	111+ G2	111+ G3	106+ G4	133+ G5	133+ G6	133+	126+		stream type = *Potential	
Stream ty Good (Stabl	-		40-63	40-63	40-63	40-63	E4 50-75	50-75	40-63	60-85	60-85	F3 85-110	85-110		80-95	40-60	40-60	85-107	85-107						stream type =	
Fair (Mod. u	ınstable	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				Modified ch	annel
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+			ina	stability ra	ing =
																	"Ka	ung is a	ujusted 1	to poten	iiai strea	ım type, r	iot exist	ırıg.	Fair	

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)														
			Estim	ating Nea	r-Bank St	ress (NB	S)							
Stream:	Sheye	nne River			Location:	Sheyenne	River-8-55	5.75						
Station:	0			S	tream Type:	E5	\	/alley Type:	X					
Observe	ers:	KP, AL						Date:	10/2/11					
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)							
(1) Chan	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	issance					
(2) Ratio	of radius of	of curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction					
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General _I	prediction					
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction					
(5) Ratio	of near-ba	nk maximum d	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction					
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction					
(7) Veloc	city profiles	/ Isovels / Velo	ocity gradientLevel IV Validation											
=								-						
Level	(1)		xtensive deposition (continuous, cross-channel)											
<u> </u>														
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank									
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)									
			\											
					Near-Bank	l								
= =	(2)	Pool Slope	Average		Stress			inant						
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)	1	Near-Bar	nk Stress						
_							Very	Low						
					Near-Bank									
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress									
	(' '	S _p	S _{rif}	S _{rif}	(NBS)									
		Noor Book												
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress									
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	ī								
=														
Level III				Near-Bank			Bankfull							
تّ		Near-Bank	Near-Bank	Shear			Shear	Ratio τ _{nb} /	Near-Bank					
	(6)	Max Depth	Slope S _{nb}	Stress τ_{nb} (lb/ft^2)	Mean Depth	Average Slope S	Stress τ _{bkf} (Stress					
		d _{nb} (ft)	Ciopo CIID	ID/IL)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)					
				Noor Danie										
Level IV	/- `	Velocity Grad	dient (ft/sec	Near-Bank Stress										
eve	(7)	/ f	,	(NBS)										
				Very Low										
		Cor	verting Va	lues to a N	Near-Bank	Stress (NF	SS) Rating							
Near-E	Bank Str	ess (NBS)				ethod numb								
	rating	s	(1)	(2)	(3)	(4)	(5)	(6)	(7)					
	Very L	ow	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					
	Modera	ate	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 -				1.81 – 2.50	1.15 – 1.19	1.61 – 2.00					
	Very H	-	(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					
	Extren	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40					
			Stress (NB	ss (NBS) rating Very Low										

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Sheyenne River Location: Sheyenne River-8-55.75									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	12261.3		Date:	10/2/2011			
Observers:	KP, AL		Valley Type:	Χ		Stream Type:	E5			
(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)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	12261.3	21.4	43295	0.17			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosion	n subtotals in Col	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	43295				
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	1604				
Convert eros by 1.3}	sion in yds ³ /yr to	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	2085				
	osion per unit len total length of str			Erosion	Total Erosion (tons/yr/ft)	0.17				

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

Stream:	Sheyenne	River	Si	ream Type:	E5	
Location:	Sheyenne	River-8-55.75	\	/alley Type:	Х	
Observers:	KP, AL			Date:	10/2/2011	
Enter Req	uired Infor	mation for Existing Condi	tion			
	D ₅₀	Riffle bed material D ₅₀ (mm)				
	D ₅₀	Bar sample D ₅₀ (mm)				
0	D _{max}	Largest particle from bar sar	mple (ft)		(mm)	304.8 mm/ft
	s	Existing bankfull water surfa	ce slope (ft/ft)			
	d	Existing bankfull mean dept	h (ft)			
1.65	γ_s	Submerged specific weight	of sediment			
Select the	Appropria	te Equation and Calculate	Critical Dimensio	nless She	ar Stress	
#DIV/0!	D ₅₀ /D ₅₀ ^	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}
#DIV/0!	τ*	Bankfull Dimensionless She	ar Stress	EQUATIO	ON USED:	#DIV/0!
Calculate	Bankfull Me	an Depth Required for Enti	rainment of Largest	Particle in	Bar Sampl	е
#DIV/0!	d	Required bankfull mean dep	oth (ft) $d = \frac{\tau}{\tau}$	* $\gamma_s D_{max}$	use (use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggrading				
Calculate Sample	Bankfull W	ater Surface Slope Requi	red for Entrainmer	t of Large	st Particle	in Bar
#DIV/0!	s	Required bankfull water surf	face slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)
	Check:	☐ Stable ☐ Aggrading	□ Degrading			
Sediment	Competen	ce Using Dimensional She	ear Stress			
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (s	substitute hydraulic rad	dius, R, with	mean depth,	d)
	$\gamma = 62.4$, o	d = existing depth, S = existing	slope			
	Predicted	largest moveable particle size	(mm) at bankfull shea	r stress τ (F	igure 3-11)	
	Predicted	shear stress required to initiate	e movement of measu	red D _{max} (m	m) (Figure 3	-11)
#DIV/0!		mean depth required to initiate ted shear stress, $\gamma = 62.4$, S =		red D _{max} (mr	$d = \frac{7}{1}$	z
#DIV/0!	Predicted	slope required to initiate move	ment of measured D _m	_{ax} (mm)	$S = \frac{T}{vd}$	<u> </u>
	τ = predic	ted shear stress, γ = 62.4, d =	existing depth		γd	

Worksheet 3-15. Bar sample data collection and sieve analysis form.

s	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, A	L		ī		
u b	Strea	ım:	Sheye	enne R	iver		•		Loca	tion:	Sheye	nne R	iver-8	·55.75	11	,	1		Date: 10/	2/2011	
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u></u>	⇒(⇒(
a a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE	Sieve			SIZE	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve				
m p		weight	Tare	mm weight	Tare	mm weight	Tare \	mm weight		mm veight	Tare \	mm veight	Tare	mm weight	Tare v	mm veight	Tare	mm veight		URFACI	
Ì	Taro (.roigin	Taio	roigni	Taro	oigni	Turo (10.0		raio	roigin	Taio (woigin	l laio .	roigin	Turo I	voigin:	MA	ATERIAL DATA	.S
e s	Sample v		Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two largest partic		rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	<u> </u>	T p:) A / T
2																			No.	Dia.	WT.
3																			2		
4																			Bucket +		ı
5																			materials		
6																			weight		
7																			Bucket tare weight		
8																					
10																			Materials weight		0
11																			Materials less		
12																			than:		mm
13																				Be sure to	
14																			// \	separate n veights to	
15 Net wt	total	0		0		0		0		0		0		0		0		0	0	otal	
		#####		#####		#####		#####		#####		#####		#####		#####		#####		7	
	ı. % =<	#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####	\Longrightarrow	#####	\longrightarrow	#####	1	#####	\longrightarrow	100%		RAND TO	ΤΔΙ
											'		u !		<u> </u>		u (1711
S	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream:	Sheyenne River	Stream Type: E5
Location:	Sheyenne River-8-55.75	Valley Type: X
Observers:	KP, AL	Date: 10/2/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	✓ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	$(B \rightarrow G), (D \rightarrow G), (C \rightarrow G), (E \rightarrow G)$	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Sheyenne River			Stream Ty	_{/pe:} E5	
Location: Sheyenne River-	8-55.75		Valley Ty	_{/pe:} X	
Observers: KP , AL			D	ate: 10/2/2011	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	ınge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Sheyenne River Stream Type: E5									
Location: Sheyenne River-8-55.75 Valley Type: X									
Observers: KP, AL	Date: 10/2/2011								
Vertical stability criteria (choose one stability category for each criterion 1–6)	Vertical Stabi	Selected							
	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	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)					
Sediment capacity (POWERSED)	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)					
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheet 3- 16)	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)					
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1				
	(1)	(2)	(3)	(4)					
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1				
	(1)	(2)	(3)	(4)					
Total points									
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Sheyenne River Stream Type: E5									
Location: Sheyenne River-8-55.75 Valley Type: X									
Observers: KP, AL Date: 10/2/2011									
Vertical stability criteria (choose one stability category for each criterion 1–5)	Vertical Stabil	Selected							
	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2				
	(2)	(4)	(6)	(8)					
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2				
		(2)	(4)	(6)	(8)				
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4				
	(2)	(4)	(6)	(8)					
Confinement (N 5 MWR _{ref}) (Works		0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1			
3-9)	(1)	(2)	(3)	(4)					
Total points									
Vertical stability category point range for channel incision / degradation									
Vertical stability channel incision, degradation (use points and check stability rating)		Not incised 9 – 11	Slightly incised 12 − 18 ✓	Moderately incised 19 – 27 □	Degradation > 27 □				

Worksheet 3-20. Channel enlargement prediction summary.

Stream: Sheyenne River Stream Type: E5											
Location: Sheyenne Rive	r-8-55.75		Valley Type:	X							
Observers: KP, AL			Date:	10/2/2011							
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)						
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2						
	(2)	(4)	(6)	(8)							
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4						
	(2)	(4)	(6)	(8)							
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2						
(Worksheet 3-18)	(2)	(4)	(6)	(8)							
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4						
(Worksheet 9-19)	(2)	(4)	(6)	(8)							
				Total points	12						
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Sheyenne River			Stream Type:	E5						
Lo	cation: Sheyenne River-	8-55.75		Valley Type:	X						
Ob	servers: KP , AL			Date:	10/2/2011						
p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points						
		Stable		1							
1	Lateral stability	Mod. unstab	ole	2	2						
! '	(Worksheet 3-17)	Unstable		3	2						
		Highly unsta	able	4							
	Vertical stability	No deposition	on	1							
2	excess deposition/	Mod. deposi	ition	2	1						
-	aggradation	Excess depo	osition	3	1						
	(Worksheet 3-18)	Aggradation	1	4							
	Vertical stability	Not incised		1							
3	channel incision/	Slightly inci	sed	2	2						
ľ	degradation	Mod. Incised	d	3	2						
	(Worksheet 3-19)	Degradation	1	4							
	Channal anlargament	No increase		1							
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2						
~	3-20)	Mod. increas	se	3	2						
	0 20)	Extensive		4							
	Pfankuch channel	Good: stable	e	1							
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2						
ľ	10)										
	10)	Poor: unsta	ble	4							
				Total Points	9						
	Category point range										
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □						

Worksheet 3-22. Summary of stability condition categories.

Stream:	Sheyenne River			Location:	tion: Sheyenne River-8-55.75						
Observers:	KP, AL	Date:	10/2/2011	Stream	n Type: E5	Valle	у Туре: Х				
Channel Dimension	Mean bankfull depth (ft): 8.26	Mean bankfull 74 width (ft):	Cross-section area (ft ²):	616.4	Width of flood- prone area (ft):	898.5	Entrenchment ratio:	12.0			
Channel Pattern	Mean: Range: MWR:	16.9 Lm/W _b	_{kf} : 16.9	Rc/	/W _{bkf} :	2.8	Sinuosity:	3.97			
	Check: Riffle/pool	☐ Step/pool ☐		Converge	nce/divergence	✓ Dunes	/antidunes/smooth be	ed			
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	io	Slope				
Features	bankfull depth (ft): 13.1	(max/me	ean): 1.6		pool spacing:	Valley:	Average bankfull:	0.0001			
	Nipanan	nt composition/density:	Potential composit	ion/density:	Remark	s: Condition, vig	or and/or usage of existing	g reach:			
	vegetation	<u> </u>			I=		I=				
	Flow P1, 2, Strear regime: 7, 9 and or	3-n	Meander pattern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D3			
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.6 Degree of stability rat	ing:	/ Incised	Modified Pfank (numeric and a	•	~ <u>-</u>	air			
	Width/depth 9.0 ratio (W/d):	Reference W/d ratio (W/d _{ref}):	9.0 Width/dept (W/d) / (W/		te 1.0		tio state y rating:	able			
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of on the MWR / MWR / MWR		ent 1. 0)	/ MWR _{ref} y rating: Unco	nfined			
Bank Erosion Summary	Length of reach ## studied (ft):	##	mbank erosion rate	s/yr/ft)	Curve used: Fig 3-9	Remarks:					
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	capacity	Remark	s:					
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Require depth _{bkf}		sting Requi				
Successional Stage Shift	→ -	→	→	-	Existing str state (type)		Potential stream state (type):	E5			
Lateral Stability	☐ Stable 🔽	Mod. unstable Г	Unstable	☐ High		Remarks/cause	es:				
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	radation	Remarks/cause	es:				
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degr	radation	Remarks/cause	es:				
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	□ Exte	nsive	Remarks/cause	es:				
Sediment Supply (Channel Source)	□ Low □	Moderate	High 🔲 Very hi	Remar	rks/causes:						

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

			Riparian Ve	egetation	
Stre	eam: Wild F	Rice River		Location: Wild Rice River-1-3.01	
	servers: KP, A		Reference reach	Disturbed (impacted reach) X Date: 10/4/2011	
spe	sting cies nposition:			Potential species composition:	
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition species composition	5
1. Overstory	Canopy layer	60%	3%		
				100%	
2. Understory	Shrub layer		3%		
		Ammuni		100%	
evel	Herbaceous		5%		
3. Ground leve	Leaf or needle litter		10%	Remarks: Condition, vigor and/or usage of existing reach:	
	Bare ground		79%		
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%		

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

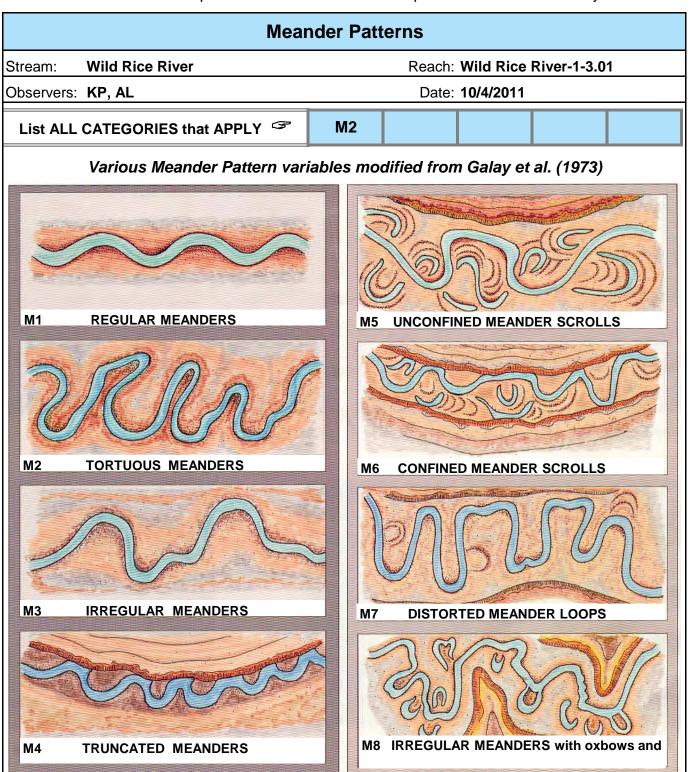
	terpretations.													
		F	LOW I	REGIMI	E									
Stream:	Wild Rice River		Location:	Wild Ric	e River-1	-3.01								
Observers:	KP, AL						Date:	10/4/201	1					
	COMBINATIONS that	P1	P2	P9										
APF	PLY													
General C	Category													
E														
S	Subterranean stream c surface flow that follows			llel to and	l near the	surface fo	or various	seasons	- a sub-					
ı	Intermittent stream cha associated with sporad losing/gaining reaches	ic and/or	seasonal f	lows and	also with	Karst (lim	estone) g	jeology w	here					
Р	Perennial stream chani	losing/gaining reaches create flows that disappear then reappear farther downstream. Perennial stream channels: Surface water persists yearlong.												
Specific (Category													
1	Seasonal variation in s	treamflow	dominated	d primarily	y by snow	melt runc	off.							
2	Seasonal variation in s	treamflow	dominated	d primarily	y by storn	nflow runc	off.							
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	, etc.						
4	Streamflow regulated b	y glacial r	melt.											
5	Ice flows/ice torrents fro	om ice da	m breache	es.										
6	Alternating flow/backwa	ater due to	tidal influ	ence.										
7	Regulated streamflow of	due to dive	ersions, da	am releas	e, dewate	ering, 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 generate	ed runoff.												

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

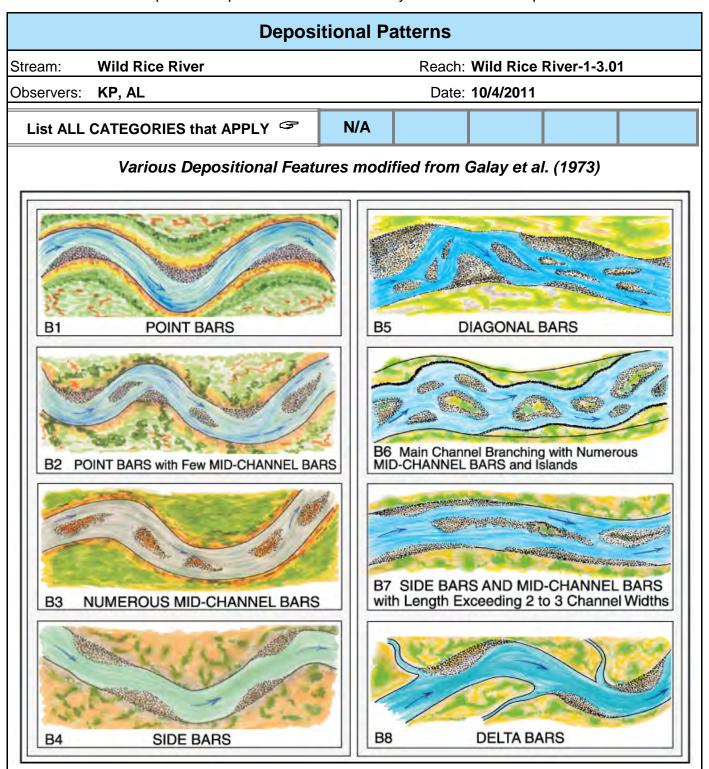
Stream Size and Order												
Stream:	Wild Rice Rive	er										
Location:	Wild Rice Rive	er-1-3.01										
Observers:	KP, AL											
Date:	10/4/2011											
Stream Size Category and Order S-7												
Category STREAM SIZE: Bankfull Check (✓) appropriate												
	meters	feet	category									
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										
	Strear	n Order										
Add categoria	as in naranthasis	for enacific etras	m order of									

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

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



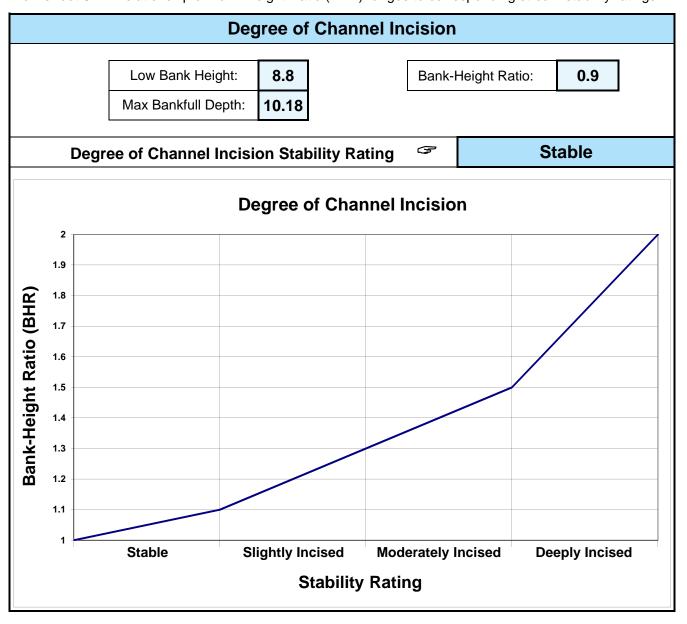
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



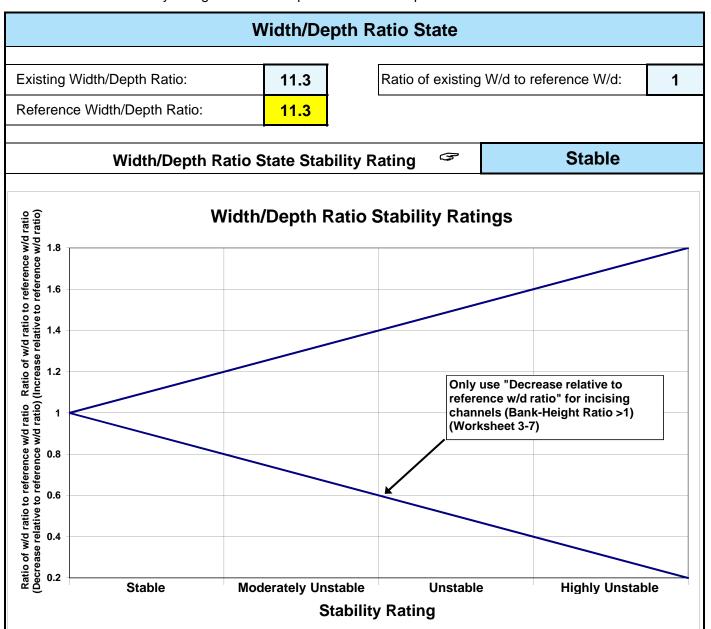
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Wild Rice F	River Location: Wild Rice River-1-3.01	
Obser	rvers: KP, AL	Date: 10/4/2011	
Desc	ription/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.	Y
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

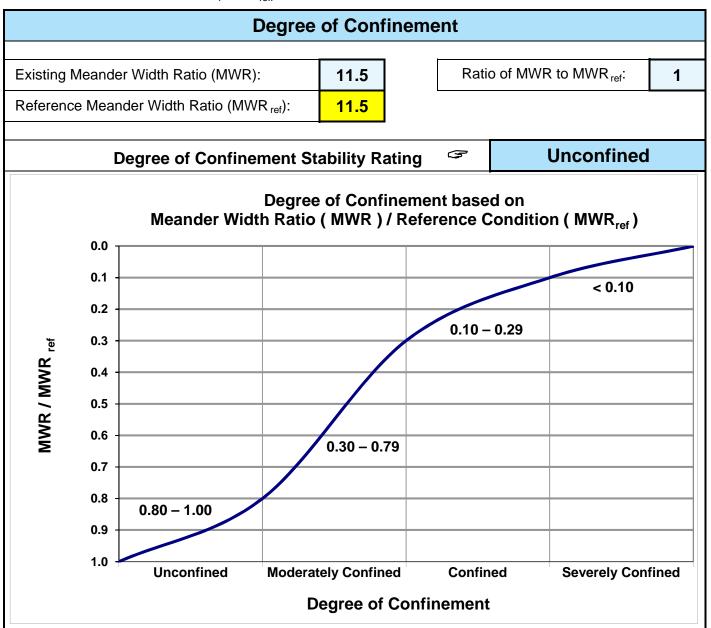
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



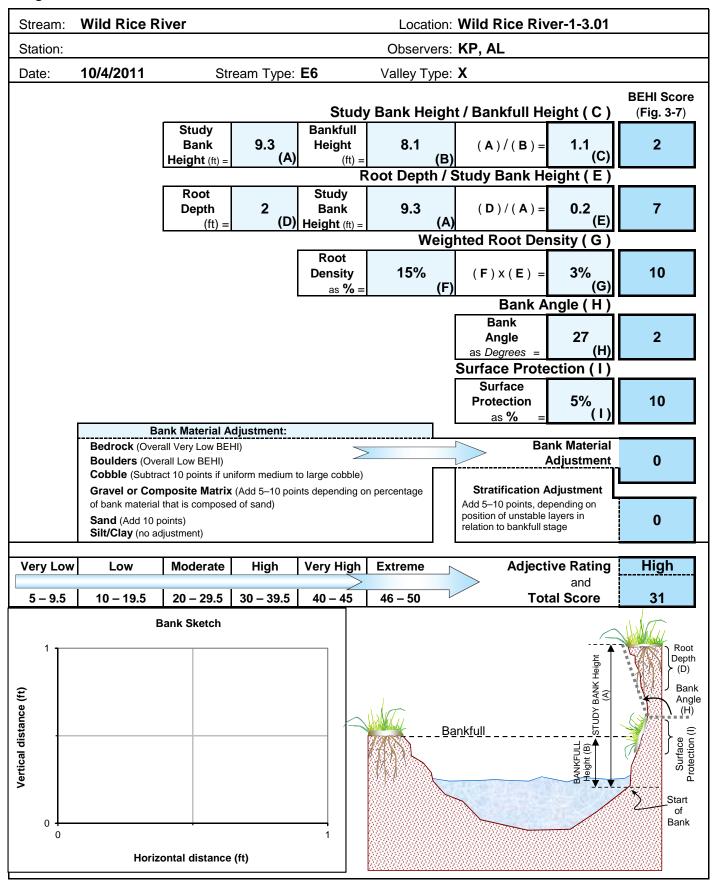
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Wild	Rice F	River				Loc	ation:	Wild	Rice F	River-	1-3.01		Valley	/ Type:	Χ		Obse	ervers:	KP, A	۸L				Date: 10/4/20	11
Loca-	Key	Caton	lorv.			Exce	llent					Go	od					Fa	air						Poor	
tion	Ney	Categ	JOI y			Descriptio	n		Rating		D	escriptio	n		Rating			Descriptio	n		Rating			Descr	iption	Rating
6	1	Landform slope	n	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	⊢60%.		6	Bank slo	ope gra	dient >	60%.	8
Upper banks	2	Mass ero	osion	No eviderosion.		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.			rly 12	
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	izes.		ounts, m		6	Modera predom	inantly	larger s	sizes.	8
O	4	Vegetative bank protection			t a deep	nsity. Vi			3		or sugg	y. Fewer est less			6	fewer s		rom a sl		ınd	9		dicating	poor, o	ver species and les discontinuous and	s 12
	5	Channel capacity		Bank heights sufficient to contain the bankfull stage is contained within banks. Bankfull stage is contained within banks. Width/depth ratio departure from reference Bankfull stage is not contained. Width/depth Bankfull stage is not contained. Width/depth Common wi								vith flows rture from	less than	ed; over-bank flows are bankfull. Width/depth ce width/depth ratio > 1. 1.3.	1. 4											
nks	6	Bank roc content	k	12"+ co	mmon.	ge angula				40–65% cobbles		y boulde	ulders and small 4 20–40%. Most in the 3–6" diameter class. 6 <20% rock fragments or less.								8					
Lower banks	7	Obstructi to flow	ions	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm. Some present causing erosive cross currents and minor pool filling. Obstructions fewer and pool filling. Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling. Frequent obstructions and pool filling.							earlong. Sediment	8														
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks		Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".		6	_			" high. I ughing (12				ts, some over 24" angs frequent.	16			
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8		arse san		new gra		12				redominantly fine bar development.	16
	10	Rock angularity		Sharp e surfaces		nd corne	rs. Plan	е	1			rs and e th and fla	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rounded in all dimessmooth.			nensions, surfaces	4
	11	Brightnes		General	lly not b				1	surface	S	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predom scoured	,	0 /	> 65%, exposed o	4
Æ	12	Consolidate particles		overlap	ping.	tightly p			2	overlap	oing.	ked with			4		loose as nt overla		nt with n	10	6	No pack easily m	•	dent. L	oose assortment,	8
Bottom	13	Bottom s distribution		No size material	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	es. Stal		12	Marked materia			ange. Stable	16
	14	Scouring depositio		<5% of depositi		affected	by scot	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr		constri			18				bottom in a state o	f 24
	15	Aquatic vegetatio			•	th moss I. In swif						e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow om may be present	4
						Exc	ellent	total =	21				Good	total =	10				Fair	total =	21				Poor tota	= 16
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	Ī		
Good (Stabl	le)	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	1	Grand total =	68
Fair (Mod. u Poor (Unsta	ıble)	48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110	91-110	106+	133+	133+	2 108-132 99-125 133+ 126+		Existing stream type :	E6	
Stream ty	-		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4				*Potential	E6		
Good (Stabl			40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107	85-107						stream type : Modified ch	
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120					
Poor (Unsta	inie)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+ ting is a	121+ djusted	126+ to poter	121+ itial strea	ım type,	not exi	sting.	stability ra Fair	iiig =

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

Estimating Near-Bank Stress (NBS)													
			Estim	ating Nea	r-Bank St	ress (NB	S)						
Stream	i: Wild R	ice River			Location:	Wild Rice	River-1-3.0)1					
Station	: 0			S	tream Type:	E6	\	/alley Type:	X				
Observ	/ers:	KP, AL						Date:	10/4/11				
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)						
(1) Cha	nnel pattern	ı, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	nissance				
(2) Rati	o of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction				
(3) Rati	o of pool slo	pe to average	water surface sl	ope (S _p / S)			Level II	General _l	prediction				
(4) Rati	o of pool slo	pe to riffle slop	e (S _p / S _{rif})				Level II General prediction						
(5) Rati	o of near-ba	ank maximum d	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III Detailed prediction						
(6) Rati	o of near-ba	ank shear stress	s to bankfull she		Level III	Detailed prediction							
(7) Velo	ocity profiles	/ Isovels / Velo		Level IV	Valid	lation							
=			ind/or central b					_					
Level	(1)		position (conti										
			NE	3S = Extreme									
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank								
	(2)	R _c (ft)	(ft)	W _{bkf}	Stress (NBS)								
	Near-Bank												
Pool Slope Average Stress Dominant													
ě	(3)	S_p	Slope S	Ratio S _p / S	(NBS)		Near-Bar	nk Stress					
							Very	Low					
					Near-Bank								
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress								
	(' '	S _p	S _{rif}	S _{rif}	(NBS)								
		Noor Ponk											
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress								
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)								
=													
Level III				Near-Bank			Bankfull						
تّ		Near-Bank	Near-Bank	Shear			Shear	Ratio τ _{nb} /	Near-Bank				
	(6)	Max Depth	Slope S _{nb}	Stress τ_{nb} (lb/ft^2)	Mean Depth	Average Slope S	Stress τ _{bkf} (Stress				
		d _{nb} (ft)	Giopo GIID	ID/IL)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)				
				Noor Danie									
Level IV	/= `	Velocity Grad	dient (ft/sec	Near-Bank Stress									
eve	(7)		t)	(NBS)	,								
_				Very Low									
		Cor	nverting Va	alues to a N	Near-Bank	Stress (NF	SS) Rating						
Near-	Bank Str	ess (NBS)	70.4119 70			ethod numb							
	rating	js	(1)	(2)	(3)	(4)	(5)	(6)	(7)				
	Very L	ow	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				
	Moder	ate	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 H	-	(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				
	Extrer	ne	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40				
Overall Near-Bank Stress (NBS) rating Ver													

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	W	ild Rice River		Location: Wild Rice River-1-3.01									
Graph Used:	Fi	g 3-9	Total Bar	nk Length (ft):	4850.3		Date:	10/4/2011					
Observers:	KF	P, AL		Valley Type:			Stream Type:						
(1) Station (ft)		(2) BEHI rating	(3) NBS rating	(4) Bank	(5) Length of	(6) Study bank	(7) Erosion	(8) Erosion					
, ,			(Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	bank (ft)	height (ft)	subtotal	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}					
1.		High	Very Low	0.165	4850.3	9.3	7443	0.07					
2.							0	#DIV/0!					
3.							0	#DIV/0!					
4.							0	#DIV/0!					
5.							0	#DIV/0!					
6.							0	#DIV/0!					
7.							0	#DIV/0!					
8.							0	#DIV/0!					
9.							0	#DIV/0!					
10.							0	#DIV/0!					
11.							0	#DIV/0!					
12.							0	#DIV/0!					
13.							0	#DIV/0!					
14.							0	#DIV/0!					
15.							0	#DIV/0!					
Sum erosion	su	btotals in Colu	ımn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	7443						
Convert eros	sion	in ft ³ /yr to yds	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	276								
Convert eros by 1.3}	sion	in yds ³ /yr to t	ons/yr {multip	on (yds ³ /yr)	Total Erosion (tons/yr)	358							
			gth of channel eam (ft) survey		Erosion	Total Erosion (tons/yr/ft)	0.07						

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

Stream:	Wild Rice	River		S	tream Type:	E6	
Location:	Wild Rice	River-1-3.01		,	Valley Type:	Х	
Observers:	KP, AL				Date:	10/4/2011	
Enter Req	uired Infor	mation for Existi	ing Conditio	n			
	D ₅₀	Riffle bed materia	al D ₅₀ (mm)				
	D ₅₀	Bar sample D ₅₀ (mm)				
0	D _{max}	Largest particle f	rom bar sampl	e (ft)		(mm)	304.8 mm/ft
	S	Existing bankfull	water surface	slope (ft/ft)			
	d	Existing bankfull	mean depth (f	t)			
1.65	γ_{s}	Submerged spec	cific weight of s	ediment			
Select the	Appropria	te Equation and	Calculate C	ritical Dimensio	nless She	ar Stress	
#DIV/0!	D ₅₀ /D ₅₀	Range: 3-7	Us	e EQUATION 1:	$\tau^* = 0.083$	34 (D ₅₀ /D	^ ₅₀) ^{-0.872}
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0) Us	e EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₍₀) ^{-0.887}
#DIV/0!	τ*	Bankfull Dimensi	ionless Shear S	Stress	EQUATIO	ON USED:	#DIV/0!
Calculate I	Bankfull Me	an Depth Require	ed for Entrair	nment of Larges	t Particle ir	Bar Sampl	e
#DIV/0!	d	Required bankful	ll mean depth ((ft) $d = \frac{\tau}{2}$	· γ _s D _{max} S	use	D _{max} in ft)
	Check:	☐ Stable ☐ A	aggrading	Degrading			
Calculate Sample	Bankfull W	ater Surface Slo	pe Required	l for Entrainmei	nt of Large	st Particle	in Bar
#DIV/0!	S	Required bankfu	ll water surface	e slope (ft/ft) S	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)
	Check:	☐ Stable ☐ A	aggrading	Degrading			
Sediment	Competen	ce Using Dimens	sional Shear	Stress			
0	Bankfull sl	hear stress τ = γd	S (lbs/ft ²) (subs	stitute hydraulic ra	dius, R, with	mean depth	, d)
	$\gamma = 62.4, c$	d = existing depth, \$	S = existing slo	рре			
	Predicted	largest moveable p	article size (mr	m) at bankfull shea	ar stress τ (F	igure 3-11)	
	Predicted	shear stress require	ed to initiate m	ovement of measu	ured D _{max} (m	m) (Figure 3	-11)
#DIV/0!		mean depth require ted shear stress, γ			ired D _{max} (mi	. a –	vs
#DIV/0!	Predicted	slope required to in	itiate moveme	nt of measured D _n	_{nax} (mm)	$S = \frac{\tau}{T}$	
	ι = predic	ted shear stress, γ	= 62.4 , $0 = exi$	isting depth		γ d	

Worksheet 3-15. Bar sample data collection and sieve analysis form.

Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis Observers: KP, AL																								
u b	Strea	ım:	Wild F	Rice Ri	ver				Loca	tion:	Wild F	Rice Ri	iver-1-	3.01					Date: 10/	4/2011				
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒(
a m		h Pan CKET	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE						
p I	Tare v	veight	Tare v	weight	Tare	weight	Tare	weight	Tare \	veight	Tare	weight	Tare	weight	Tare	weight	Tare	weight		SURFACE MATERIALS				
e s	Sample v	veights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two l	DATA (Two largest particle				
Ů	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net						
1																			No	Dia.	WT.			
2																			1	<u> </u>				
3																			2					
5																			Bucket + materials					
6																			weight					
7																			Bucket tare					
8																			weight					
9																			Materials					
10																			weight		0			
11																			Materials less	3				
12																			than:		mm			
13																				Be sure to separate n				
15																				weights to total	grand			
Net wt	total	0		0		0		0		0		0		0		0		0	0	lulai				
		#####		#####		#####		#####		#####		#####		#####		#####		#####		7				
Accum	1. % =<	#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	100%		RAND TO	TAI			
		•	•								'		•											
S	ample lo	cation no	otes				Sar	nple loca	ation sk	etch														

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

Stream:	Wild Rice River	Stream Type: E6
Location:	Wild Rice River-1-3.01	Valley Type: X
Observers:	KP, AL	Date: 10/4/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	, $(B \rightarrow G)$, $(D \rightarrow G)$, $(C \rightarrow G)$, $(E \rightarrow G)$	Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} E6	
Location: Wild Rice River-1	I-3.01		Valley Ty	_{/pe:} X	
Observers: KP, AL			Da	ate: 10/4/2011	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	11
	La	teral stability c	ategory point ra	inge	
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Rice Riv	er		Stream Type:	E6	
Location: Wild Rice Riv	er-1-3.01		Valley Type:	X	
Observers: KP, AL			Date:	10/4/2011	
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	n / Aggradation	Selected
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)
Sediment 1 competence (Worksheet 3-14)	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)	
Sediment capacity (POWERSED)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2
	(2)	(4)	(6)	(8)	
Stream succession 4 states (Worksheet 3- 16)	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)	
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1
3-5)	(1)	(2)	(3)	(4)	
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	2
	(1)	(2)	(3)	(4)	
				Total points	11
	Vertical stal		int range for exces adation	s deposition /	
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 3-19. Vertical stability prediction for channel incision or degradation.

Str	ream: Wild Rice Riv	er		Stream Type:	E6	
Lo	cation: Wild Rice Riv	er-1-3.01		Valley Type:	X	
Ob	oservers: KP, AL			Date:	10/4/2011	
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
		(2)	(4)	(6)	(8)	
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
		(2)	(4)	(6)	(8)	
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	2
	(Worksheet 3-7)	(2)	(4)	(6)	(8)	
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2
		(2)	(4)	(6)	(8)	
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1
	3-9)	(1)	(2)	(3)	(4)	
					Total points	9
		Vertical stab		nt range for char dation	nel incision /	
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Stream: Wild Rice Rive	r		Stream Type:	E6	
Location: Wild Rice Rive	r-1-3.01		Valley Type:	X	
Observers: KP, AL			Date:	10/4/2011	
Channel enlargement	Char	Selected			
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2
	(2)	(4)	(6)	(8)	
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4
	(2)	(4)	(6)	(8)	
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2
(Worksheet 3-18)	(2)	(4)	(6)	(8)	
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2
(Worksheet o 19)	(2)	(4)	(6)	(8)	
				Total points	10
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Wild Rice River			Stream Type:	E6
Lo	cation: Wild Rice River-	1-3.01		Valley Type:	X
Ob	servers: KP, AL			Date:	10/4/2011
p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	2
! '	(Worksheet 3-17)	Unstable		3	2
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. depos	ition	2	1
~	aggradation	Excess dep	osition	3	'
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci	sed	2	1
٦	degradation	Mod. Incised	d	3	1
	(Worksheet 3-19)	Degradation	1	4	
	Channal anlargement	No increase		1	
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1
"	3-20)	Mod. increa	se	3	•
	<i>3 23)</i>	Extensive		4	
	Pfankuch channel	Good: stable	e	1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				
	10)	Poor: unsta	ble	4	
				Total Points	7
			Category p	oint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River													
Observers:	KP, AL	Date:	10/4/2011	Stream	n Type: E6	Valley Type: X								
Channel Dimension	Mean bankfull 7.01 depth (ft):	Mean bankfull 79 width (ft):	.16 Cross-section area (ft ²):	n 556.2	Width of flood- prone area (ft):	333	Entrenchment ratio:	4.2						
Channel Pattern	Mean: MWR:	11.5 Lm/W _b	kf: 11.5	Rc/	W _{bkf} :	1.7	Sinuosity:	3.9						
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converger	nce/divergence	Dunes	/antidunes/smooth be	ed						
River Profile and Bed	Max Riffle	Pool Depth r	Riffle	Pool	Pool to Rat	io	Slope							
Features	bankfull 10.2 depth (ft):	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull:	to total						
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vio	gor and/or usage of existin	g reach:						
	vegetation													
	Flow P1, 2, Stream regime: 9 and or	N=/	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D3, 4						
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	0.9 Degree of stability rat		table	Modified Pfank (numeric and a	•		air						
·	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	11 () ·	Width/depth ratio state (W/d) / (W/d _{ref}):			o state rating:							
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of (MWR / M	confineme WR _{ref}):	nt 1.0		/ MWR _{ref} y rating: Unco	onfined						
Bank Erosion Summary	Length of reach studied (ft):	10U	mbank erosion rate s/yr) 0.07 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:								
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	y Excess capacity Rema										
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		isting Requ pe _{bkf} : slope							
Successional Stage Shift	→ -	→ →	→	→	Existing strestate (type)		Potential stream state (type):	E6						
Lateral Stability	☐ Stable 🔽	Mod. unstable ☐	Unstable	☐ Highl	ly unstable	Remarks/cause	es:							
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	temarks/cause	es:							
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	Mod. incised	☐ Degr	adation	demarks/cause	es:							
Channel Enlargement	▼ No increase □	Slight increase	Mod. increase	□ Exte	nsive	temarks/cause	98:							
Sediment Supply (Channel Source)	□ Low 🔽	Moderate	High 🔲 Very h	igh	ks/causes:									

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

			Riparian Ve	getation						
Stre	eam: Wild F	Rice River		Location: Wild Rice River-2-4.23						
Obs	servers: KP, A	L	Reference reach	Disturbed (impacted reach) X Date: 10/4/2011						
spe	sting cies nposition:			Potential species composition:						
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition Percent of total species composition						
1. Overstory	Canopy layer	75%	5%							
				100%						
2. Understory	Shrub layer		10%							
				100%						
level	Herbaceous		10%							
3. Ground level	Leaf or needle litter		5%	Remarks: Condition, vigor and/or usage of existing reach:						
	Bare ground		70%							
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%							

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

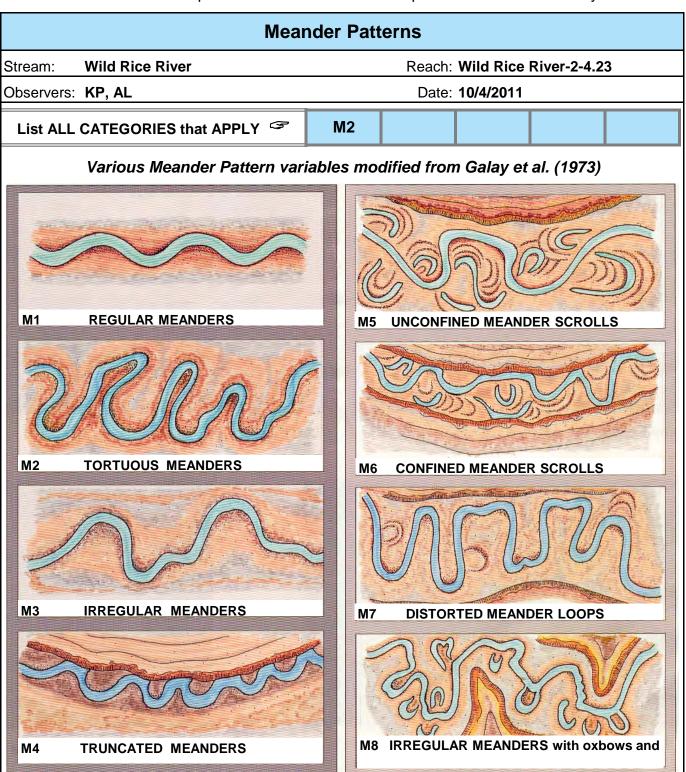
	•												
		F	LOW I	REGIM	E								
Stream:	Wild Rice River		Location:	Wild Ric	e River-2	2-4.23							
Observers:	KP, AL						Date:	10/4/201	1				
List ALL													
API	APPLY P1 P2 P9												
General Category													
E	Ephemeral stream channels: Flows only in response to precipitation												
s	Subterranean stream c surface flow that follow			llel to and	d near the	surface fo	or various	seasons	- a sub-				
I	associated with sporad	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.											
Р	Perennial stream chani	Perennial stream channels: Surface water persists yearlong.											
Specific (Category												
1	Seasonal variation in s	treamflow	dominated	d primaril	y by snow	melt runc	off.						
2	Seasonal variation in s	treamflow	dominated	d primaril	y by storn	nflow runc	off.						
3	Uniform stage and asso	ociated st	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.					
4	Streamflow regulated b	y glacial r	melt.										
5	Ice flows/ice torrents fro	om ice da	m breache	es.									
6	Alternating flow/backwa	ater due to	tidal influ	ence.									
7	Regulated streamflow	due to div	ersions, da	ım releas	e, dewate	ering, etc.							
8	Altered due to develope conversions (forested t												
9	Rain-on-snow generate	ed runoff.											

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

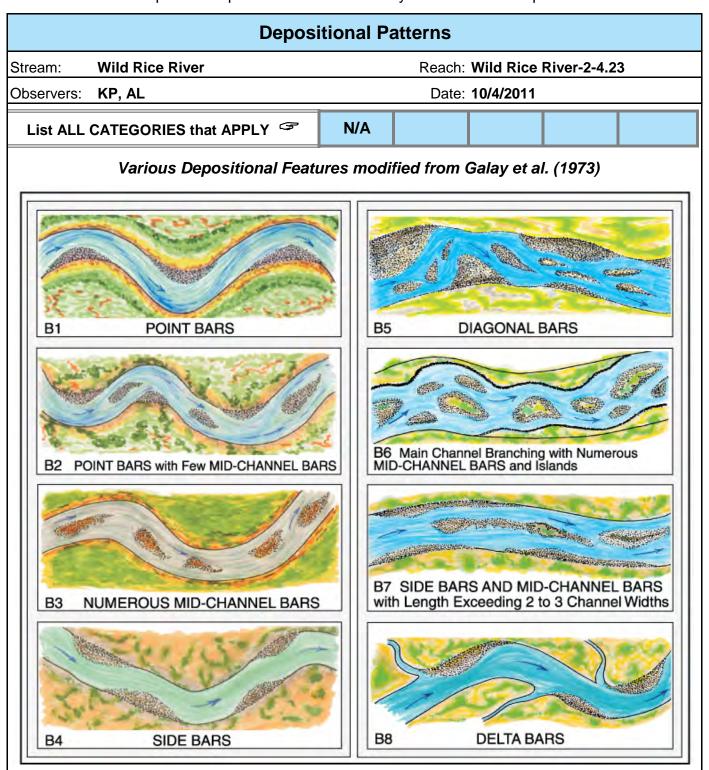
	Stream Siz	e and Orde	r								
Stream:	Wild Rice Rive	er									
Location: Wild Rice River-2-4.23											
Observers:	KP, AL										
Date:	10/4/2011										
Stream Siz	Stream Size Category and Order S-7										
STREAM SIZE: Bankfull Check (✓) Category width appropriate											
	meters feet										
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									
	Strear	n Order									
Add categorie	es in parenthesis	for specific strea	m order of								

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

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



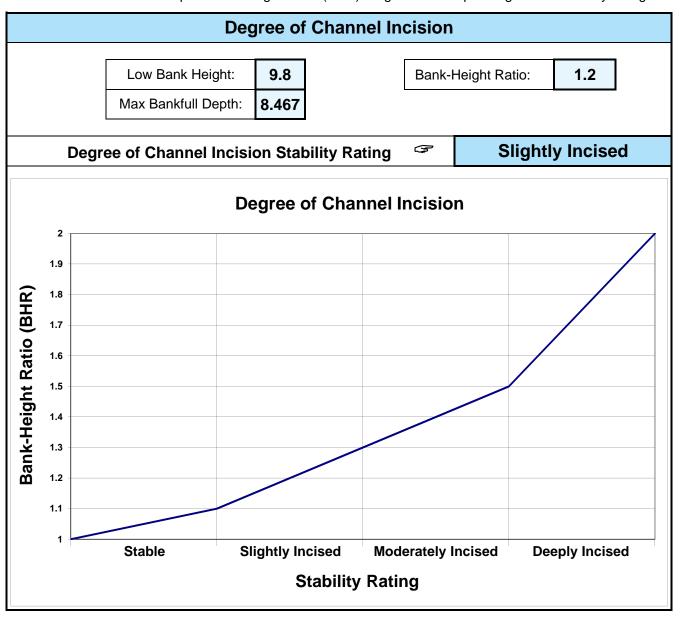
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



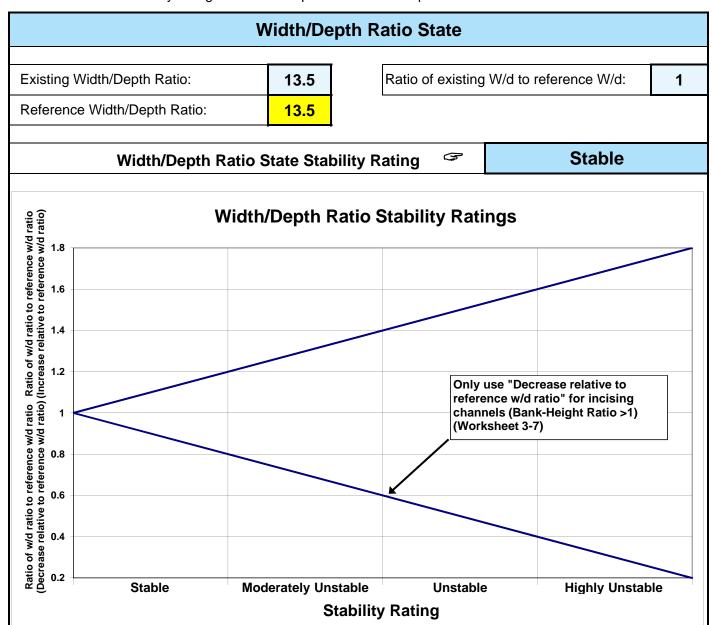
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages								
Stream	m: Wild Rice R	River Location: Wild Rice River-2-4.23								
Obser	rvers: KP, AL	Date: 10/4/2011								
Desc	ription/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.								
D1	None	Minor amounts of small, floatable material.								
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.								
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	~							
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.								
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.								
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.								
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.								
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.								
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.								
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.								

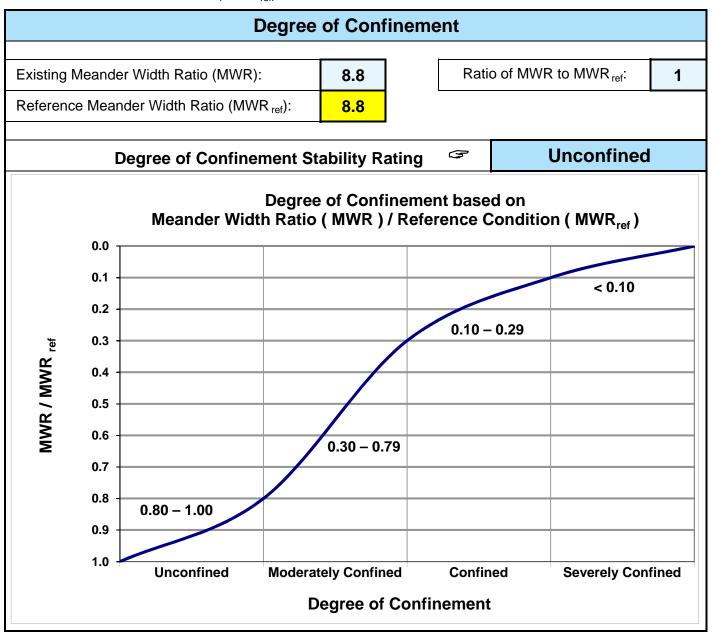
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



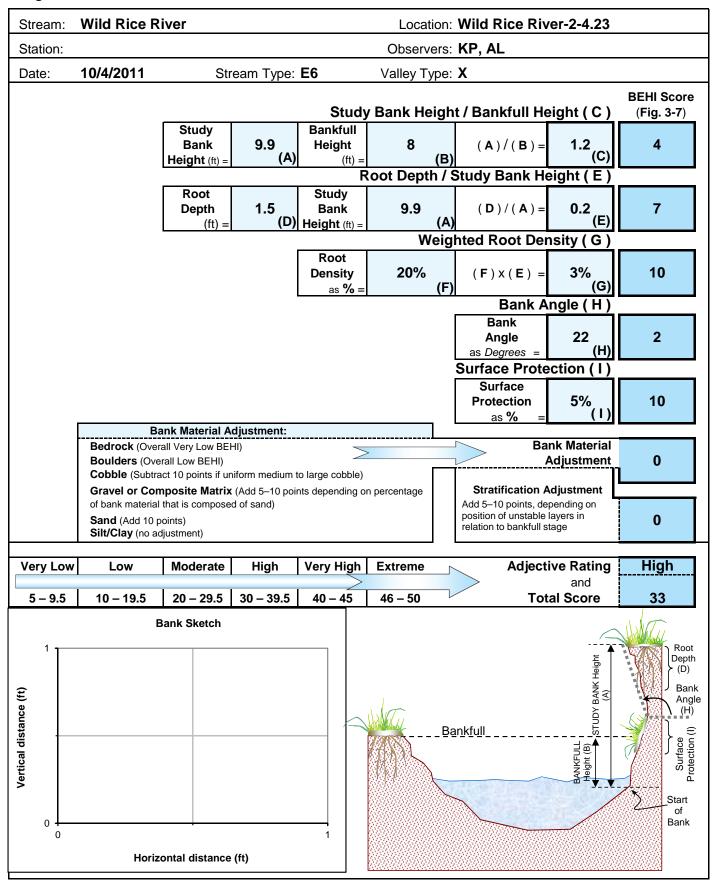
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Wild	Rice R	iver	ver Location: Wild Rice River-2-4.23 Valley Type: X										Obse	X Observers: KP, AL						Date: 10/4/2011								
Kov	Catoni	arv.			Exce	llent			Good								Fa	air						Poor				
itey	Calege	Ji y			Descriptio	n		Rating			Description	n		Rating	Description F			Rating		[Descrip	otion		Rating				
1	Landform slope		Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-4 0%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradie	ent > (60%.		8		
2	Mass eros	sion I			past or	future m	ass	3								ediment 9						12						
3	potential		channel	l area.				2	limbs.	mbs.					Moderate to heavy amounts, mostly larger sizes.			6	predomir	nantly lar	ger si	zes.		8				
4	bank	:	suggest	t a deep		_	-	3	less vig	or sugg				6	fewer s	pecies f	rom a sl	nallow,	nd	9	vigor ind	cating po	oor, d			12		
5	Channel capacity	:	stage. Wic	dth/depth width/dep	ratio depar	ture from		1	Width/dep width/dep	th ratio de th ratio = 1	parture fro	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/dep	th ratio	3	common wi	th flows les ure from re	s than ference	bankfull. Width/depthe width/depth ratio >		4		
6	Bank rock content		12"+ co	mmon.				2			y boulde	rs and	small	4	class.					6	or less.				-3"	8		
7	Obstruction to flow	ons	pattern	w/o cutt				2	currents fewer an	and mind d less fir	or pool fill m.	ing. Obs	tructions	4	move wi	th high flo				6	cause ba	ınk erosi	on ye	arlong. Sedimen	t	8		
8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4	,		,			6	U			U		12	12			· · · · · · · · · · · · · · · · · · ·		16		
9	Deposition	n .			irgement	t of char	nnel or	4		Some new bar increase, mostly from				8	and coarse sand on old and some new bars.			12	particles. Accelerated ba					16				
10	Rock angularity			-		rs. Plan	е	1				•		2			lges we	l rounde	ed in 2	3		nded in a	ll dim	ensions, surface	S	4		
11	Brightnes					tained.			surface	S.			6 bright	2	mixture range.			mixture range. 3 scoured s			,		65%, exposed	or	4			
12	Consolidati particles		overlapp	ping.				2			ked with	some		4	Mostly loose assortment with no apparent overlap.			6 No packing evident. I easily moved.			nt. Lo	ose assortment,		8				
1.3				_		. Stable		4	50–80%	, o.			aterial	8	materia	ls 20–50	0%.			12				ange. Stable		16		
14	·				affected	by scou	ır or	6	constric	tions ar	d where	grades		12	at obstr	uctions,	constri	ctions ar		18					of	24		
15	Aquatic vegetatior			•										2	backwa	iter. Sea	sonal a		wth	3						4		
•		-			Exc	ellent	total =	25				Good	total =	4				Fair	total =	21				Poor tot	al =	16		
ne l	Δ1	Δ2	Δ3	ΔΛ	Δ5	Δ۵	R1	R2	B3	B4	B5	B6	C1	Co	C3	C4	C5	Ce	D3	D4	D5	D6	Ī					
e)																								Grand total	=	66		
nstable	44-47 4	4-47	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		Existing stream type	_	E6		
oe e																					.00.		ŀ		_			
e)																											_	E6
nstable														Modified channel		nel												
ole)			87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+								
			L										ı			*Ra	ting is a	djusted t	to poten	tial strea	m type, r	not existi	ng.	Fai				
	Key	1 Landform slope 2 Mass eros 3 Debris jar potential 4 bank protection 5 Channel capacity 6 Bank rock content 7 Obstruction 7 Obstruction 8 Cutting 9 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Aquatic vegetation 17 Obstruction 18 Cutting 19 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Obstruction 17 Obstruction 18 Cutting 19 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Obstruction 17 Obstruction 18 Cutting 19 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Obstruction 17 Obstruction 18 Cutting 19 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Obstruction 16 Obstruction 17 Obstruction 18 Cutting 19 Deposition 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 15 Aquatic vegetation 16 Obstruction 16 Obstruction 17 Obstruction 18 Obstruction 19 Obstruction 10 Rock angularity 11 Brightnes 12 Consolidati particles 13 Bottom siz distribution 14 Scouring deposition 16 Obstruction 17 Obstruction 18 Obstruction 18 Obstruction 19 Obstruction 10	1 Landform slope 2 Mass erosion 3 Debris jam potential 4 Vegetative bank protection 5 Channel capacity 6 Bank rock content 7 Obstructions to flow 8 Cutting 9 Deposition 10 Rock angularity 11 Brightness 12 Consolidation of particles 13 Bottom size distribution 14 Scouring and deposition 15 Aquatic vegetation 16 Position Security and Security	Key Category Bank slope 1 Landform slope Bank slope 2 Mass erosion No evid erosion 3 Debris jam potential channe Sesential channe 4 bank suggest vegetative protection > 90% pank suggest protection 5 Channel capacity Bank heig stage. Wireference Ratio (BH 12"+ co.) 6 Bank rock content > 65% to. 7 Obstructions to flow Rocks apattern Stable bit of flow 8 Cutting Little or <6".	Landform slope Bank slope gra	Category	Category Bank slope gradient < 30%.	Start Sharp Sharp Sharp Sharp Stable Sharp Stable Sharp Stable Sharp Stable Sharp Stable Sharp Stable Sharp Sharp	Category	Category	Category	Category	Category	Category	Category	Category	Category	Category	Landform Slope Bank slope gradient 40%. 2 Bank slope gradient 30-40%. 4 Bank slope gradient 40-60%. 5 Bank slope gradient 4		Category Description Description Rating Description Paper Description Rating Description Rating Description Paper Description Rating Description Paper Description Description Paper Description P	Secondary Seco	Category Excellent Score Sexpension Description Description	Part Part	Catagory	Control Cardgory Excellent Secretary Secreta		

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

01001011	erosion rate.											
			Estim	ating Nea	r-Bank St	ress (NB:	S)					
Stream:	Wild R	ice River			Location:	Wild Rice	River-2-4.2	23				
Station:	0			Stream Type: E6 Valley Type: X								
Observe	ers:	KP, AL						Date:	10/4/11			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chan	nel pattern	, transverse ba	or split channe	el/central bar cr	eating NBS	Level I	Recona	aissance				
(2) Ratio	of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ear stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Veloc	ity profiles						Level IV		lation			
6	(4)											
Levell	(1)											
		Radius of	Bankfull	Thearlact thig		girig now			30 - Extreme			
	(0)	Curvature	Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)	Ī						
=					Near-Bank		_	_	•			
Level II	(3)	Pool Slope	Average	Datia C. / C.	Stress			inant				
Le	(,	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress				
							very	Low	L			
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank Stress							
	(4)	S _p	S _{rif}	S _{rif}	(NBS)							
		Near-Bank			Near-Bank	ı						
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress							
_	(0)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)							
Level III				Near-Bank			Bankfull		1			
-ev		Near-Bank		Shear			Shear		Noor Ponk			
_	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ _{nb} /	Near-Bank Stress			
	(-)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
>				Near-Bank		<u> </u>						
Level IV	(7)	-	lient (ft/sec	Stress								
Le	, ,	/ f	()	(NBS)								
				Very Low]							
			verting Va	lues to a l	Near-Bank							
Near-E		ess (NBS)	(4)	(6)		ethod numb		(6)	/=\			
	rating		(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 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			
	Modera		See	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 Very Hi		(1)	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00			
	Extren	_	Above	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00	1.20 – 1.60	2.01 – 2.40 > 2.40			
	LAUGII	10	, 10010									
				Overali N	ear-Bank S	otress (NB	s) rating	very	Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	W	ild Rice River			Location:	: Wild Rice River-2-4.23			
Graph Used:	Fi	g 3-9	Total Bar	nk Length (ft):	3730.5		Date:	10/4/2011	
Observers:	KF	P, AL		Valley Type:		Stream Type: E6			
(1) Station (ft)		(2) BEHI rating	(3) NBS rating	(4) Bank	(5) Length of	(6) Study bank	(7) Fresion	(8) Erosion	
			(Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	bank (ft)	height (ft)	subtotal	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}	
1.		High	Very Low	0.165	3730.5	9.9	6094	0.08	
2.							0	#DIV/0!	
3.							0	#DIV/0!	
4.							0	#DIV/0!	
5.							0	#DIV/0!	
6.							0	#DIV/0!	
7.							0	#DIV/0!	
8.							0	#DIV/0!	
9.							0	#DIV/0!	
10.							0	#DIV/0!	
11.							0	#DIV/0!	
12.							0	#DIV/0!	
13.							0	#DIV/0!	
14.							0	#DIV/0!	
15.							0	#DIV/0!	
Sum erosion subtotals in Column (7) for each BEHI/NBS combination Sum erosion subtotals in Column (7) for each BEHI/NBS combination (ft³/yr) Total Total Total									
Convert eros	Convert erosion in ft³/yr to yds³/yr {divide Total Erosion (ft³/yr) by 27} Erosion (yds³/yr) 226								
Convert eros by 1.3}	sion	in yds ³ /yr to t	ons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	293		
			gth of channel am (ft) survey		Erosion	Total Erosion (tons/yr/ft)	0.08		

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

Stream:	Wild Rice	River	S	tream Type:	E6					
Location:	Wild Rice	River-2-4.23		Valley Type:						
Observers:	KP, AL			Date:	10/4/2011					
Enter Required Information for Existing Condition										
	D ₅₀	Riffle bed material D ₅₀ (mi	m)							
	D ₅₀	Bar sample D ₅₀ (mm)								
0	D _{max}	Largest particle from bar s	sample (ft)		(mm)	304.8 mm/ft				
	s	Existing bankfull water sur	rface slope (ft/ft)							
	d	Existing bankfull mean de	pth (ft)							
1.65	γ_{s}	Submerged specific weigh	nt of sediment							
Select the	Appropria	te Equation and Calcula	te Critical Dimensio	nless She	ar Stress					
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless Sl	hear Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate	Bankfull Me	an Depth Required for Er	ntrainment of Larges	t Particle ir	Bar Sampl	е				
#DIV/0!	d	Required bankfull mean d	epth (ft) $d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading								
Calculate Sample	Bankfull W	ater Surface Slope Requ	uired for Entrainmer	nt of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water so	urface slope (ft/ft) S :	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading	g Degrading							
Sediment Competence Using Dimensional Shear Stress										
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²)	(substitute hydraulic ra	dius, R, with	mean depth,	d)				
γ = 62.4, d = existing depth, S = existing slope										
	Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)									
	Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)									
#DIV/0!	#DIV/0! Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{vs}$									
#DIV/0!	τ = predicted shear stress, γ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope τ = τ = τ									
	ι = predic	ted shear stress, γ = 62.4, d	= existing depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMF	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KP, Al	L				
u b	Strea	ım:	Wild F	Rice R	iver		ır		Loca	tion:	Wild F	Rice R	iver-2-	4.23	ı				Date: 10	/4/201	1
		⇒ (⇒(⇒(⇒(⇒ (⇒(⇒ (⇒ (⇒(
a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE			
m p I	Tare	weight	Tare	weight	Tare	weight	Tare	weight	Tare \	weight	Tare v	veight	Tare v	weight	Tare v	weight	Tare	weight		SURFA	ALS
e s	Sample	Ť	Sample		Sample		Sample	_ <u> </u>	Sample		Sample		Sample		Sample		Sample		(Two	DATA largest	A particles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	N	o. Dia	WT.
2																			IN IN		VVI.
3																				_	
4																			Bucket +		
5																			materials		
6																			weight		
7 8																			Bucket tare weight	•	
9																			Materials		
10																			weight		0
11																			Materials le	ss	
12																			than:		mm
13																				Be sure	to add e material
15																					to grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0		
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		V	
Accum	n. % =<	#####	$\qquad \qquad >$	#####	\Rightarrow	#####	\Longrightarrow	#####	$\longrightarrow \hspace{0.5cm} \nearrow$	#####		#####		#####		#####		100%		RAND 1	OTAL
			-4				0		-4:l-	-4-1-											
8	ampie io	cation no	oies				Sar	nple loc	ation ske	eccn											

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

Stream:	Wild Rice River	Stream Type: E6
Location:	Wild Rice River-2-4.23	Valley Type: X
Observers:	KP, AL	Date: 10/4/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	☑ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	, $(B \rightarrow G)$, $(D \rightarrow G)$, $(C \rightarrow G)$, $(E \rightarrow G)$	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} E6				
Location: Wild Rice River-2	2-4.23		Valley Ty	_{/pe:} X				
Observers: KP, AL			Da	ate: 10/4/2011				
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected			
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)			
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2			
	(2)	(4)	(6)	(8)				
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1			
	(1)	(2)	(3)	(4)				
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3			
	(1)		(3)					
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)				
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1			
(Worksheet 3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Rice Riv	er		Stream Type:	E6					
Location: Wild Rice Riv	er-2-4.23		Valley Type:	X					
Observers: KP, AL			Date:	10/4/2011					
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected				
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)				
Sediment 1 competence (Worksheet 3-14)	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)					
Sediment capacity (POWERSED)	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)					
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2				
	(2)	(4)	(6)	(8)					
Stream succession 4 states (Worksheet 3- 16)	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)					
Depositional 5 patterns (Worksheet 3-5)	B1	B2, B4	B3, B5	B6, B7, B8	1				
3-3)	(1)	(2)	(3)	(4)					
6 Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1				
	(1)	(2)	(3)	(4)					
Total points									
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Wild Rice Riv	/er		Stream Type:	E6				
Location: Wild Rice Riv	/er-2-4.23		Valley Type:	X				
Observers: KP , AL			Date:	10/4/2011				
Vertical stability	Vertical Stabil	ity Categories for	Selected					
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2			
	(2)	(4)	(6)	(8)				
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2			
	(2)	(4)	(6)	(8)				
Degree of channel 3 incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	4			
(WOIKSHEEL 3-7)	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4			
	(2)	(4)	(6)	(8)				
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 - 0.79	0.10 – 0.29	< 0.10	1			
3-9)	(1)	(2)	(3)	(4)				
				Total points	13			
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 3-20. Channel enlargement prediction summary.

Stream: Wild Rice Rive	r		Stream Type:	E6					
Location: Wild Rice Rive	r-2-4.23		Valley Type:	X					
Observers: KP, AL			Date:	10/4/2011					
Channel enlargement	Char	Selected							
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)				
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2				
	(2)	(4)	(6)	(8)					
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4				
	(2)	(4)	(6)	(8)					
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2				
(Worksheet 3-18)	(2)	(4)	(6)	(8)					
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4				
(Worksheet o 19)	(2)	(4)	(6)	(8)					
	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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Wild Rice River			Stream Type:	E6					
Loc	cation: Wild Rice River-	2-4.23		Valley Type:	X					
Ob	servers: KP, AL			Date:	10/4/2011					
p c	everall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points					
		Stable		1						
1	Lateral stability	Mod. unstab	ole	2	2					
l '	(Worksheet 3-17)	Unstable		3	2					
		Highly unsta	able	4						
	Vertical stability	No deposition	on	1						
2	excess deposition/	Mod. depos	ition	2	1					
	aggradation	Excess dep	osition	3	1					
	(Worksheet 3-18)	Aggradation	1	4						
	Vertical stability	Not incised		1						
3	channel incision/	Slightly inci	sed	2	2					
٦	degradation	Mod. Incised	d	3	2					
	(Worksheet 3-19)	Degradation	1	4						
	Channal anlargament	No increase								
4	Channel enlargement prediction (Worksheet	Slight increa			2					
~	3-20)	Mod. increa	se	3	2					
	0 20)	Extensive		4						
	Pfankuch channel	Good: stable	e	1						
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2					
١	10)				2					
	10)	Poor: unsta	ble	4						
	Total Points 9									
	Category point range									
ra	everall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □					

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River				Location	: Wild Rice	River-2-4.23		
Observers:	KP, AL		Date: 10	/4/2011	Strea	m Type: E6	Valle	ey Type: X	
Channel Dimension	Mean bankfull depth (ft): 6.23	Mean bankf width (ft):	X4 (1	Cross-section area (ft ²):	¹ 525.3	Width of floo prone area (od- (ft): 283.6667	Entrenchment ratio:	3.4
Channel Pattern	Mean: Range: MWR:	8.8	Lm/W _{bkf} :	8.8	Ro	c/W _{bkf} :	1.8	Sinuosity:	2.26
	Check: Riffle/pool	☐ Step/pool	□ Pla		Converge	ence/divergen	ce 🔽 Dunes	/antidunes/smoot	th bed
River Profile and Bed	Max Riffle	Pool	Depth ratio	Riffle	Pool	Pool to F	Ratio	Slope	
Features	bankfull 8.5 depth (ft):		(max/mean			pool spacing:	Valley:	Ave banl	~ X X = -115
	Nipanan	nt composition/der	nsity:	Potential composi	tion/density	r: Rem	arks: Condition, vig	gor and/or usage of ex	xisting reach:
	vegetation								
	Flow P1, 2, Strea regime: 9 and o	•)-/	eander ttern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1 /	gree of inci ability rating:	300000	y Incised		nkuch stability r d adjective ratin		Fair
	Width/depth ratio (W/d):	Reference W/ratio (W/d _{ref}):	^{/d} 13.	Width/dept (W/d) / (W/		ate	1.0 stabilit	itio state y rating:	Stable
	Meander Width Ratio (MWR):	8.8 Refere	22	Degree of (MWR / M\		ent	10	/ MWR _{ref} y rating:	Inconfined
Bank Erosion	Length of reach	/ 31	ıal streamba	ank erosion rate	1	Curve used	: Remarks:		
Summary	studied (ft):	293	(tons/yr)	0.08 (tor	rs/yr/ft)	Fig 3-9			
Sediment Capacity (POWERSED)	✓ Sufficient capacity	/ 🗌 Insuffic	ient capacit	y 🗆 Excess	capacity	, Rem	arks:		
Entrainment/	Largest particle from	_	_	**	Existing	Requ	ıired Ex	isting R	equired
Competence	bar sample (mm):	1	; =	τ*=	depth _{bkf} :	depth	n _{bkf} : slo	pe _{bkf} : sl	ope _{bkf} :
Successional Stage Shift	→ -	→ -	→			Existing state (type	oe):	Potential str state (type):	F6
Lateral Stability	□ Stable F	Mod. unstat	ole 🗀 U	Jnstable	□ Higl	hly unstable	Remarks/cause		
Vertical Stability (Aggradation)	✓ No deposition	☐ Mod. depos	ition 🗆 E	Ex. deposition	☐ Agg	gradation	Remarks/cause	es:	
Vertical Stability (Degradation)	☐ Not incised F	Slightly incis	sed 🗆 N	/lod. incised	□ Deg	gradation	Remarks/cause	es:	
Channel Enlargement	☐ No increase F	Slight increa	ase 🗆 N	/lod. increase	□ Exte	ensive	Remarks/cause	es:	
Sediment Supply (Channel Source)	□ Low	Moderate	☐ Hig	h 🔲 Very hi	gh	arks/causes:			

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

	Riparian Vegetation										
Stre	eam: Wild F	Rice River		Location: Wild Rice Rive	er-3-17.52						
	servers: KD, JI		Reference reach	Disturbed (impacted reach) X							
spe	sting cies nposition:			Potential species composition:							
Riparian cover categories Percent aerial cover*			Percent of site coverage**	Species composition	Percent of total species composition						
ry				Trees	100%						
. Overstory	Canopy layer	60%	2%								
					100%						
				Shrubs	100%						
Understory											
nder	Shrub layer		25%								
2. U											
					100%						
				Grass, weeds	100%						
	Herbaceous		5%								
_	rierbaceous		3 /0								
leve											
3. Ground level	Leaf or needle litter		5%	Remarks: Condition, vigor and/or usage of existing reach:	100%						
	Bare ground		63%	<u>-</u>							
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%								

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

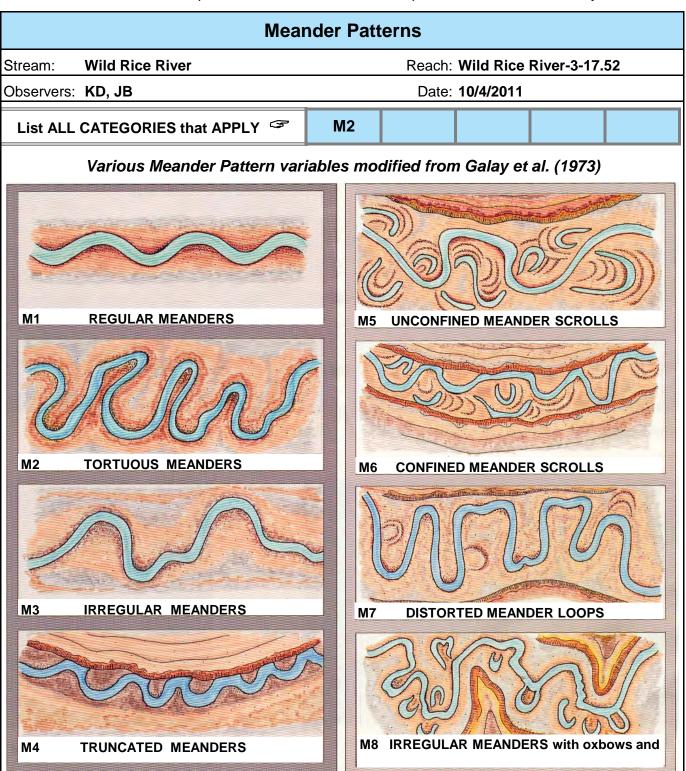
	FLOW REGIME												
Stream:	Wild Rice River		Location:	Wild Ric	e River-3	-17.52							
Observers:	KD, JB						Date:	10/4/201	1				
List ALL	COMBINATIONS that	P1	P2	P9									
API	PLY [©]	Г	ГД	ГЭ									
General C	General Category												
E Ephemeral stream channels: Flows only in response to precipitation													
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface 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.												
Р													
Specific (Category												
1	Seasonal variation in st	treamflow	dominate	d primarily	y by snow	melt runo	ff.						
2	Seasonal variation in st	treamflow	dominate	d primarily	y by storm	nflow runc	ff.						
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	, etc.					
4	Streamflow regulated b	y glacial ı	melt.										
5	Ice flows/ice torrents fro	om ice da	m breache	es.									
6	Alternating flow/backwa	ater due to	o tidal influ	ence.									
7	Regulated streamflow of	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 generate	ed runoff.											

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

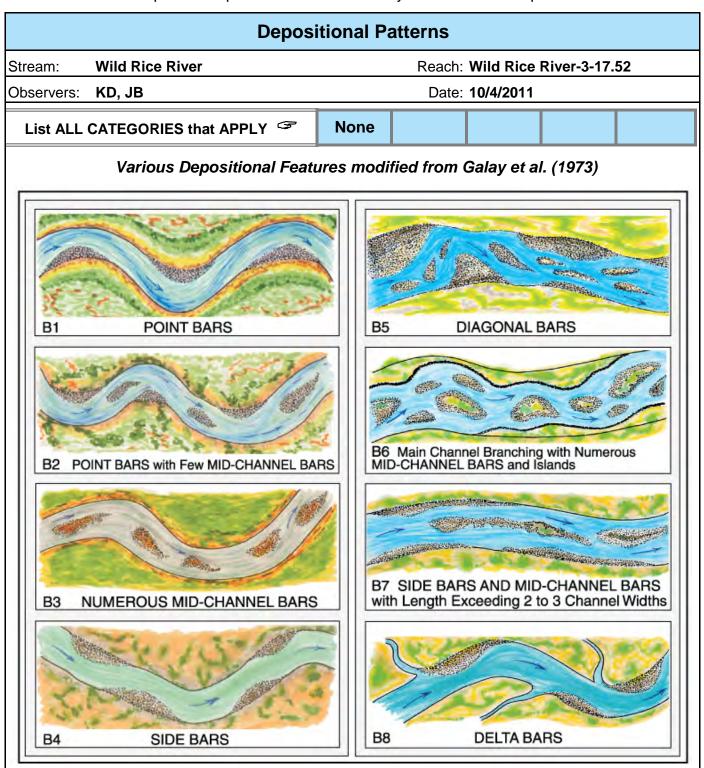
Stream Size and Order												
Stream:	Wild Rice Rive	er										
Location:	Wild Rice Rive	er-3-17.52										
Observers:	KD, JB											
Date:	10/4/2011											
Stream Size Category and Order S-6												
Category												
	meters	feet	category									
S-1	0.305	<1										
S-2	0.3 – 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 categoria	as in naranthasis	for enacific etras	m order of									

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

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



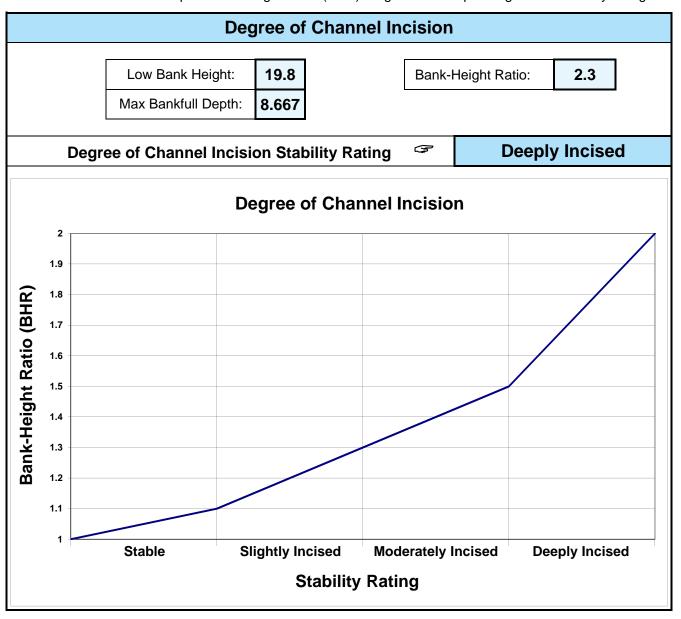
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



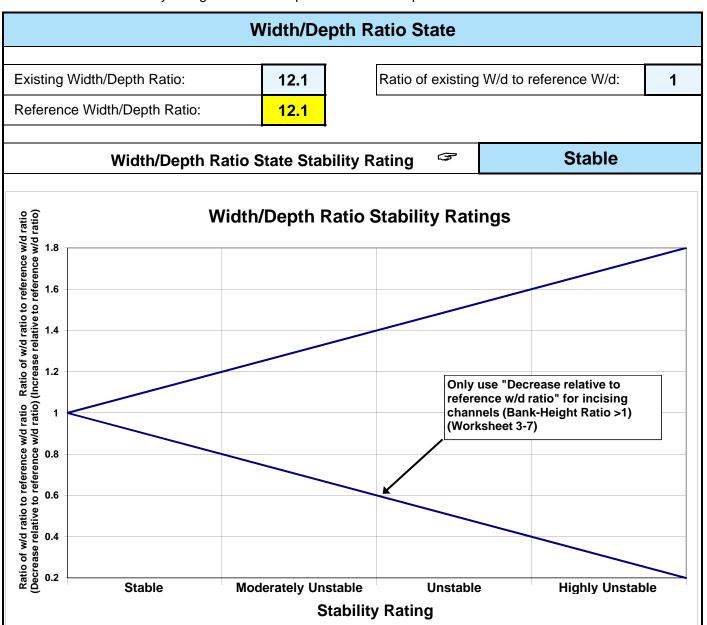
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages										
Strea	m: Wild Rice F	River Location: Wild Rice River-3-17.52									
Obsei	rvers: KD, JB	Date: 10/4/2011									
Desc	ription/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.	V								
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	•								
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.									
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.									
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.									
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.									
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.									
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.									

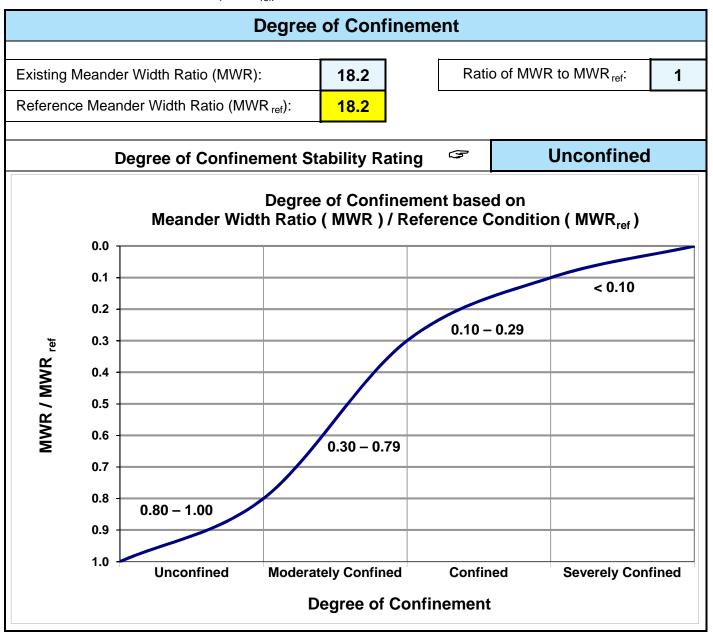
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



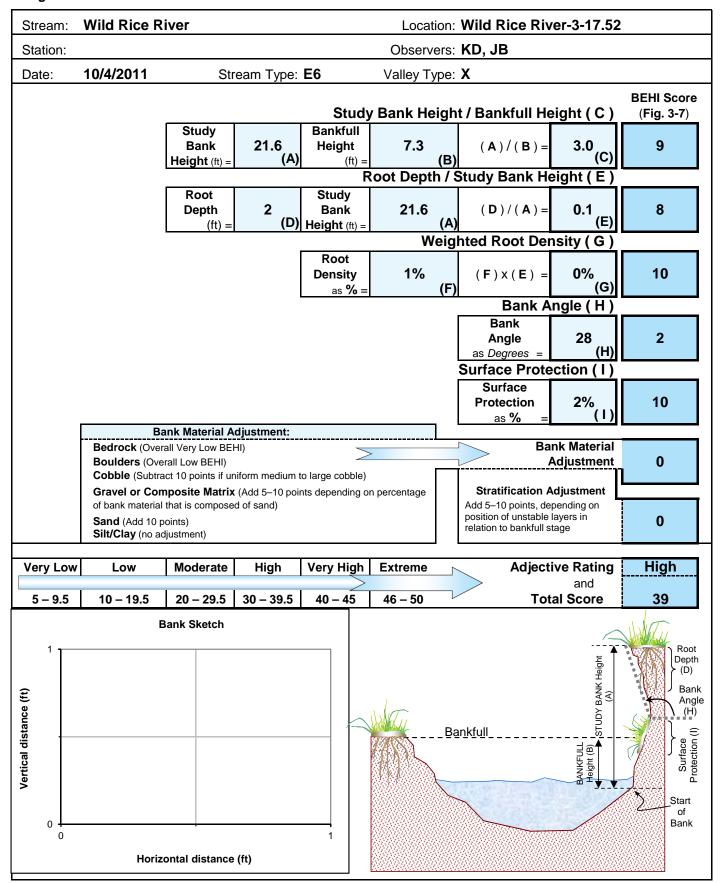
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Wild	Rice R	River				Loc	ation:	Wild Rice River-3-17.5 Valley Type: X Observ					Observers: KD, JB					Date: 10/4/20	11						
Loca-	Key	Caton	orv.			Exce	llent					Go	od					Fa	air						Poor	
tion	ney	Categ	Ory		[Descriptio	n		Rating		D	Descriptio	n		Rating		[Descriptio	n		Rating			Descri	iption	Rating
(0	1	Landform slope	1	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	ope grad	dient >	60%.	8
Upper banks	2	Mass ero	sion	No eviderosion.		past or	future m	nass	3		ent. Mos otential.	stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9	Frequent or large, caus yearlong OR imminent			12	
pper	3	Debris ja potential		channel	l area.	ent from			2	Present, but mostly small twigs and limbs. 70–90% density. Fewer species or				4	larger s	izes.		ounts, m		6	Moderate to heavy amo predominantly larger size			sizes.	8	
n	4	Vegetativ bank protection			t a deep	nsity. Vi , dense			3		or sugg	y. Fewer est less			6	fewer s		rom a sl		ınd	9	<50% density plus fe vigor indicating poor, shallow root mass.				12
	Channel stage. Width/depth ratio departure from Width/depth ratio departure from reference stage. Width/depth ratio departure from reference stage is not contained. Width/depth ratio departure from reference common with flows le					ess than reference	ed; over-bank flows are a bankfull. Width/depth be width/depth ratio > 1.4 1.3.	. 4																		
nks	6	Bank roc	k	12"+ co	mmon.	ge angula			2	40–65% cobbles		y boulde	rs and s	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3	8
Lower banks	7	7 Upstructions pattern w/o cutting or deposition. 2 currents and minor pool filling. Obstructions 4 move with high flows causing bank cutting 6 causing 6 causi		cause b	ank eros	sion ye	and deflectors earlong. Sediment ration occurring.	8																		
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at o aw bank			6				l" high. I ughing (12				s, some over 24" angs frequent.	16
	9	Depositio	on	Little or point ba		argemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba	arse san		new gra		12				redominantly fine bar development.	16
	10	Rock angularity		Sharp edges and corners. Plane surfaces rough.			е	1			rs and e	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.		all dim	nensions, surfaces	4	
	11	Brightnes	ss	Surface General	,	dark or st right.	tained.		1	Mostly dull, but may have <35% bright surfaces.		2	mixture range.		3	Predomi scoured	,	0 ,	> 65%, exposed or	4						
E	12	Consolidat particles		Assorte overlap		tightly pa	acked o	r	2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	10	6	No packing evident. Lo easily moved.			No packing evident. Loose assortment, easily moved.	
Bottom	13	Bottom si distribution		No size material	•	e evident 0%.	. Stable		4	50-80%	· .	it light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable	16
_	14	Scouring depositio		<5% of depositi		affected	by scot	ır or	6	constric	tions an	d. Scour nd where depositi	grades		12	at obstr		constri			18				bottom in a state o yearlong.	24
	15	Aquatic vegetatio			•	th moss I. In swif			1		_	e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellow m may be present.	4
						Exc	ellent	total =	23				Good	total =					Fair	total =	12				Poor total	= 44
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5 D6				
Good (Stab	•		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		Grand total =	79
Fair (Mod. u Poor (Unsta		44-47 48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110 111+	91-110 111+	86-105 106+	108-132 133+	108-132 133+	108-132 108-132 99-125 Existing 133+ 133+ 126+ stream ty		Existing stream type =	E 6	
Stream ty	ре	DA3	DA4	DA5	DA6	E3	E4	E5	E 6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential	E6
Good (Stab	le)	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				stream type =	
Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 86-105 86-105 86-105 111-125 111-125 111-125 116-130 96-110 61-78 61-78 108-120 108-120 113-125 108-120 Modified cha																										
Poor (Unsta	able)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability rat	ing =
																	*Ra	ting is a	djusted	to poter	itial strea	am type,	not exis	sting.	Fair	
*Rating is adjusted to potential stream type, not existing. Fair																										

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

erosion rate.													
			Estim	ating Nea	r-Bank St	ress (NB:	S)						
		ice River			Location:	Wild Rice	River-3-17	.52					
Station:	0			S	tream Type:	E6	\	Valley Type:	Х				
Observe	rs:	KD, JB						Date:	10/4/11				
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)						
(1) Chani	nel pattern	, transverse ba	r or split channe	el/central bar cr	Level I	Recona	aissance						
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction				
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction				
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction				
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction				
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction				
(7) Veloc	ty profiles						Level IV		dation				
)	(4)				or discontinuo								
Levell	(1)				-channel)								
				meanuer mig	ration, conver	girig liow			S = EXHEILIG				
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress								
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)								
_					Near-Bank	l							
el II	(2)	Pool Slope	Average		Stress			inant					
Level II	(3)	S_p	Slope S	Ratio S _p / S	(NBS)	1	Near-Bai	nk Stress					
							Very	Low					
					Near-Bank	•							
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress								
	(-)	S _p	S _{rif}	S _{rif}	(NBS)								
		Name Danie											
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress								
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)								
=													
Level III				Near-Bank			Bankfull						
Le		Near-Bank	Naar Dank	Shear			Shear		Near-Bank				
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	3 -	Stress τ _{bkf} (Ratio τ _{nb} /	Stress				
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)				
≥		Velocity Cros	dient (ft / sec	Near-Bank Stress									
Level IV	(7)	/ f		(NBS)									
Le))	Very Low]								
					y 	04	10) D. ('						
Noor B	ank Str	Cor ess (NBS)	iverting Va	liues to a l	Near-Bank								
iveai-E	rating		(1)	(2)	(3)	ethod numb (4)	(5)	(6)	(7)				
	Very Lo		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				
	Modera		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 Hi		(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				
	Extrem	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40				
					•———								
			Overall Near-Bank Stress (NBS) rating Very Low										

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Stream: Wild Rice River Location: Wild Rice River-3-17.52											
Graph Used:	Fi	g 3-9	Total Bar	nk Length (ft):	5215.2		Date:	10/4/2011				
Observers:	ΚI	O, JB		Valley Type:			Stream Type:					
(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)	subtotal	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}				
1.		High	Very Low	0.165	5215.2	21.6	18587	0.17				
2.							0	#DIV/0!				
3.							0	#DIV/0!				
4.							0	#DIV/0!				
5.							0	#DIV/0!				
6.							0	#DIV/0!				
7.							0	#DIV/0!				
8.							0	#DIV/0!				
9.							0	#DIV/0!				
10.							0	#DIV/0!				
11.							0	#DIV/0!				
12.							0	#DIV/0!				
13.							0	#DIV/0!				
14.							0	#DIV/0!				
15.							0	#DIV/0!				
Sum erosion	Total Erosion (ft ³ /yr)	18587										
Convert eros	sion	in ft ³ /yr to yds	Total Erosion (yds³/yr)	688								
Convert eros by 1.3}	sion	in yds ³ /yr to t	ons/yr {multip	ly Total Erosi	on (yds³/yr)	Total Erosion (tons/yr)	895					
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.17												

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

Stream:	Wild Rice	River	S	tream Type:	E6							
Location:	Wild Rice	River-3-17.52		Valley Type:								
Observers:	KD, JB			Date:	10/4/2011							
Enter Req	uired Infor	mation for Existing Cond	dition									
	D ₅₀	Riffle bed material D ₅₀ (mr	n)									
	D ₅₀	Bar sample D ₅₀ (mm)										
0	D _{max}	Largest particle from bar s	ample (ft)		(mm)	304.8 mm/ft						
	S	Existing bankfull water sur	face slope (ft/ft)									
	d	Existing bankfull mean dep	oth (ft)									
1.65 γ_s Submerged specific weight of sediment												
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress												
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}						
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}						
#DIV/0!	$ au^*$	Bankfull Dimensionless Sh	near Stress	EQUATIO	ON USED:	#DIV/0!						
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample												
#DIV/0!	d	Required bankfull mean de	epth (ft) $d = \frac{\tau}{2}$	' * γ _s D _{max} S	use (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading										
Calculate Sample	Bankfull W	ater Surface Slope Requ	ired for Entrainmer	nt of Large	st Particle	in Bar						
#DIV/0!	s	Required bankfull water su	urface slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading	g Degrading									
Sediment	Competen	ce Using Dimensional SI	near Stress									
0	Bankfull sl	hear stress $\tau = \gamma dS$ (lbs/ft ²)	(substitute hydraulic ra	dius, R, with	mean depth,	d)						
	$\gamma = 62.4, c$	d = existing depth, S = existing	ig slope									
	Predicted	largest moveable particle siz	e (mm) at bankfull shea	ar stress τ (F	igure 3-11)							
	Predicted	shear stress required to initia	ate movement of measu	ıred D _{max} (m	m) (Figure 3	-11)						
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) τ = predicted shear stress, γ = 62.4, S = existing slope											
#DIV/0!	Predicted	slope required to initiate mov	rement of measured D _m	_{lax} (mm)	$S = \frac{T}{2d}$)						
	τ = predic	ted shear stress, γ = 62.4, d	= existing depth		γd							

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	DATA: Size Distribution Analysis Observers: KD, JB												
u b	Strea	ım:	Wild F	Rice R	ver				Loca	tion:	Wild F	Rice R	iver-3-	17.52					Date: 10/	4/2011	
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒(⇒(
s a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm			
m p	Tare		Tare	weight	Tare	weight	Tare \			veight	Tare \		Tare	weight	Tare v		Tare v	veight		URFACE	
ì				9		9					Late Height								MA	ATERIAL DATA	.S
e s	Sample		Sample		Sample		Sample weights		Sample weights			Sample weights		weights	Sample weights		Sample		(Two la	argest pa	rticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No.	Dia.	WT.
2																			1 1	Dia.	VVI.
3																			2		
4																			Bucket +		
5																			materials weight		
7																					
8																			Bucket tare weight		
9																			Materials		
10																			weight	(0
11																			Materials less than:		
12																					mm
14																				Be sure to separate n	naterial
15																				veights to otal	grand
Net wt		0		0		0		0		0		0		0		0		0	0		
		#####		#####		#####		#####		#####		#####		#####	1 1 1	#####		#####			
Accun	1. % =<	#####		#####		#####		#####		#####		#####		#####		#####		100%	GF	RAND TO	TAL
s	Sample location notes Sample loca									cation sketch											

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

Stream:	Wild Rice River	Stream Type: E6				
Location:	Wild Rice River-3-17.52	Valley Type: X				
Observers:	KD, JB	Date: 10/4/2011				
Stream type changes due to successional stage shifts (Figure 3-14) Stability rating (changes due to appropriate rating appropriate rating states are successional stage shifts (Figure 3-14)						
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable				
	(E→C), (C→High W/d C)					
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable				
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable				

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} E6							
Location: Wild Rice River-3	3-17.52		Valley Ty	_{/pe:} X							
Observers: KD, JB			Da	ate: 10/4/2011							
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected						
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)						
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2						
,	(2)	(4)	(6)	(8)							
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1						
	(1)	(2)	(3)	(4)							
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3						
	(1)		(3)								
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)							
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1						
(Worksheet 3-9)	(1)	(2)	(3)	(4)							
				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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Rice River Stream Type: E6											
Location: Wild Rice Rive	er-3-17.52		Valley Type:	X							
Observers: KD, JB			Date:	10/4/2011							
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected						
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)						
Sediment 1 competence (Worksheet 3-14)	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)							
Sediment capacity (POWERSED)	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)							
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2						
	(2)	(4)	(6)	(8)							
Stream succession 4 states (Worksheet 3- 16)	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)							
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1						
3-5)	(1)	(2)	(3)	(4)							
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	2						
	(1)	(2)	(3)	(4)							
Total points											
	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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Wild Rice River Stream Type: E6											
Lo	cation: Wild Rice Riv	er-3-17.52		Valley Type:	X						
Ob	servers: KD, JB			Date:	10/4/2011						
	ertical stability	Vertical Stabil	ity Categories for	r Channel Incisio	n / Degradation	Selected					
s	riteria (choose one tability category for ach criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)					
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2					
		(2)	(4)	(6)	(8)						
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2					
		(2)	(4)	(6)	(8)						
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8					
	(WOIRSHEEL 3-7)	(2)	(4)	(6)	(8)						
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4					
		(2)	(4)	(6)	(8)						
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1					
	3-9)	(1)	(2)	(3)	(4)						
					Total points	17					
Vertical stability category point range for channel incision / degradation											
o p	Pertical stability for channel incision/legradation (use total coints and check tability rating)	Not incised 9 – 11	Slightly incised 12 – 18 ✓	Moderately incised 19 – 27 □	Degradation > 27 □						

Worksheet 3-20. Channel enlargement prediction summary.

Stream: Wild Rice River Stream Type: E6								
Loc	Location: Wild Rice River-3-17.52 Valley Type: X							
Obs	Observers: KD, JB Date: 10/4/2011							
Channel enlargement		Char	Selected					
(cl	rediction criteria hoose one stability itegory for each criterion -4)	No increase	Slight increase Moderate increase		Extensive	points (from each row)		
Successional stage shift (Worksheet 3-16)		Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2		
		(2)	(4)	(6)	(8)			
	Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4		
		(2)	(4)	(6)	(8)			
3	Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2		
	(Worksheet 3-18)	(2)	(4)	(6)	(8)			
4	Vertical stability incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4		
	(Workshoet o 15)	(2)	(4)	(6)	(8)			
Total points								
Category point range								
pr pc	hannel enlargement rediction (use total pints and check stability ting)	No increase 8 – 10	Slight increase 11 − 16 ✓	Moderate increase 17 – 24	Extensive > 24			

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

Str	Stream: Wild Rice River Stream Type: E6							
Location: Wild Rice River-3-17.52 Valley Type: X								
Ob	Observers: KD, JB Date:							
p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points			
		Stable		1				
1	Lateral stability	Mod. unstab	ole	2	2			
! '	(Worksheet 3-17)	Unstable		3	2			
		Highly unsta	able	4				
	Vertical stability	No deposition	on	1				
2	excess deposition/	Mod. depos	ition	2	1			
-	aggradation	Excess dep	osition	3	1			
	(Worksheet 3-18)	Aggradation	1	4				
	Vertical stability	Not incised		1				
3	channel incision/	Slightly inci	sed	2	2			
ľ	degradation	Mod. Incised	d	3	2			
	(Worksheet 3-19)	Degradation	1	4				
	Channal anlargament	No increase		1				
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2			
~	3-20)	Mod. increa	se	3	2			
	0 20)	Extensive		4				
	Pfankuch channel	Good: stable	e	1				
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2			
ľ	10)							
	10)	Poor: unsta	ble	4				
	Total Points 9							
	Category point range							
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □			

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River			Location:	Wild Rice Riv	/er-3-17.52		
Observers: KD, JB		Date:	10/4/2011	Strean	n Type: E6	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 6.11	Mean bankfull width (ft):	3.8 Cross-section area (ft ²):	n 450.7	Width of flood- prone area (ft):	150.6667	Entrenchment ratio: 2	.0
Channel Pattern	Mean: Range: MWR:	18.2 Lm/W _b	18.2	Rc/	/W _{bkf} :	3.8	Sinuosity: 1.54	1
	Check: Riffle/pool	Step/pool	Plane bed	Converge	nce/divergence	✓ Dunes.	/antidunes/smooth bed	
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	io	Slope	
Features	bankfull depth (ft):	(max/me	ean): 1.4		pool spacing:	Valley:	Average bankfull: 7.	3E-05
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existing read	ch:
	vegetation	<u> </u>			I=		I	
	Flow P1, 2, Stream regime: 9 and o	rder:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	blockage(s):	1-4
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.3 Degree of stability rat	ting:	y Incised	Modified Pfank (numeric and a	djective ratin	g):	
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12.1 Width/dep (W/d) / (W		te 1.0	1	tio state y rating: Stable	1
	Meander Width Ratio (MWR):	18.2 Reference MWR _{ref} :	Degree of (MWR / M		ent 1.0	1	/ MWR _{ref} Unconfin y rating:	ed
Bank Erosion Summary	Length of reach studied (ft):	215 	mbank erosion rate	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity \square Excess	s capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		sting Required pe _{bkf} : slope _{bkf} :	
Successional Stage Shift	→ -	→	→	→	Existing strestate (type)		Potential stream state (type):	E 6
Lateral Stability	☐ Stable •	Mod. unstable Γ	Unstable	☐ High	ly unstable	Remarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	radation	Remarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised	Slightly incised	Mod. incised	□ Degr	radation	Remarks/cause	es:	
Channel Enlargement	☐ No increase №	Slight increase	Mod. increase	□ Exte	nsive	Remarks/cause	es:	
Sediment Supply (Channel Source)	□ Low •	Moderate	High 🔲 Very h	igh	ks/causes:			

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

Riparian Vegetation							
Stre	eam: Wild F	Rice River		Location: Wild Rice River-4-22.94			
	servers: KD, JI		Reference reach	Disturbed (impacted reach) Date: 10/3/2011			
Existing species composition:				Potential species composition:			
Riparian cover Percent aerial categories cover*			Percent of site coverage**	Species composition	Percent of total species composition		
ıry				Trees	100%		
Overstory	Canopy layer	75%	3%				
1.							
				Shrubs	100%		
story				Shrubs	100%		
Understory	Shrub layer		5%				
2. U							
		XIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII			100%		
				Weeds, grass	100%		
	Herbaceous		15%				
<u> </u>	10/0						
d lev					100%		
3. Ground level	Leaf or needle litter		5%	Remarks: Condition, vigor and/or usage of existing reach:	100%		
	Bare ground		72%	-			
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%				

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

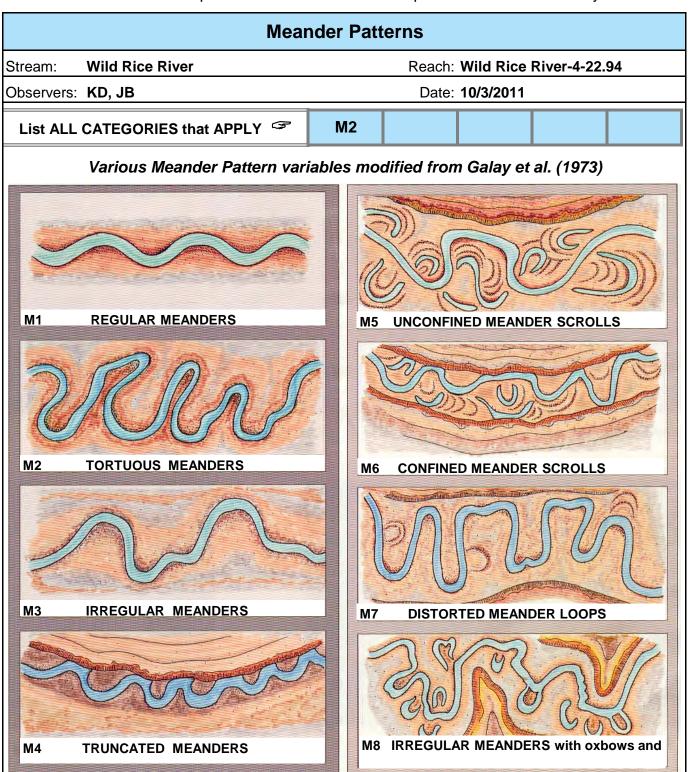
FLOW REGIME									
Stream:	Wild Rice River		Location:	Wild Ric	e River-4	-22.94			
Observers:	Observers: KD, JB Date: 10/3/2011							1	
List ALL	List ALL COMBINATIONS that								
APPLY									
General C	ategory								
E	Ephemeral stream chai	nnels: Flo	ows only in	respons	e to preci	pitation			
S	Subterranean stream c surface flow that follows			llel to and	I near the	surface fo	or various	seasons	- a sub-
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.								
Р	Perennial stream chanr	nels: Surf	ace water	persists y	earlong.				
Specific C	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	4 Streamflow regulated by glacial melt.								
5	5 Ice flows/ice torrents from ice dam breaches.								
6	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									

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

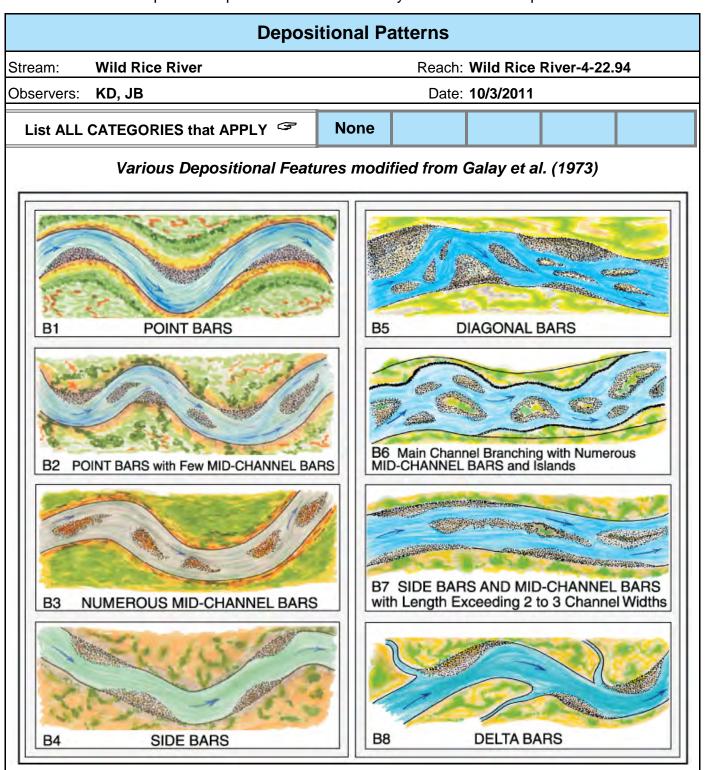
Stream Size and Order									
Stream: Wild Rice River									
Location: Wild Rice River-4-22.94									
Observers: KD, JB									
Date:									
Stream Size Category and Order S-7									
STREAM SIZE: Bankfull Check (Category width appropria									
	meters feet category								
S-1	0.305	<1							
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									

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

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



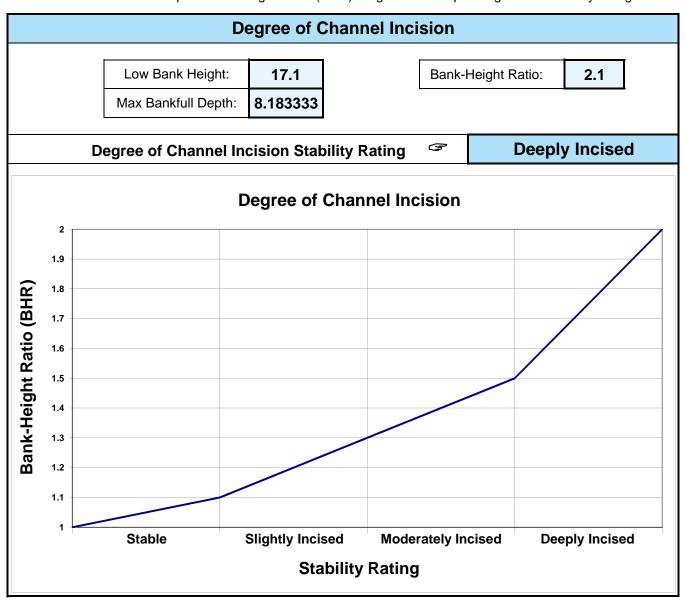
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



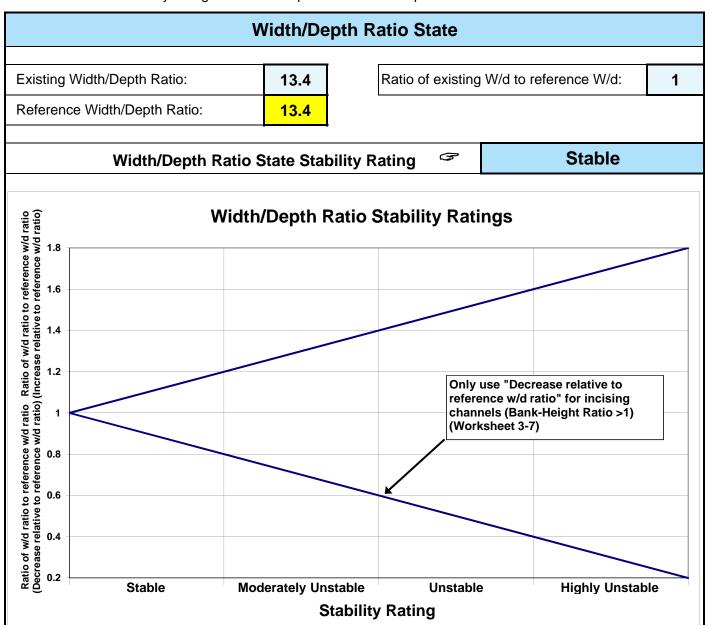
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Strea	m: Wild Rice F	River Location: Wild Rice River-4-22.94	
Obsei	rvers: KD, JB	Date: 10/3/2011	
Desc	ription/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.	V
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

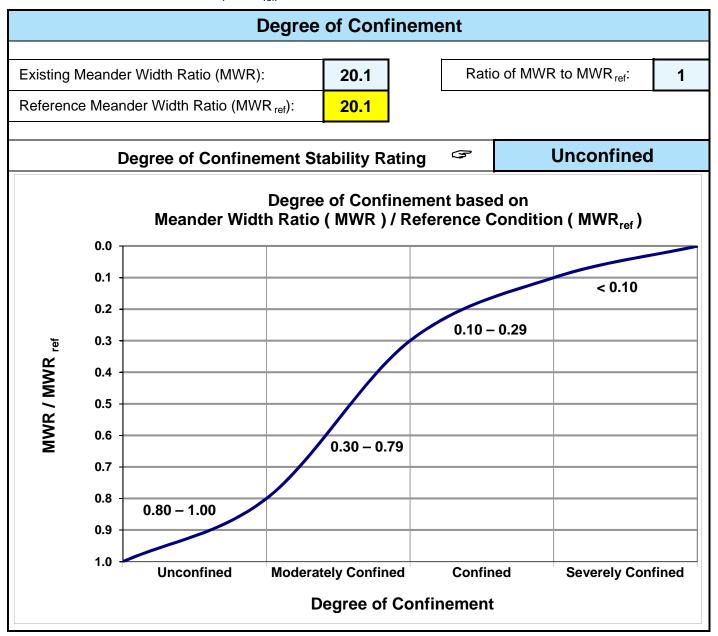
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



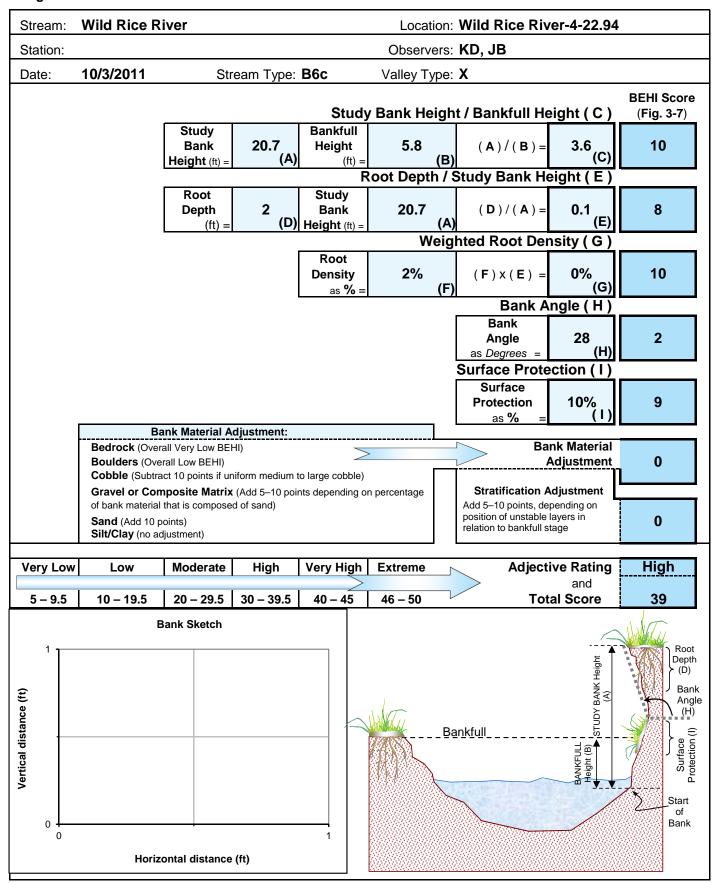
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Part	8 d less and 12 s are ppth > 1.4. 4 , 1-3" 8 ent 8 g.
1 Landform Slope Bank slope gradient - 30%. 2 Bank slope gradient 30-40%. 4 Bank slope gradient 40-60%. 5 Bank slope gradient 40-60%. 6 Bank slope gradient	8 nearly ne.
Source Sank slope gradient <0.0%. 4 Eank slope gradient <0.0%. 5 Sank slope gradient <0.0%. 5 Sank slope gradient <0.0%. 5 Sank slope gradient <0.0%. 6 Sank slope gradient slope slope gradient 6 Sank slope gradient 6	nearly ne. 8 d less and 12 s are ppth > 1.4. 4 , 1-3" 8 ent 8 g.
Suppose Supp	8 d less and 12 s are uppth
Suppose Supp	d less and 12 s are ppth 4 , 1–3" 8 ent 8 g.
Suppose Supp	and 12 s are ppth > 1.4. 4 , 1—3" 8 ent 8 g.
Sank heights sufficient to contain the bankfull stage is contained within banks. Middly the part of participes and contained to everlament or meterence width/depth ratio e-parture from reference width/depth ratio departure from reference	ppth 4 , 1–3" 8 ent 8 g.
Common 12"+ common 2 cobbles 6-12". 4 class 5 clas	ent 8 g.
Parameter Para	ent 8 g.
Paragric	4"
Peposition Deposition	.,,
angularity surfaces rough. 1 Brightness Surfaces dull, dark or stained. Generally not bright. 1 Consolidation of particles overlapping. 1 Surfaces smooth and flat. 2 dimensions. 3 smooth. 4 Mixture dull and bright, i.e., 35–65% and bright is surfaces. 5 Mixture range. 6 No packing evident. Loose assort apparent overlap. 1 Distribution shift light. Stable material solutions and deposition. 1 Surfaces smooth and flat. 2 dimensions. 3 smooth. 4 Mostly dull and bright, i.e., 35–65% and size with some overlapping. 4 Mostly loose assortment with no apparent overlap. 6 No packing evident. Loose assort materials solution shift light. Stable material solution shift light. Stable materials solution apparent overlap. 4 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 5 Souring and deposition. 6 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 6 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 6 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 7 Souring and deposition. 8 Moderate change in sizes. Stable materials 20–50%. 9 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 1 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 1 Distribution shift light. Stable material solutions and where grades steepen. Some deposition in pools. 1 Distribution shift light. Stable material solutions and steepen. Some deposition in pools. 1 Distribution shift light. Stable material solutions and steepen. Some deposition in pools. 1 Distribution shift light. Stable material solutions. Some filling of pools. 1 Distribution shift light. Stable material solutions. Some filling of pools. 1 Distribution shift light. Stable material solutions. Some filling of pools. 1 Distribution shift light. Stab	16
Generally not bright. 1 Surfaces. 1 Surfaces. 2 mixture range. 3 scoured surfaces. 4 Mostly loose assortment with no apparent overlap. 5 No packing evident. Loose assorted sizes tightly packed or overlapping. 6 No packing evident. Loose assorted sizes tightly packed or overlapping. 7 Moderately packed with some overlapping. 8 Moderate change in sizes. Stable materials 20–50%. 12 Scouring and deposition 13 Scouring and deposition 14 Scouring and deposition. 15 Scouring and deposition. 16 Common Algae forms in low velocity. 17 Scouring and deposity. 18 More than 50% of the bottom in a flux or change nearly yearlong. 19 Present but spotty, mostly in Personal types scarce or absent.	ices 4
Particles overlapping. 12 particles overlapping. 13 Bottom size distribution material 80–100%. 14 Scouring and deposition deposition. 15 Possible material 80–100%. 16 Distribution shift light. Stable material 8 material 8 materials 20–50%. 18 Moderate change in sizes. Stable materials 20–50%. 19 Marked distribution change. Stab materials 20–50%. 10 Marked distribution change. Stab materials 20–50%. 11 Marked distribution change. Stab materials 20–50%. 12 More than 50% of the bottom in a flux or change nearly yearlong. 18 More than 50% of the bottom in a flux or change nearly yearlong. 18 Present but spotty, mostly in Personal types scarce or absent	ed or 4
Scouring and deposition	nt, 8
Scouring and deposition	16
	ate of 24
vegetation green perennial. In swift water too. and pool areas. Moss here too. green, short-term bloom may be	4
Excellent total = 23 Good total = 8 Fair total = 0	otal = 44
Stream type	
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 60-85 70-90 70-90 60-85 85-107 85-107 85-107 67-98	
Fair (Mod. unstable 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 Existing	al = 75
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	B6c
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 50-75 50-75 40-63 60-85 60-85 85-110 90-115 80-95 40-60 40-60 85-107 90-112 85-107 90-112 85-107 85-107 90-112 85-107 85-107 90-112 85-107 85-107 90-112 85-107 85-107 90-112 85-107 85-107 90-112 85-107 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107 90-112 85-107	pe = B6c
Fair (Mod. unstable 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 64-86 76-96 76-96 64-86 86-105 86-105 111-125 111-125 111-125 116-130 96-110 61-78 61-78 108-120 108-120 108-120 113-125 108-120	B6c De = B6c
	B6c De = B6c
*Rating is adjusted to potential stream type, not existing.	pe = B6c

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

61081011	rosion rate.									
			Estim	ating Nea	r-Bank St	ress (NB:	S)			
		ice River					River-4-22	.94		
Station:	0			S	tream Type:	B6c	\	/alley Type:	X	
Observe	rs:	KD, JB						Date:	10/3/11	
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)			
(1) Chan	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Reconaissance		
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction	
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction	
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction	
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction	
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ear stress ($ au_{nb}$ /	′ τ _{bkf})		Level III	Detailed	prediction	
(7) Veloc	ity profiles						Level IV		lation	
) I I	(4)				or discontinuo					
Levell	(1)				-channel) gration, conver					
		Radius of	Bankfull	Theanaci inig		girig now			30 - Extreme	
	(0)	Curvature	Width W _{bkf}	Ratio R _c /	Near-Bank Stress					
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)					
_					Near-Bank				•	
Level II	(3)	Pool Slope	Average	D-#- 0 /0	Stress			inant		
Le	(-)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress		
						ļ	very	Low	L	
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank Stress					
	(4)	S _p	S _{rif}	S _{rif}	(NBS)					
		Near-Bank			Near-Bank	1				
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress					
_	(-)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)	l				
Level III				Near-Bank			Bankfull		I	
-ev		Near-Bank		Shear			Shear		Near-Bank	
	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ_{nb} /	Stress	
	(-)	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)	
≥				Near-Bank						
Level IV	(7)	-	dient (ft/sec	Stress						
Le	, ,	/ f		(NBS) Very Low						
			Į.		<u> </u>					
			nverting Va	lues to a	Near-Bank					
Near-E		ess (NBS)	/4\	(2)		ethod numb		<i>(c</i>)	(7)	
	rating Very Lo		(1) N/A	(2)	(3)	(4) < 0.40	(5)	(6)	(7)	
	Low		N/A	> 3.00 2.21 – 3.00	< 0.20 0.20 – 0.40	0.41 – 0.60	< 1.00 1.00 – 1.50	< 0.80 0.80 – 1.05	< 0.50 0.50 – 1.00	
	Modera		N/A	2.21 – 3.00	0.20 - 0.40	0.41 - 0.80	1.51 – 1.80	1.06 – 1.14	1.01 – 1.60	
	High		See	1.81 – 2.00	0.41 - 0.80	0.81 – 0.80	1.81 – 2.50	1.15 – 1.19	1.61 – 2.00	
	Very Hi		(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	
	Extren	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40	
					lear-Bank \$				Low	
				Overall IV	cai-Dalik C	ou coo (MD	o, raining	very	LUW	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Stream: Wild Rice River Location: Wild Rice River-4-22.94									
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	9465.7		Date:	10/3/2011			
Observers:	KD, JB		Valley Type:	Χ		Stream Type:	B6c			
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}			
1.	High	Very Low	0.165	9465.7	20.7	32330	0.16			
2.						0	#DIV/0!			
3.						0	#DIV/0!			
4.						0	#DIV/0!			
5.						0	#DIV/0!			
6.						0	#DIV/0!			
7.						0	#DIV/0!			
8.						0	#DIV/0!			
9.						0	#DIV/0!			
10.						0	#DIV/0!			
11.						0	#DIV/0!			
12.						0	#DIV/0!			
13.						0	#DIV/0!			
14.						0	#DIV/0!			
15.						0	#DIV/0!			
Sum erosior	n subtotals in Colu	combination	Total Erosion (ft ³ /yr)	32330						
Convert eros	sion in ft ³ /yr to yd	Total Erosion (yds³/yr)	1197							
Convert eros by 1.3}	sion in yds ³ /yr to t	Total Erosion (tons/yr)	1557							
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.16				

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

Stream:	Wild Rice	River	S	tream Type:	B6c					
Location:	Wild Rice	River-4-22.94	\	/alley Type:	Х					
Observers:	KD, JB			Date:	10/3/2011					
Enter Req	uired Infor	mation for Existing Condi	tion							
	D ₅₀	Riffle bed material D ₅₀ (mm))							
	D ₅₀	Bar sample D ₅₀ (mm)								
0	D _{max}	Largest particle from bar sa	mple (ft)		(mm)	304.8 mm/ft				
	s	Existing bankfull water surfa	ace slope (ft/ft)							
	d Existing bankfull mean depth (ft)									
1.65 γ_s Submerged specific weight of sediment										
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress										
#DIV/0! D_{50}^{1}/D_{50}^{1} Range: 3 – 7 Use EQUATION 1: $\tau^* = 0.0834 (D_{50}^{1}/D_{50}^{1})^{-0.872}$										
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	84 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless She	ear Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample										
#DIV/0!	d	Required bankfull mean dep	oth (ft) $d = \frac{\tau}{\tau}$	* γ _s D _{max}	(use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading								
Calculate Sample	Bankfull W	ater Surface Slope Requi	red for Entrainmer	nt of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water sur	face slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D max (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading	□ Degrading							
Sediment	Competen	ce Using Dimensional Sho	ear Stress							
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (s	substitute hydraulic rac	dius, R, with	mean depth,	d)				
	$\gamma = 62.4, c$	d = existing depth, S = existing	slope							
	Predicted	largest moveable particle size	(mm) at bankfull shea	ır stress τ (F	igure 3-11)					
	Predicted	shear stress required to initiate	e movement of measu	red D _{max} (m	m) (Figure 3	-11)				
#DIV/0!		mean depth required to initiate ted shear stress, γ = 62.4, S =		red D _{max} (mı	$\mathbf{d} = \frac{7}{1}$	z				
#DIV/0!	Predicted	slope required to initiate move	ment of measured D _m	_{ax} (mm)	$S = \frac{T}{vd}$					
	ι = predic	ted shear stress, γ = 62.4, d =	existing depth		γd					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Point / Side BAR-BULK MATERIALS SA							LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, JI	В					
u b	Strea	ım:	Wild F	Rice Ri	ver				Loca	Location: Wild Rice River-4-22.94							Date: 10/3/2011					
		→		→		⇒ (⇒ (⇒(
s a		h Pan	Sieve	SIZE		SIZE	Sieve		Sieve		Sieve	SIZE	Sieve		Sieve	SIZE	Sieve	SIZE	[
m p	Tare	CKET	Tare	mm weight		mm weight	Tare \	mm	Tare v	mm	Tare	mm weight	Tare v	mm veight	Tare	mm weight	Tare	mm weight		SURFACE		
1	Tare	voigni	Taic	weight	raio	weight	Taro	voigin	raicv	veignt	Tare	voigiti	raicv	voigiti	Tare	Weight	Tare	Weight	MATERIALS DATA		S	
e s	Sample		Sample	_	Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		(Tw		rgest par	ticles)
4	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Di-	\A/T
2																			 	1 1	Dia.	WT.
3																				2		
4																			Bucket	+		
5																			materia weight			
6																						
7																			Bucket ta weight			
9																			Materia	ls		
10																			weight		()
11																			Materials	less		
12																			than:			mm
13																				se	e sure to a eparate m	aterial
15																			<i></i>		eights to g tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	7	
-	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		<u>\</u>		
Accum	1. % =<	#####	\longrightarrow	#####	\Longrightarrow	#####		#####	\longrightarrow	#####	\longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	#####		100%]	GRA	AND TO	TAL
	amnla lo	cation no	ntas				Sar	nple loca	ation sky	atch												
	апріс ю	cation ne	7.63				Jai	iipie ioca	ation ske	JUIT												

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

Stream:	Wild Rice River	Stream Type: B6c
Location:	Wild Rice River-4-22.94	Valley Type: X
Observers:	KD, JB	Date: 10/3/2011
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	☑ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)	, $(B \rightarrow G)$, $(D \rightarrow G)$, $(C \rightarrow G)$, $(E \rightarrow G)$	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} B6c				
Location: Wild Rice River-4	1-22.94		Valley Ty	_{/pe:} X				
Observers: KD, JB			Da	ate: 10/3/2011				
Lateral stability criteria		Lateral Stabilit	y Categories		Selected			
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)			
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2			
	(2)	(4)	(6)	(8)				
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1			
	(1)	(2)	(3)	(4)				
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3			
	(1)		(3)					
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)				
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1			
(Worksheet 3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Rice Rive	er		Stream Type:	B6c				
Location: Wild Rice Rive	er-4-22.94		Valley Type:	X				
Observers: KD, JB			Date:	10/3/2011				
Vertical stability criteria	Vertical Stabi	lity Categories fo	r Excess Deposition	on / Aggradation	Selected			
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14)	Sufficient depth and/or slope to transport largest size available	Trend toward insufficient depth and/or slopeslightly 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)				
Sediment capacity (POWERSED)	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)				
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
	(2)	(4)	(6)	(8)				
Stream succession 4 states (Worksheet 3- 16)	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)				
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1			
3-5)	(1)	(2)	(3)	(4)				
6 Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1			
	(1)	(2)	(3)	(4)				
Total points								
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 3-19. Vertical stability prediction for channel incision or degradation.

Str	ream: Wild Rice Riv	er		Stream Type:	B6c		
Lo	cation: Wild Rice Riv	er-4-22.94		Valley Type:	X		
Ob	oservers: KD, JB			Date:	10/3/2011		
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected	
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)	
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
		(2)	(4)	(6)	(8)		
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
		(2)	(4)	(6)	(8)		
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8	
	(WOIRSHeet 3-7)	(2)	(4)	(6)	(8)		
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4	
		(2)	(4)	(6)	(8)		
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1	
	3-9)	(1)	(2)	(3)	(4)		
					Total points	17	
Vertical stability category point range for channel incision / degradation							
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Strea	ım: Wild Rice River			Stream Type:	B6c			
Locat	tion: Wild Rice River	-4-22.94		Valley Type:	X			
Obse	ervers: KD, JB			Date:	10/3/2011			
	annel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected		
cho(diction criteria pose one stability egory for each criterion)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)		
Successional stage 1 shift (Worksheet 3-16)		Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2		
		(2)	(4)	(6)	(8)			
	ateral stability Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4		
		(2)	(4)	(6)	(8)			
_γ e	/ertical stability excess deposition/ ggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2		
(Worksheet 3-18)	(2)	(4)	(6)	(8)			
4 ir	/ertical stability ncision/ degradation Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4		
•	vvorkoncet o 10)	(2)	(4)	(6)	(8)			
	Total points							
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	tream: Wild Rice River Stream Type: B6c									
Lo	cation: Wild Rice River-	4-22.94		Valley Type:	Χ					
Ob	servers: KD, JB			Date:	10/3/2011					
C p c	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points					
		Stable		1						
1	Lateral stability	Mod. unstab	ole	2	2					
'	(Worksheet 3-17)	Unstable		3	2					
		Highly unsta	able	4						
	Vertical stability	No deposition	on	1						
2	excess deposition/	Mod. depos	ition	2	1					
_	aggradation	Excess dep	osition	3	'					
	(Worksheet 3-18)	Aggradation	1	4						
	Vertical stability	Not incised		1						
3	channel incision/	Slightly inci	sed	2	2					
ľ	degradation	Mod. Incised	d	3	2					
	(Worksheet 3-19)	Degradation	1	4						
	Channal anlargement	No increase		1						
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2					
~	3-20)	Mod. increa	se	3	2					
	3-20)	Extensive		4						
	Pfankuch channel	Good: stable	е	1						
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2					
ľ	10)									
	10)	Poor: unsta	ble	4						
	Total Points 9									
Category point range										
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □					

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River			Location:	Wild Rice Riv	er-4-22.94		
Observers:	KD, JB	Date:	10/3/2011	Strean	n Type: B6c	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 5.63	Mean bankfull 75 width (ft):	.47 Cross-section area (ft²):	n 424.6	Width of flood- prone area (ft):	144.3333	Entrenchment ratio:	1.9
Channel Pattern	Mean: Range: MWR:	20.1 Lm/W _b	kf: 20.1	Rc/	/W _{bkf} :	8.1	Sinuosity:	1.75
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converge	nce/divergence	✓ Dunes/	/antidunes/smooth be	ed
River Profile and Bed	Max Riffle	Pool Depth r	atio	Pool	Pool to Rati	0	Slope	
Features	bankfull depth (ft): 8.2	(max/me	ean): 1.5		pool spacing:	Valley:	Average bankfull	0.00014
	Nipanan	nt composition/density:	Potential compos	tion/density:	Remarks	s: Condition, vig	or and/or usage of existin	g reach:
	vegetation	<u> </u>					I=	
	Flow P1, 2, Strear regime: 9 and or	der:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D1-3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.1 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective rating	g):	air
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12/1				atio state Stable ity rating:	
	Meander Width Ratio (MWR):	20.1 Reference MWR _{ref} :	Degree of (MWR / M		nt 1.0	I I	/ MWR _{ref} y rating: Unc o	onfined
Bank Erosion Summary	Length of reach 94 studied (ft):	- bb	mbank erosion rate s/yr) 0.16 (to	ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remark	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Required depth _{bkf} :		isting Requ pe _{bkf} : slope	
Successional Stage Shift	→ -	→	→	→	Existing stre		6c Potential stream state (type):	В6с
Lateral Stability	☐ Stable 🔽	Mod. unstable Г	Unstable	☐ High	ly unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	adation	emarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degr	adation	emarks/cause	98:	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exte	nsive	temarks/cause	es:	
Sediment Supply (Channel Source)	□ Low ▽	Moderate	High 🔲 Very h	igh	ks/causes:			

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

			Riparian Ve	getation	
Stre	eam: Wild F	Rice River		Location: Wild Rice Rive	r-5-
	servers: KF, J E		Reference reach	Disturbed (impacted reach)	10/2/2011
spe	sting cies nposition:			Potential species composition:	
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition
1. Overstory	Canopy layer	70%	3%	Trees	100%
					100%
2. Understory	Shrub layer		10%	Shrubs	100%
-					100%
level	Herbaceous		5%	Grass, weeds	100%
3. Ground level	Leaf or needle litter		10%	Remarks: Condition, vigor and/or usage of existing reach:	100%
	Bare ground		72%		
	ed on crown closure. ed on basal area to	surface area.	Column total = 100%		

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

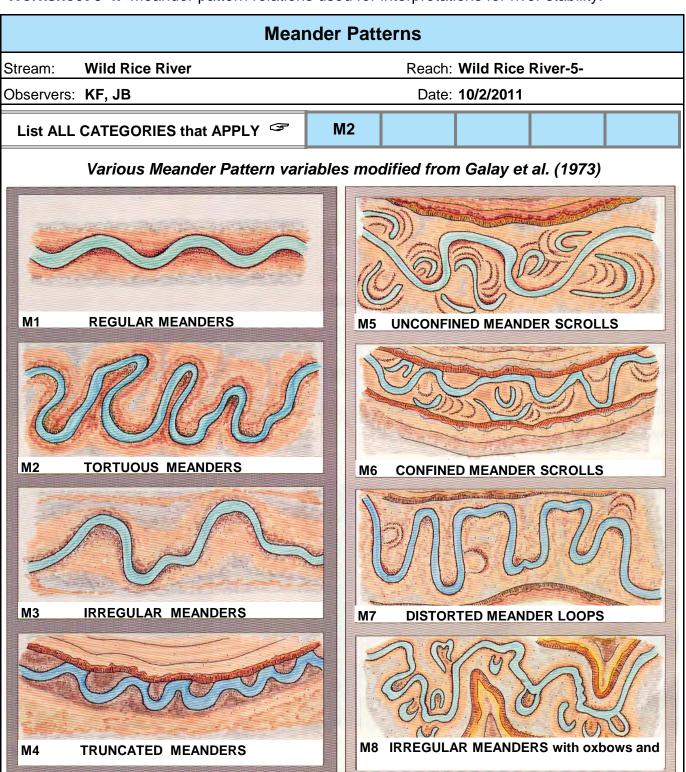
		F	FLOW I	REGIMI	E							
Stream:	Wild Rice River		Location:	Wild Ric	e River-5	-						
Observers:	KF, JB						Date:	10/2/201	1			
List ALL	COMBINATIONS that	P1	P2	P9								
API	PLY [©]	Г	ГД	ГЭ								
General (Category											
E Ephemeral stream channels: Flows only in response to precipitation												
S	S Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.											
I	associated with sporad	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 st	treamflow	dominate	d primarily	y by snow	melt runo	ff.					
2	Seasonal variation in st	treamflow	dominate	d primarily	y by storm	nflow runc	ff.					
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	, etc.				
4	Streamflow regulated b	y glacial ı	melt.									
5	Ice flows/ice torrents fro	om ice da	m breache	es.								
6	Alternating flow/backwa	ater due to	o tidal influ	ence.								
7	Regulated streamflow of	due to div	ersions, da	am releas	e, dewate	ring, 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 generate	ed runoff.										

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

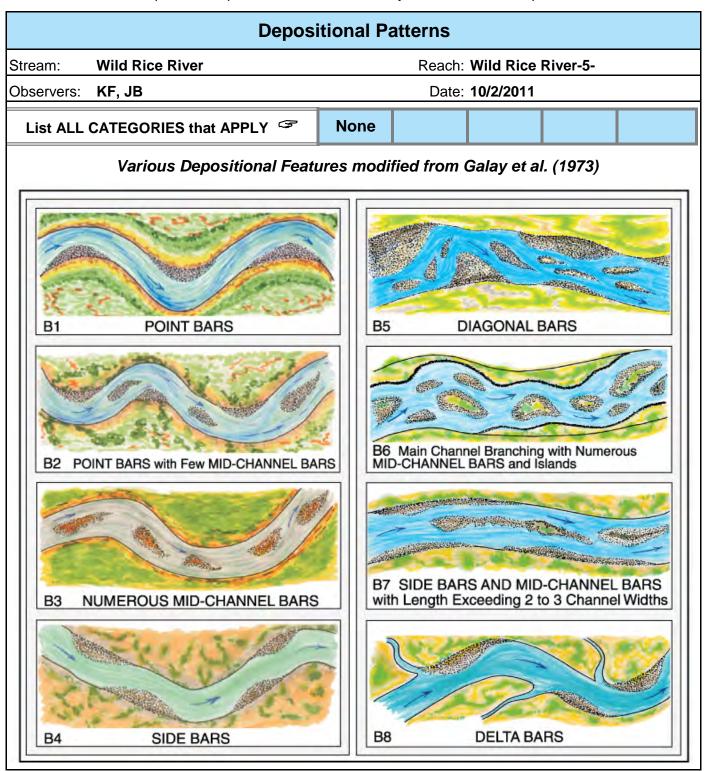
Stream Size and Order											
Stream:	Wild Rice Rive	er									
Location:	Wild Rice Rive	er-5-									
Observers: KF, JB											
Date:	10/2/2011										
Stream Size Category and Order S-6											
Category STREAM SIZE: Bankfull Check (1) appropriate											
	meters	feet	category								
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											
۱ ما ما مماده مرمران											

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

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



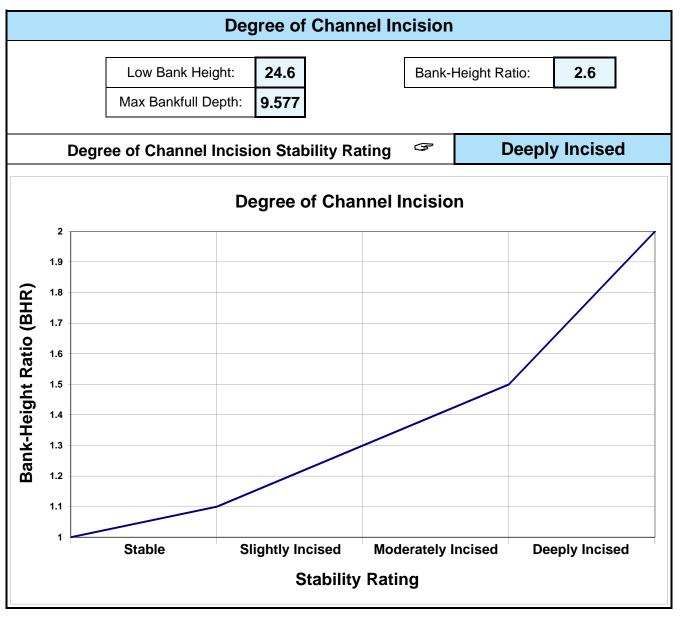
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



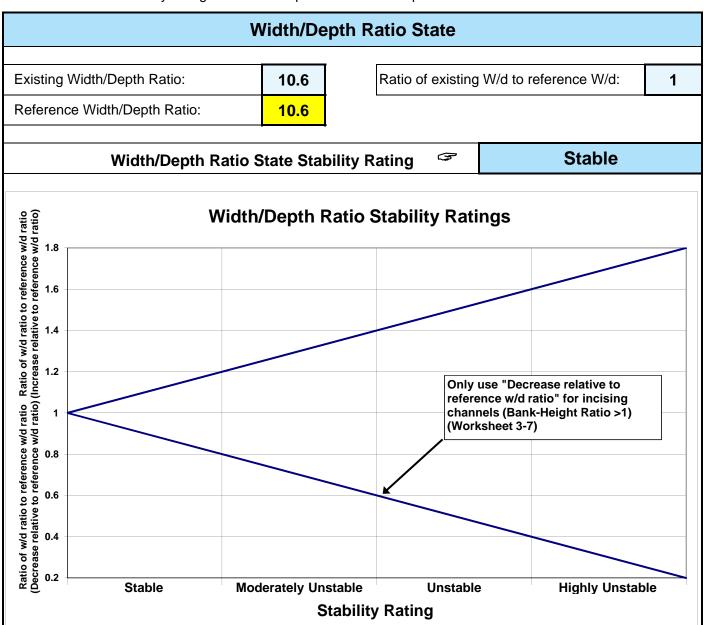
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages	
Stream	m: Wild Rice F	River Location: Wild Rice River-5-	
Obser	rvers: KF, JB	Date: 10/2/2011	
Desc	ription/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.	7
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	~
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.	>
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	>
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

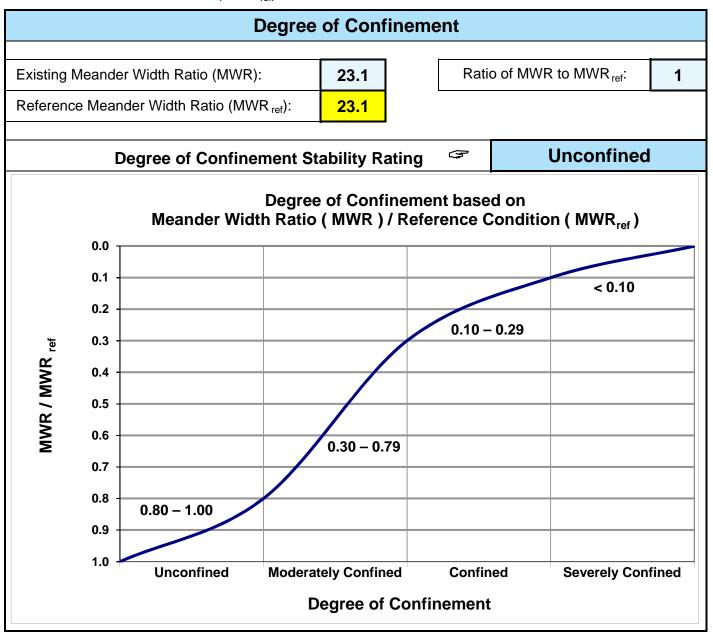
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



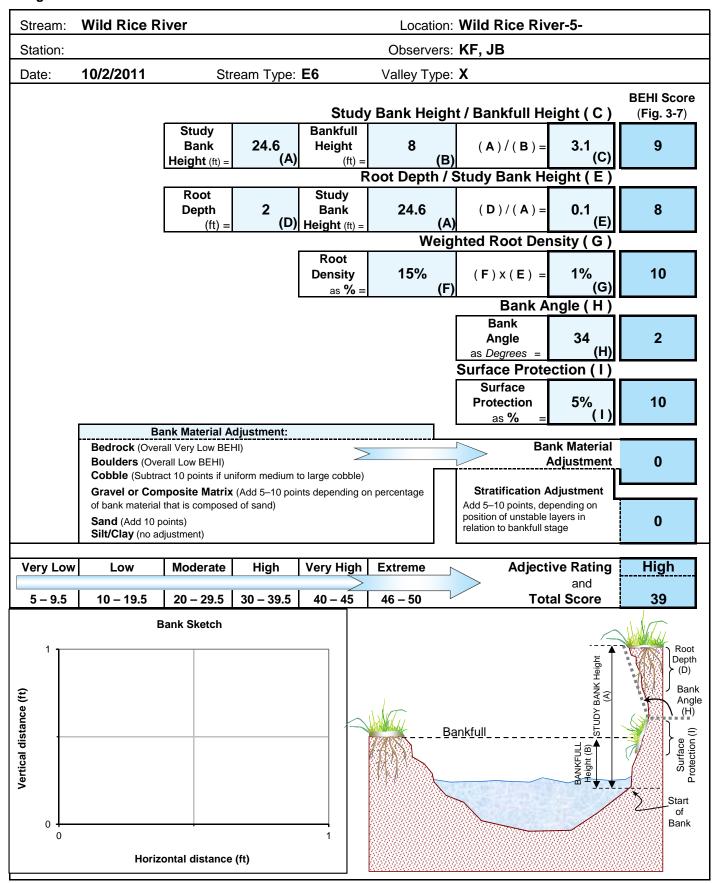
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Category andform lope Mass erosion Debris jam otential regetative ank rotection Channel apacity	Bank No everosio Esser chanr > 90% sugge root n	idence of on. Itially absoluted area. It plant desist a deepnass.	past or ent from	n 0%. future m immedi		3	Bank slo	ope grad	tly heale	-40%.		Rating 4	Bank el	С	Fa Descriptio	air n		Rating		Des	Poor cription	Rating						
andform lope Mass erosion Debris jam otential Gegetative ank rotection Channel	Bank No everosio Esser chanr > 90% sugge root n	idence of on. Itially absoluted area. It plant desist a deepnass.	past or ent from	0%. future m immedi		3	Infreque	ope grad	dient 30-	-40%.			Rank el	С	escriptio	n		Rating		Des	cription	Rating						
lope Mass erosion Debris jam otential regetative ank rotection Channel	Esser chanr > 90% sugger root n	idence of in. Itially absoluted area. It plant de est a deep nass.	past or ent from	future m		3	Infreque	nt. Mos	tly heale			4	Bank sl			Rating Description Rating Description Rating												
Debris jam otential //egetative ank rotection	Esser chanr > 90% sugge root n	ntially absuel area. b plant dest a deepnass.	ent from	immedi						d 0			Darik Si	ope grad	dient 40	-60%.		6	Bank slop	e gradient	> 60%.	8						
otential 'egetative ank rotection Channel	chanr > 90% sugge root n	el area. plant de st a deep ass.	nsity. Vi		ate	0				a over.	Low	6		nt or larg	•	ing sedi	ment	9			ausing sediment nearly nt danger of same.	12						
ank rotection Channel	sugge root n	st a deep ass.		nor and			Present limbs.		-			4	larger s	izes.	-	ounts, m	-		predomin	to heavy a antly larger	sizes.	8						
			, aonoe	_	-		70–90% less vigo root mas	or sugge				6	fewer s		rom a sh		nd			cating poor	ewer species and less , discontinuous and	12						
араспу	referen	eights suffic Vidth/depth ce width/dep BHR) = 1.0.	ratio depar	ture from		1	Bankfull st Width/dept width/dept (BHR) = 1.	th ratio de h ratio = 1	parture fro	m referer	nce	2	Bankfull s ratio depa	tage is not	t contained reference	d. Width/de width/dep (BHR) = 1.	th ratio	3	common wit ratio departi	h flows less th	ined; over-bank flows are an bankfull. Width/depth nce width/depth ratio > 1.4. > 1.3.	4						
sank rock ontent	12"+	common.	, ,			2			/ boulde	rs and s	small	4	class.					6	or less.		s of gravel sizes, 1-3"	8						
Obstructions of low	patter	n w/o cut				2	currents a	and mind d less firr	or pool filli n.	ing. Obs	tructions	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.		move with high flows causing bank cutting			6	cause ba	nk erosion	yearlong. Sediment	8						
Cutting	Little <6".	or none. I	nfrequer	nt raw ba	anks				•			6	_			•		12				16						
eposition			argemen	t of char	nnel or	4			ncrease	, mostly	/ from	8	and coa	arse san				12	· · · · · · · · · · · · · · · · · · ·				· · · · · · · · · · · · · · · · · · ·		· · · · · ·		•	16
Rock ngularity		-		rs. Plan	е	1				•		2			ges wel	l rounde	d in 2	3	smooth.	smooth.		4						
Brightness				tained.			surfaces	S			6 bright	2	mixture range.			, ,	t, > 65%, exposed or	4										
onsolidation of articles	overla	pping.				-			ked with	some		4	Mostly loose assortment with no apparent overlap.		6			Loose assortment,	8									
sottom size istribution		•		. Stable			50–80%).			aterial	8	materia	ls 20–50	0%.			12			change. Stable	16						
couring and eposition			affected	by scou	ır or	6	constric	tions an	d where	grades		12	at obstr	uctions,	constric	ctions ar		18				24						
quatic egetation		•										2	backwa	ter. Sea	sonal al		wth	3				4						
	-		Exc	ellent	total =	23				Good	total =	0				Fair	total =	33			Poor total =	16						
A1 A2	Δ3	Δ4	Δ5	Δ6	B1	B2	В³	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6								
	_		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			Grand total =	72						
44-47 44-4	7 91-12	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	9-125	Existing stream type =	E 6						
																			.00.	,								
	_	_																				E6						
																						nnel						
		87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+			stability ratin							
		•		I		1	I	1											m type, n	ot existing.	Fair							
	position atting position atting position ack gularity ightness ansolidation of articles atticles attinuous attinuous atticles atticl	12"+ content	ntent 12"+ common. Postructions flow Rocks and logs pattern w/o cut Stable bed. Little or none. I deposition Little or no enlar point bars. Assorted sizes overlapping. No size change material 80–10 couring and deposition. Abundant grow green perenniar A1 A2 A3 A4 8-43 38-43 54-90 60-95 4-47 44-47 91-129 96-132 48+ 48+ 130+ 133+ DA3 DA4 DA5 DA6 0-63 40-63 40-63 40-63 40-63 4-86 64-86 64-86 64-86 64-86	Intent 12"+ common. Rocks and logs firmly in pattern w/o cutting or distable bed. Little or none. Infrequer <6". Little or no enlargement point bars. Dock Sharp edges and corne surfaces rough. Surfaces dull, dark or signerally not bright. Assorted sizes tightly poverlapping. No size change evident material 80–100%. Couring and eposition Couring and eposition Couring and eposition Abundant growth moss green perennial. In swift Exc. A1 A2 A3 A4 A5 8-43 38-43 54-90 60-95 60-95 4-47 44-47 91-129 96-132 96-142 48+ 48+ 130+ 133+ 143+ DA3 DA4 DA5 DA6 E3 0-63 40-63 40-63 40-63 40-63 4-86 64-86 64-86 64-86 64-86	ntent 12"+ common. Rocks and logs firmly imbedded pattern w/o cutting or deposition Stable bed. Little or none. Infrequent raw bases of ". Little or no enlargement of char point bars. Little or no enlargement of char point bars. Dock Sharp edges and corners. Plan surfaces rough. Surfaces dull, dark or stained. Generally not bright. Insolidation of Assorted sizes tightly packed or overlapping. No size change evident. Stable material 80–100%. Couring and eposition Couring and eposition Abundant growth moss-like, dare grean perennial. In swift water to the stable material surfaces of the sta	12"+ common.	12"+ common. 2 2 2 2 2 2 2 2 2	Cobblest	2	Some present causing erost currents and minor pool fillife were and less firm.	Intent 12"+ common. Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed. Little or none. Infrequent raw banks <6". Beposition continued by the position of point bars. Cock growing and prosition of protection of position. Little or no enlargement of channel or point bars. Cock growing and protection of point bars. Cock growing and corners and corners and enders. Plane surfaces dull, dark or stained. Generally not bright. Common at the protection of point bars of the protection of point bars. Cock growing and protection of point bars. Cock growing and corners and edges. Cock growing and protection of point bars. Cock growing and protection of point bars. Common at the protection of point bars. Cock growing and protection of point bars. Common at the protection o	12"+ common. 2 cobbles 6–12".	Some new bar increase, mostly from coarse gravel. 1 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 3 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 5 Some new bar increase, mostly from coarse gravel. 1 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 1 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 3 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 5 Some new bar increase, mostly from coarse gravel. 1 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 1 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 2 Some new bar increase, mostly from coarse gravel. 3 Some new bar increase, mostly from coarse gravel. 3 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 3 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostly from coarse gravel. 4 Some new bar increase, mostl	Cobbles 6-12". Cobb		Cobbles 6-12". Cobbles 6-12". A class.				A Class A	A	12 20 20 20 20 20 20 20						

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	erosion rate.											
			Estim	ating Nea	r-Bank St	ress (NB:	S)					
Stream:	Wild Ri	ice River			Location:	Wild Rice	River-5-					
Station:	0			S	tream Type:	E6	1	/alley Type:	X			
Observe	rs:	KF, JB						Date:	10/2/11			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chanı	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	issance			
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})			Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p /S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d	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												
-												
Levell	(1)											
				meander mig		ging now		INE	oo = Extreme			
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress							
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)							
_					Near-Bank	•			•			
Level II	(3)	Pool Slope	Average	D # 0 /0	Stress			inant				
Le	(-)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress				
							very	Low	L			
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank Stress							
	(4)	S _p	S _{rif}	S _{rif}	(NBS)							
		Near-Bank			Near-Bank							
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress							
_	(-)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)							
Level III				Near-Bank			Bankfull		l			
-ev		Near-Bank		Shear			Shear		Near-Bank			
_	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ_{nb} /	Stress			
	` ,	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
≥			_	Near-Bank								
Level IV	(7)	Velocity Grad / f	dient (ft/sec	Stress (NBS)								
Le		0.		Very Low								
			Į.		<u> </u>							
			verting Va	lues to a l	Near-Bank							
Near-B	Bank Stro rating	ess (NBS)	(1)	(2)	(3)	ethod numb (4)	per (5)	(6)	(7)			
									(7)			
	Low		N/A	2.21 – 3.00	0.20 - 0.40	0.41 – 0.60	1.00 – 1.50					
	Modera		N/A	2.01 – 2.20	0.41 – 0.60	0.61 - 0.80	1.51 – 1.80					
	High		See	1.81 – 2.00	0.61 – 0.80	0.81 – 1.00	1.81 – 2.50					
	Very Hi		(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			
	Extrem	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40			
					ear-Bank S				Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Wild Rice River Location: Wild Rice River-5-										
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	10300.8		Date:	10/2/2011				
Observers:	KF, JB		Valley Type:	X		Stream Type:	E6				
(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.	High	Very Low	0.165	10300.8	24.6	41811	0.20				
2.						0	#DIV/0!				
3.						0	#DIV/0!				
4.						0	#DIV/0!				
5.						0	#DIV/0!				
6.						0	#DIV/0!				
7.						0	#DIV/0!				
8.						0	#DIV/0!				
9.						0	#DIV/0!				
10.						0	#DIV/0!				
11.						0	#DIV/0!				
12.						0	#DIV/0!				
13.						0	#DIV/0!				
14.						0	#DIV/0!				
15.						0	#DIV/0!				
Sum erosior	n subtotals in Colu	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	41811					
Convert eros	sion in ft ³ /yr to yd	Total Erosion (yds³/yr)	1549								
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds³/yr)	Total Erosion (tons/yr)	2013					
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.20											

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

Stream:	Wild Rice	River	S	tream Type:	E6						
Location:	Wild Rice	River-5-		Valley Type:							
Observers:	KF, JB			Date:	10/2/2011						
Enter Req	uired Infor	mation for Existing Condition									
	D ₅₀	Riffle bed material D ₅₀ (mm)									
	D ₅₀	Bar sample D ₅₀ (mm)									
0	D _{max}	Largest particle from bar sample	(ft)		(mm)	304.8 mm/ft					
	s	Existing bankfull water surface s	lope (ft/ft)								
	d	Existing bankfull mean depth (ft)									
1.65	γ_{s}	Submerged specific weight of se	diment								
Select the	Appropria	te Equation and Calculate Cri	tical Dimensio	nless She	ar Stress						
#DIV/0!	D ₅₀ /D [^] ₅₀	Range: 3 – 7 Use	EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}					
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 Use	EQUATION 2:	$\tau^* = 0.038$	4 (D _{max} /D ₅	₀) ^{-0.887}					
#DIV/0!	τ*	Bankfull Dimensionless Shear St	tress	EQUATIO	ON USED:	#DIV/0!					
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample											
#DIV/0!	d	Required bankfull mean depth (fi	$d = \frac{\tau}{2}$	· * γ _s D _{max} S	- (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐	Degrading								
Calculate Sample	Bankfull W	ater Surface Slope Required	for Entrainmer	nt of Large	st Particle	in Bar					
#DIV/0!	S	Required bankfull water surface	slope (ft/ft) S:	$= \frac{\tau * \gamma_s L}{d}$) _{max} (use	D _{max} in ft)					
	Check:	☐ Stable ☐ Aggrading ☐	Degrading								
Sediment	Competen	ce Using Dimensional Shear S	Stress								
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (subst	itute hydraulic ra	dius, R, with	mean depth,	d)					
	$\gamma = 62.4, c$	d = existing depth, S = existing slop	е								
	Predicted	largest moveable particle size (mm) at bankfull shea	ar stress τ (F	igure 3-11)						
	Predicted	shear stress required to initiate mo	vement of measu	ıred D _{max} (m	m) (Figure 3	-11)					
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\tau = \text{predicted shear stress}, \ \gamma = 62.4, \ S = \text{existing slope}$										
#DIV/0!	Predicted	slope required to initiate movement	t of measured D _m	_{nax} (mm)	$S = \frac{\tau}{\gamma d}$						
	t = predic	ted shear stress, γ = 62.4, d = exis	ung deptil		yu						

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poi	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMF	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KF, JI	3				
u b	Strea	ım:	Wild F	Rice Ri	ver				Loca	tion:	Wild F	Rice Ri	iver-5-						Date: 10/	2/2011	
		→ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (⇒ (
a m		h Pan CKET	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE			
p I	Tare	weight	Tare v	weight	Tare	weight	Tare	weight	Tare v	weight	Tare	weight	Tare	weight	Tare	weight	Tare	weight		URFACI ATERIAL	
e s	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two la	DATA argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1																			No.	Dia.	WT.
3																			1 2		
4																			Bucket +		
5																			materials		
6																			weight		
7																			Bucket tare		
8																			weight		
10																			Materials weight		0
11																			Materials less		
12																			than:		mm
13 14																				Be sure to separate n	
15																				weights to otal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	otai	
% Gra	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		7	
Accum	n. % =<	#####	\longrightarrow	#####	\longrightarrow	#####		#####		#####	\longrightarrow	#####		#####	>	#####		100%	GF	RAND TO	TAL
S	ample lo	cation no	otes				Sar	nple loca	ation ske	etch											

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

Stream:	Wild Rice River	Stream Type: E6				
Location:	Wild Rice River-5-	Valley Type: X				
Observers:	KF, JB	Date: 10/2/2011				
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)				
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	☑ Stable				
	(E→C), (C→High W/d C)					
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable				
(C→D)	, $(B \rightarrow G)$, $(D \rightarrow G)$, $(C \rightarrow G)$, $(E \rightarrow G)$	☐ Highly unstable				

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} E6						
Location: Wild Rice River-	5-		Valley Ty	_{/pe:} X						
Observers: KF , JB			Da	ate: 10/2/2011						
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected					
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)					
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2					
,	(2)	(4)	(6)	(8)						
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1					
	(1)	(2)	(3)	(4)						
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3					
	(1)		(3)							
Dominant BEHI / NBS (Worksheet 3-13)	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)	(4)	(6)	(8)						
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1					
(Worksheet 3-9)	(1)	(2)	(3)	(4)						
				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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Rice River Stream Type: E6												
Location: Wild Rice Rive	er-5-		Valley Type:	Х								
Observers: KF , JB			Date:	10/2/2011								
Vertical stability criteria	Vertical Stabi	ity Categories fo	r Excess Deposition	on / Aggradation	Selected							
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)							
Sediment 1 competence (Worksheet 3-14)	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)								
Sediment capacity (POWERSED)	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)								
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2							
	(2)	(4)	(6)	(8)								
Stream succession 4 states (Worksheet 3- 16)	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)								
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1							
3-5)	(1)	(2)	(3)	(4)								
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	3							
	(1)	(2)	(3)	(4)								
	Total points											
	Vertical stal	•	int range for exces adation	ss deposition /								
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 3-19. Vertical stability prediction for channel incision or degradation.

Str	eam: Wild Rice Riv	er		Stream Type:	E6	
Lo	cation: Wild Rice Riv	er-5-		Valley Type:	X	
Ob	servers: KF, JB			Date:	10/2/2011	
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected
s	riteria (choose one tability category for ach criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2
		(2)	(4)	(6)	(8)	
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2
		(2)	(4)	(6)	(8)	
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8
	(WOIRSHEEL 3-7)	(2)	(2) (4)		(8)	
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4
	•	(2)	(4)	(6)	(8)	
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1
	3-9)	(1)	(2)	(3)	(4)	
					Total points	17
		Vertical stab	ility category poi degra	nt range for char dation	nnel incision /	
d p	Tertical stability for hannel incision/ legradation (use total oints and check tability rating)	Not incised 9 – 11	Slightly incised 12 – 18 ✓	Moderately incised 19 – 27 □	Degradation > 27 □	

Worksheet 3-20. Channel enlargement prediction summary.

Stream: Wild Rice River Stream Type: E6											
Location: Wild Rice Rive	r-5-		Valley Type:	X							
Observers: KF, JB			Date:	10/2/2011							
Channel enlargement	Char	nnel Enlargement	Prediction Categ	ories	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)						
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2						
	(2)	(4)	(6)	(8)							
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4						
	(2)	(4)	(6)	(8)							
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2						
(Worksheet 3-18)	(2)	(4)	(6)	(8)							
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4						
(Worksheet 6 19)	(2)	(4)	(6)	(8)							
				Total points	12						
		Category p	ooint 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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Wild Rice River	Stream Type:	E6		
Lo	cation: Wild Rice River-	5-		Valley Type:	Х
Ob	servers: KF, JB			Date:	10/2/2011
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	2
•	(Worksheet 3-17)	Unstable		3	2
		Highly unsta		4	
	Vertical stability	No deposition		1	
2	excess deposition/	Mod. depos		2	1
_	aggradation	Excess depo		3	•
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci		2	2
	degradation	Mod. Incised		3	_
	(Worksheet 3-19)	Degradation		4	
	Channel enlargement	No increase		1	
4	prediction (Worksheet	Slight increa		2	2
	3-20)	Mod. increas	se	3	_
	,	Extensive		4	
	Pfankuch channel	Good: stable		1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
	10)	Poor: unsta	ble	4	
				Total Points	9
			Category p	oint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River			Location:	Wild Rice Riv	er-5-		
Observers:	KF, JB	Date:	10/2/2011	Stream	n Type: E6	Valle	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 6.98	Mean bankfull 74 width (ft):	Cross-section area (ft ²):	n 516.1	Width of flood- prone area (ft):	236	Entrenchment ratio: 3.	2
Channel Pattern	Mean: Range: MWR:	23.1 Lm/W _b	kf: 23.1	Rc/	W _{bkf} :	4.8	Sinuosity: 1.94	
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converger	nce/divergence	✓ Dunes	/antidunes/smooth bed	
River Profile and Bed	Max Riffle	Pool Depth r	ratio Riffle	Pool	Pool to Rat	0	Slope	
Features	bankfull 9.6 depth (ft):	(max/me	ean): 1.4		pool spacing:	Valley:	bankfull:	1E-05
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	gor and/or usage of existing reacl	h:
	vegetation	<u> </u>					I=	
	Flow P1, 2, Strear regime: 9 and or	der:	Meander pattern(s):	IVIZ	Depositional pattern(s):	NONE	Debris/channel blockage(s):	, 4, 5
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.6 Degree of stability rat	ing:	y incisea	Modified Pfank (numeric and a	djective ratin	g):	
	Width/depth 10.6 ratio (W/d):	Reference W/d ratio (W/d _{ref}):	10.6 Width/dep (W/d) / (W	th ratio stat /d _{ref}):	te 1.0		tio state y rating: Stable	
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of (MWR / M	confinemei WR _{ref}):	nt 1.0		/ MWR _{ref} y rating: Unconfine	ed
Bank Erosion	Length of reach	1111	mbank erosion rate		Curve used:	Remarks:		
Summary	studied (ft):	2013 (ton	s/yr) 0.20 (to	ns/yr/ft)	Fig 3-9	0:		
Sediment Capacity (POWERSED)	Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remark			
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		isting Required slope _{bkf} : slope _{bkf} :	
Successional Stage Shift	→ -	→	→	-	Existing stre state (type)		Potential stream state (type):	E6
Lateral Stability	☐ Stable 🔽	Mod. unstable Γ	Unstable	☐ Highl	ly unstable	temarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggra	adation	temarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degra	adation	temarks/cause	98:	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exter	nsive	temarks/cause	PS:	
Sediment Supply (Channel Source)	□ Low ▽	Moderate	High 🔲 Very h	igh	ks/causes:			

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

			Riparian Ve	getation	Riparian Vegetation											
Stre	eam: Wild F	Rice River		Location:	Wilc	d Rice River	-6-42.36									
	servers: KD, J		Reference reach Disturbed (impacted reach) X Date:				10/1/2011									
spe	sting cies nposition:			Potential species composition:												
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species (Percent of total species composition											
Σ				Trees			100%									
1. Overstory	Canopy layer	85%	5%													
							100%									
2. Understory	Shrub layer		20%	Shrubs			Percent of total species composition									
							100%									
evel	Herbaceous		5%	Grass, weed	ls		100%									
3. Ground leve	Leaf or needle litter		5%	Remarks: Condition, vigo usage of existir			100%									
	Bare ground		65%													
	ed on crown closure. ed on basal area to		Column total = 100%													

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

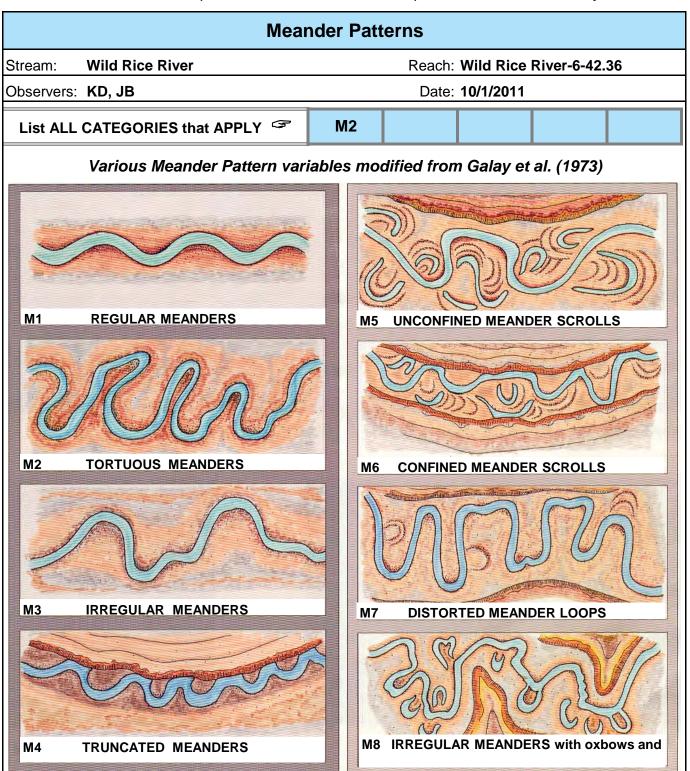
	•										
	FLOW REGIME										
Stream:	Wild Rice River		Location:	Wild Ric	e River-6	-42.36					
Observers:	KD, JB						Date:	10/1/201	1		
List ALL	COMBINATIONS that	P1	P2	P9							
APF	PLY	F1	FZ	ГЭ							
General Category											
E	E Ephemeral stream channels: Flows only in response to precipitation										
S	Subterranean stream cl surface flow that follows			llel to and	I near the	surface fo	or various	seasons	- a sub-		
ı	Intermittent stream cha associated with sporadi losing/gaining reaches	c and/or s	seasonal f	lows and	also with	Karst (lim	estone) g	jeology wl	here		
Р	Perennial stream chanr	nels: Surf	face water	persists	yearlong.						
Specific (Category										
1	Seasonal variation in st	reamflow	dominated	d primaril	y by snow	melt runo	ff.				
2	Seasonal variation in st	reamflow	dominate	d primaril	y by storn	nflow runc	off.				
3	Uniform stage and asso	ciated str	reamflow o	lue to spr	ing-fed co	ondition, b	ackwater	, etc.			
4	Streamflow regulated b	y glacial r	melt.								
5	Ice flows/ice torrents fro	om ice da	m breache	·S.							
6	Alternating flow/backwa	iter due to	tidal influ	ence.							
7	Regulated streamflow of	lue to dive	ersions, da	ım releas	e, dewate	ering, etc.					
8	Altered due to developr conversions (forested to										
9	Rain-on-snow generate	d runoff.									

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

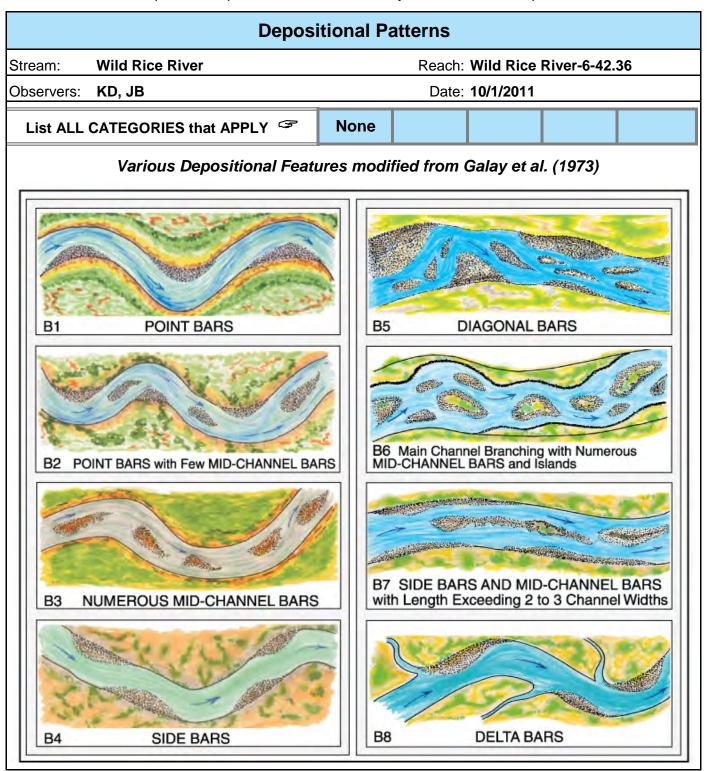
	Stream Size and Order										
Stream:	Wild Rice Rive	er									
Location:	Wild Rice Rive	er-6-42.36									
Observers:	KD, JB										
Date:	10/1/2011										
Stream Size Category and Order S-7											
STREAM SIZE: Bankfull Check (✓) Category width appropriate											
	meters	feet	category								
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 categori	as in naranthasis	for enacific etrasi	m order of								

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

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



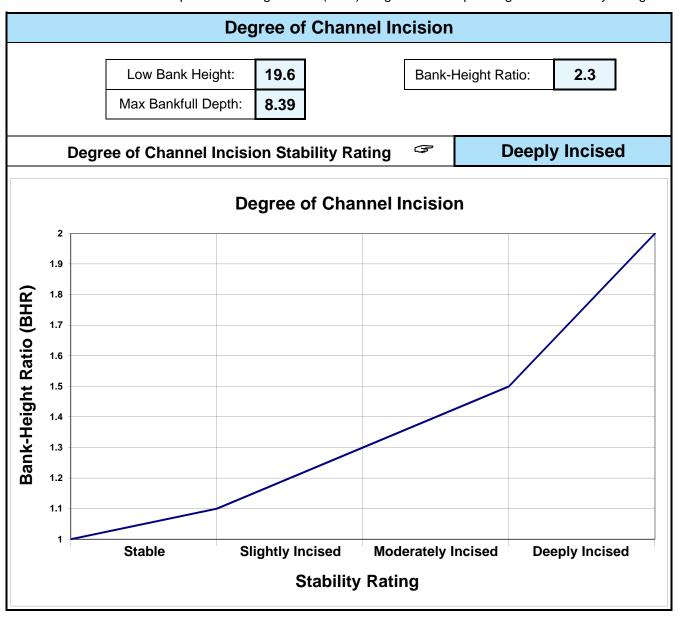
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



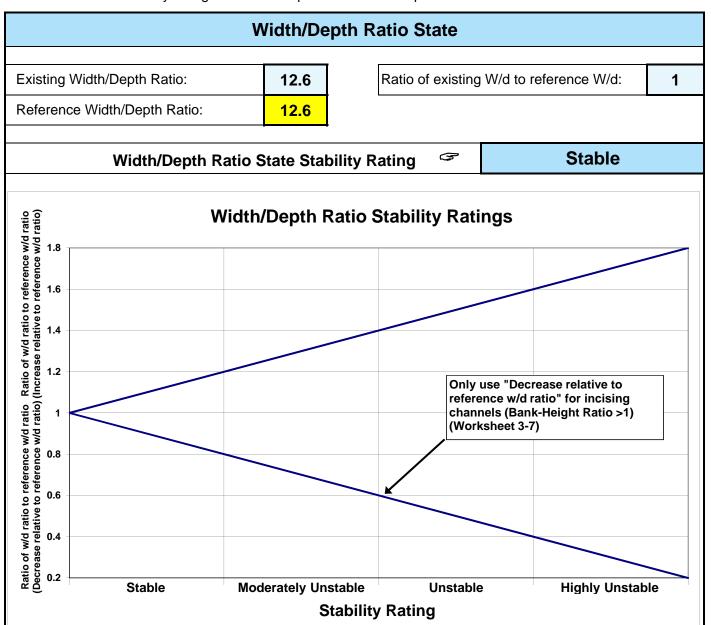
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

		Channel Blockages				
Stream	m: Wild Rice F	River Location: Wild Rice River-6-42.36				
Obser	rvers: KD, JB	Date: 10/1/2011				
Desc	ription/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.	7			
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.	>			
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.	>			
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.				
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.				
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.				
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.				
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.				
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.				
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.				

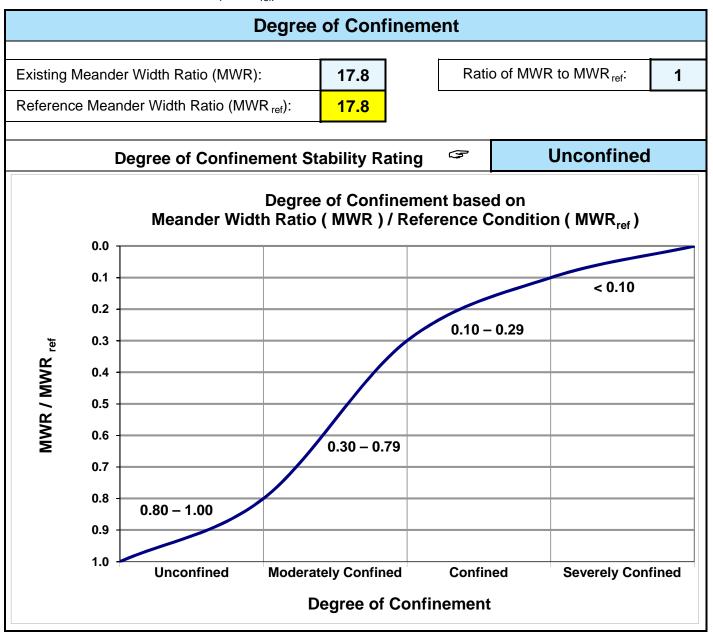
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



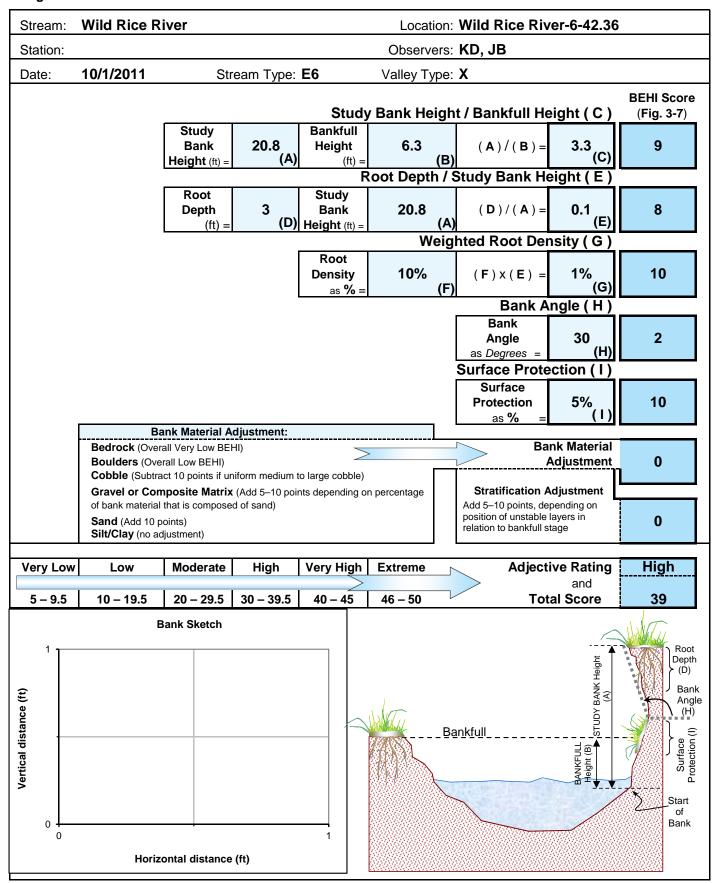
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Wild	Rice R	River				Loc	ation:	Wild	Rice F	River-	6-42.3		Valley	Type:	Χ		Obse	ervers:	KD, J	JB				Date: 10/1/201	1
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor	
tion	Key	Catego	Ory			Descriptio	n		Rating			Description	n		Rating			Description	n		Rating			Descri	ption	Rating
ω.	1	Landform slope	1	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-4 0%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe grad	ient >	60%.	8
banks	2	Mass ero	sion	No eviderosion.		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6	Frequent or large, causing sediment nearly yearlong.			9				sing sediment nearly danger of same.	12		
Upper	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma	_		4	larger s	izes.	-	ounts, m	-	6	Moderate predomin	nantly la	irger s	izes.	8
ס	4	Vegetativ bank protection			a deep	nsity. Vi , dense	_		3		or sugg	y. Fewer est less			6	fewer s		rom a sl		nd	9		icating p	oor, d	rer species and less discontinuous and	12
	5	Channel capacity		stage. Wid	dth/depth i width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/dep width/dep (BHR) = 1	oth ratio	3	common w	ith flows le	ess than referenc	ed; over-bank flows are bankfull. Width/depth e width/depth ratio > 1.4. .3.	4
nks	6	Bank rock content		12"+ co	mmon.	je angula			2	40–65% cobbles		y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	neter	6	or less.			of gravel sizes, 1–3"	8
Lower banks	7	Obstruction to flow	ons	pattern	ocks and logs firmly imbedded. Flow attern w/o cutting or deposition. table bed.			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	cause ba	ank eros	ion ye	and deflectors earlong. Sediment ration occurring.	8	
Low	8	Cutting		Little or <6".	none. lı	nfrequer	nt raw ba	anks	4			ently at o aw bank			6	_			" high. F ughing e		12				s, some over 24" ings frequent.	16
	9	Depositio	on	Little or point ba		irgement	t of char	nel or	4	Some n		increase	e, mostly	/ from	8		arse san		new gra I and so		12				eposit of predominantly fine ccelerated bar development.	
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e	•		2	Corners dimens		lges we	l rounde	ed in 2	3	Well roui smooth.			nensions, surfaces	4
	11	Brightnes		Surface General		lark or st right.	tained.			surface	3.	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predomi scoured	,	0 /	> 65%, exposed or	4
E	12	Consolidat particles		overlap	ping.	tightly pa			2	Modera overlap		ked with	some		4		loose as nt overla		nt with n	0	6	No packi easily mo		ent. Lo	oose assortment,	8
Bottom	13	Bottom si distributio		No size material	•	e evident 0%.	. Stable		4	50–80%	· .	it light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable	16
_	14	Scouring deposition		<5% of depositi		affected	by scou	ır or	6	constric	0% affected. Scour at strictions and where grades spen. Some deposition in pools.		12	at obstr		constri			18	More tha flux or ch			bottom in a state of earlong.	24		
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				e or absent. Yellow- m may be present.	4
						Exc	ellent	total =	21				Good	total =	0				Fair	total =	18				Poor total =	44
Stream ty	/pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	В5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6			
Good (Stab			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		67-98		Grand total =	83
Fair (Mod. u	unstable	44-47	44-47 48+		96-132 133+		81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+							32 108-132 99-125 Exis		Existing stream type =	E6	
Stream ty	_		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6				*Potential							
Good (Stab	-		40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107			stream type =	E6				
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified cha	nnel
Poor (Unsta			87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability ratio	
		•															*Ra	ting is a	djusted t	to poten	tial strea	ım type, r	not exist	ing.	Fair	
																		-						-		

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

CIOSIO	erosion rate.											
			Estim	ating Nea	r-Bank St	ress (NB	S)					
Stream	: Wild R	ice River			Location:	Wild Rice	River-6-42	.36				
Station	: 0			S	tream Type:	E6	\	/alley Type:	X			
Observ	ers:	KD, JB						Date:	10/1/11			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Cha	nnel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Recona	issance			
(2) Rati	o of radius o	of curvature to b	ankfull width (F	R _c / W _{bkf})			Level II	General	prediction			
(3) Rati	o of pool slo	pe to average	water surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Rati	o of pool slo	pe to riffle slop	e (S _p /S _{rif})				Level II	General	prediction			
(5) Rati	o of near-ba	ınk maximum d	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6) Rati	o of near-ba	ınk shear stress	to bankfull she	ear stress (τ _{nb} /	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Velo	city profiles	/ Isovels / Velo	city gradient				Level IV	Valid	lation			
=		Transverse a	nd/or central b	ars-short and	or discontinuo	ous		NBS = Hig	h / Very High			
Level	(1)		position (conti									
<u> </u>			, down-valley	meander mig	ration, conver	ging flow		NE	3S = Extreme			
		Radius of Curvature	Bankfull	Ratio R _c /	Near-Bank							
	(2)	R _c (ft)	Width W _{bkf} (ft)	W _{bkf}	Stress (NBS)							
		0 ()	(1-7	DRI	(1)							
					Near-Bank							
Level II	(0)	Pool Slope	Average		Stress		Dom	inant				
ě	(3)	S _p	Slope S	Ratio S _p / S	(NBS)	Ī	Near-Bar	nk Stress				
_							Very	Low				
					Near-Bank				-			
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress							
	``	S _p	S _{rif}	S _{rif}	(NBS)							
		Near Ponk										
		Near-Bank Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress							
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)							
=												
Level III				Near-Bank			Bankfull					
ت		Near-Bank	Near-Bank	Shear			Shear	Ratio τ _{nb} /	Near-Bank			
	(6)	Max Depth	Slope S _{nb}	Stress τ_{nb} (lb/ft^2)	Mean Depth	Average	Stress τ _{bkf} (Stress			
		d _{nb} (ft)	Siera elib	ID/IL)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
				Noor Danie								
Level IV	(-)	Velocity Grad	dient (ft/sec	Near-Bank Stress								
eve	(7)	/ f		(NBS)	,							
		0.	04	Very Low								
		Col	nverting Va	alues to a N	Near-Bank	Stress (NF	S) Rating					
Near-	Bank Str	ess (NBS)	70.111.9			ethod numb						
	rating	ıs	(1)	(2)	(3)	(4)	(5)	(6)	(7)			
	Very L	ow	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			
	Modera	ate	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 H	-	(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			
	Extrer	ne	Above < 1.50 > 1.00 > 1.20 > 3.00 > 1.60 > 2.40									
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Wild Rice Rive	ſ		Location:	Wild Rice R	iver-6-42.36			
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	9723.3		Date:	10/1/2011		
Observers:	KD, JB		Valley Type:			Stream Type:			
(1)	(2)	(3)	(4) Bank	(5)	(6) Study bank	(7)	(8) Erosion		
Station (ft)	BEHI rating (Worksheet 3-11) (adjective)	NBS rating (Worksheet 3-12) (adjective)	erosion rate (Figure 3-9 or 3-10) (ft/yr)	Length of bank (ft)	height (ft)	subtotal [(4)×(5)×(6)] (ft ³ /yr)	Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}		
1.	High	Very Low	0.165	9723.3	20.8	33370	0.17		
2.						0	#DIV/0!		
3.						0	#DIV/0!		
4.						0	#DIV/0!		
5.						0	#DIV/0!		
6.						0	#DIV/0!		
7.						0	#DIV/0!		
8.						0	#DIV/0!		
9.						0	#DIV/0!		
10.						0	#DIV/0!		
11.						0	#DIV/0!		
12.						0	#DIV/0!		
13.						0	#DIV/0!		
14.						0	#DIV/0!		
15.						0	#DIV/0!		
Sum erosion subtotals in Column (7) for each BEHI/NBS combination Total Erosion (ft³/yr) 33370									
Convert eros	sion in ft ³ /yr to yd	s ³ /yr {divide T	otal Erosion (t	ft ³ /yr) by 27}	Total Erosion (yds³/yr)	1236			
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	1607			
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/fft) 0.17									

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

Stream:	Wild Rice	River	S	tream Type:	E6				
Location:	Wild Rice	River-6-42.36		Valley Type:					
Observers:	KD, JB			Date:	10/1/2011				
Enter Req	uired Infor	mation for Existing Cond	lition						
	D ₅₀	Riffle bed material D ₅₀ (mn	n)						
	D ₅₀	Bar sample D ₅₀ (mm)							
0	D _{max}	Largest particle from bar sa	ample (ft)		(mm)	304.8 mm/ft			
	S	Existing bankfull water surf	face slope (ft/ft)						
d Existing bankfull mean depth (ft)									
1.65	γ_{s}	Submerged specific weight	t of sediment						
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress									
#DIV/0! D_{50}^{1}/D_{50}^{1} Range: 3 – 7 Use EQUATION 1: $\tau^* = 0.0834 (D_{50}^{1}/D_{50}^{1})^{-0.872}$									
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}			
#DIV/0!	τ*	Bankfull Dimensionless Sh	ear Stress	EQUATIO	ON USED:	#DIV/0!			
Calculate	Bankfull Me	an Depth Required for En	trainment of Larges	t Particle ir	Bar Sampl	е			
#DIV/0!	d	Required bankfull mean de	epth (ft) $d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading							
Calculate Sample	Bankfull W	ater Surface Slope Requ	ired for Entrainmer	nt of Large	st Particle	in Bar			
#DIV/0!	s	Required bankfull water su	rface slope (ft/ft) S:	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)			
	Check:	☐ Stable ☐ Aggrading	□ Degrading						
Sediment	Competen	ce Using Dimensional Sh	near Stress						
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²)	(substitute hydraulic ra	dius, R, with	mean depth,	d)			
	$\gamma = 62.4, c$	d = existing depth, S = existing	g slope						
	Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)								
	Predicted	shear stress required to initia	te movement of measu	ıred D _{max} (m	m) (Figure 3	-11)			
#DIV/0!	#DIV/0! Predicted mean depth required to initiate movement of measured D_{max} (mm) $d = \frac{\tau}{v^2}$								
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, S slope required to initiate mov	ement of measured D _m	_{nax} (mm)	$S = \frac{T}{2d}$)			
	τ = predic	ted shear stress, γ = 62.4, d	existing depth		γd				

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	nt / Sid	e BAR	-BULK	MATE	RIALS	SAMP	LE DA	TA: S	ize Dis	tributio	n Anal	ysis	Obse	ervers:	KD, J	В				
u b	Strea	am:	Wild F	Rice R	ver				Loca	tion:	Wild F	Rice R	iver-6-	42.36					Date: 10/	1/2011	
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(⇒ (<u> </u>	⇒(⇒(
s a		h Pan ICKET	Sieve	SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm			
m p		weight	Tare	weight	Tare	weight	Tare v			veight	Tare \		Tare	weight	Tare v		Tare v	veight		URFACE	
i				9		9													M.A	ATERIAL DATA	.S
e s	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample		(Two la	argest pa	rticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	No.	Dia.	WT.
2																			1	Dia.	VV 1.
3																			2		
4																			Bucket +		
5																			materials weight		
7																	-		Bucket tare		
8																			weight		
9																			Materials		
10																			weight		0
11																	-		Materials less than:		
13																			 	Be sure to	mm
14																				separate n veights to	naterial
15																				otal	granu
Net wt		0		0		0		0		0		0		0		0		0		7_	
-	and total	##### #####		##### #####		##### #####		##### #####		##### #####		##### #####	4	##### #####	1 1 1	##### #####	4	##### 100%			
7.00011	1. 70 – 1	ппппп		ппппп		ппппп		mmmm		ппппп		ппппп		ппппп		ппппп		10070	J GF	RAND TO	IAL
S	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream:	Wild Rice River	Stream Type: E6		
Location:	Wild Rice River-6-42.36	Valley Type: X		
Observers:	KD, JB	Date: 10/1/2011		
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)		
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable		
	(E→C), (C→High W/d C)			
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable		
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable		

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wild Rice River			Stream Ty	_{/pe:} E6				
Location: Wild Rice River-6	5-42.36		Valley Ty	_{/pe:} X				
Observers: KD, JB			Da	ate: 10/1/2011				
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected			
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)			
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2			
	(2)	(4)	(6)	(8)				
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1			
	(1)	(2)	(3)	(4)				
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		3			
	(1)		(3)					
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)				
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1			
(Worksheet 3-9)	(1)	(2)	(3)	(4)				
Total points								
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wild Ric	e River		Stream Type:	E6				
Location: Wild Ric	e River-6-42.36		Valley Type:	Х				
Observers: KD, JB			Date:	10/1/2011				
Vertical stability cr	iteria	bility Categories fo	r Excess Deposition	on / Aggradation	Selected			
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)			
Sediment 1 competence (Worksheet 3-14	Sufficient depth and/or slope to transport larges size available	and/or slope-	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)				
Sediment capaci (POWERSED)	Sufficient capacity to transport annual load	Trend toward insufficient al 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)				
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2			
		2) (4)	(6)	(8)				
Stream successi 4 states (Workshe 16)			(C→High W/d C), (B→High W/d B), (C→F)	(C→D), (F→D)	2			
	(2) (4)	(6)	(8)				
Depositional 5 patterns (Works 3-5)	neet B1	B2, B4	B3, B5	B6, B7, B8	1			
3-3)	((1)	(3)	(4)				
Debris / blockag (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1			
	(1) (2)	(3)	(4)				
Total points								
Vertical stability category point range for excess deposition / aggradation								
Vertical stability fo excess deposition aggradation (use to points and check sta rating)	No deposition	Moderate n deposition 15 – 20	Excess deposition 21 – 30	Aggradation > 30				

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

Str	ream: Wild Rice Riv	er		Stream Type:	E6		
Lo	cation: Wild Rice Riv	er-6-42.36		Valley Type:	X		
Ob	oservers: KD, JB			Date:	10/1/2011		
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected	
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)	
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
		(2)	(4)	(6)	(8)		
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
		(2)	(4)	(6)	(8)		
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	8	
	(WOIRSHEEL 3-7)	(2)	(4)	(6)	(8)		
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4	
		(2)	(4)	(6)	(8)		
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1	
	3-9)	(1)	(2)	(3)	(4)		
					Total points	17	
Vertical stability category point range for channel incision / degradation							
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Stream: Wild Rice River	r		Stream Type:	E6				
Location: Wild Rice River	r-6-42.36		Valley Type:	Х				
Observers: KD, JB			Date:	10/1/2011				
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected			
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)			
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2			
	(2)	(4)	(6)	(8)				
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	4			
	(2)	(4)	(6)	(8)				
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2			
(Worksheet 3-18)	(2)	(4)	(6)	(8)				
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4			
(Worksheet 3-13)	(2)	(4)	(6)	(8)				
	Total points							
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Wild Rice River			Stream Type:	E6				
Lo	cation: Wild Rice River-	6-42.36		Valley Type:	Χ				
Ob	servers: KD, JB			Date:	10/1/2011				
p c	Overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points				
		Stable		1					
1	Lateral stability	Mod. unstab	ole	2	2				
! '	(Worksheet 3-17)	Unstable		3	2				
		Highly unsta	able	4					
	Vertical stability	No deposition	on	1					
2	excess deposition/	Mod. depos	ition	2	1				
-	aggradation	Excess dep	osition	3	1				
	(Worksheet 3-18)	Aggradation	1	4					
	Vertical stability	Not incised		1					
3	channel incision/	Slightly inci	sed	2	2				
ľ	degradation	Mod. Incised	d	3	2				
	(Worksheet 3-19)	Degradation	1	4					
	Channal anlargement	No increase		1					
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	2				
~	3-20)	Mod. increa	se	3	2				
	0 20)	Extensive		4					
	Pfankuch channel	Good: stable	e	1					
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2				
ľ	10)								
	10)	Poor: unsta	ble	4					
	Total Points 9								
	Category point range								
ra	Overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ☑	High 11 – 15 □	Very High 16 – 20 □				

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wild Rice River			Location:	Wild Rice Riv	er-6-42.36		
Observers:	KD, JB	Date:	10/1/2011	Strean	n Type: E6	Valle	у Туре: Х	
Channel Dimension	Mean bankfull depth (ft): 6.07	Mean bankfull 76 width (ft):	.21 Cross-section area (ft²):	n 462.2	Width of flood- prone area (ft):	157.6667	Entrenchment ratio:	2.1
Channel Pattern	Mean: Range: MWR:	17.8 Lm/W _b	kf: 17.8	Rc	/W _{bkf} :	4.3	,	2.7
	Check: Riffle/pool	☐ Step/pool ☐	Plane bed	Converge	nce/divergence	✓ Dunes	antidunes/smooth bed	b
River Profile and Bed	Max Riffle	Pool Depth r	atio	Pool	Pool to Rat	io	Slope	
Features	bankfull depth (ft):	(max/me	ean): 1.4		pool spacing:	Valley:	Average bankfull:	8.8E-05
	Nipanan	nt composition/density:	Potential compos	ition/density:	Remark	s: Condition, vig	or and/or usage of existing	reach:
	vegetation	<u> </u>					I=	
	Flow P1, 2, Strear regime: 9 and or	rder:	Meander pattern(s):	M2	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D1-3
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	2.3 Degree of stability rat	ing:	y Incised	Modified Pfank (numeric and a	djective rating	g):	nir
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12.6 Width/dep (W/d) / (W		te 1.0		tio state y rating:	ble
	Meander Width Ratio (MWR):	17.8 Reference MWR _{ref} :	Degree of (MWR / M		ent 1.0		/ MWR _{ref} y rating: Unco r	nfined
Bank Erosion Summary	Length of reach studied (ft):	23	mbank erosion rate s/yr) 0.17 (to	e: ns/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	s capacity	Remark	s:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Require depth _{bkf} :		sting Requir	
Successional Stage Shift	→ -	→	→	→	Existing strestate (type)		Potential stream state (type):	E6
Lateral Stability	☐ Stable 	₹ Mod. unstable Γ	Unstable	☐ High	ly unstable	Remarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggr	radation	demarks/cause	es:	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	☐ Degr	radation	demarks/cause	es:	
Channel Enlargement	☐ No increase ☑	Slight increase	Mod. increase	☐ Exte	nsive	temarks/cause	es:	
Sediment Supply (Channel Source)	□ Low ▼	Moderate	High 🔲 Very h	igh	rks/causes:			

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

			Riparian Ve	getation				
		erton Creek	Reference	Location: Wolverton Creek - 1 - 0.64 Disturbed (impacted X				
Exis	Observers: KP, AL reach Existing species composition:			reach) Date: Potential species composition:	11/19/2010			
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition	Percent of total species composition			
1. Overstory	Canopy layer							
		<u> </u>			100%			
2. Understory	Shrub layer							
					100%			
level	Herbaceous							
3. Ground level	Leaf or needle litter			Remarks: Condition, vigor and/or usage of existing reach:	100%			
	Bare ground			None				
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%					

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

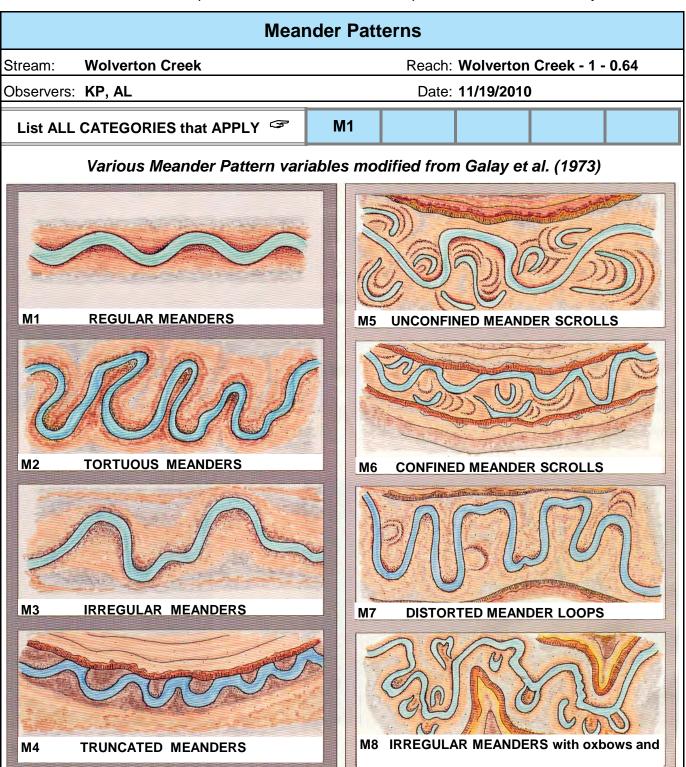
noiogical interpretations.											
FLOW REGIME											
Stream:	Wolverton Creek		Location:	Wolverto	on Creek	- 1 - 0.64					
Observers:	KP, AL						Date:	11/19/20	10		
	COMBINATIONS that	P1	P2	P9							
APF	APPLY										
General Category											
E	Ephemeral stream chai	nnels: Flo	ows only in	respons	e to precij	pitation					
S	Subterranean stream c surface flow that follows			llel to and	l near the	surface fo	or various	seasons	- a sub-		
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.										
Р											
Specific (Category										
1	Seasonal variation in st	treamflow	dominated	d primarily	y by snow	melt runc	off.				
2	Seasonal variation in st	treamflow	dominated	d primarily	y by storn	nflow runc	off.				
3	Uniform stage and asso	ociated st	reamflow o	due to spr	ing-fed co	ondition, b	ackwater	, etc.			
4	Streamflow regulated b	y glacial r	melt.								
5	Ice flows/ice torrents fro	om ice da	m breache	es.							
6	Alternating flow/backwa	ater due to	o tidal influ	ence.							
7	7 Regulated streamflow due to diversions, dam release, dewatering, etc.										
8	Altered due to develope conversions (forested to										
9	Rain-on-snow generate	ed runoff.									

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

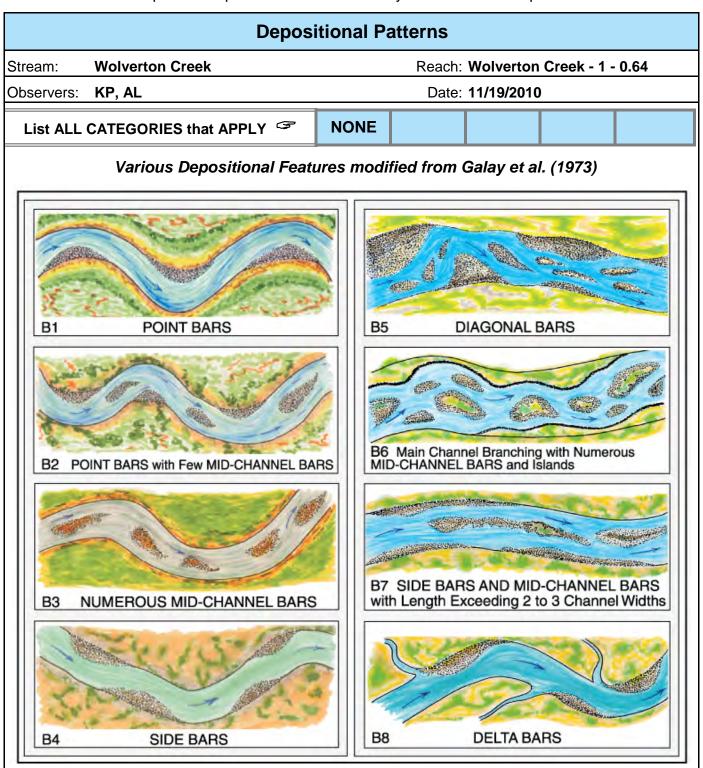
Stream Size and Order									
Stream:	Stream: Wolverton Creek								
Location:	Wolverton Cre	ek - 1 - 0.64							
Observers:	KP, AL								
Date:	11/19/2010								
Stream Siz	e Category and	l Order 🤝	S-4						
Category		ZE: Bankfull dth	Check (✓) appropriate						
	meters	feet	category						
S-1	0.305	<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								
S-13	>305	>1000							
	Strear	n Order							
Add categoria	Add categories in parenthesis for specific stream order of								

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

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



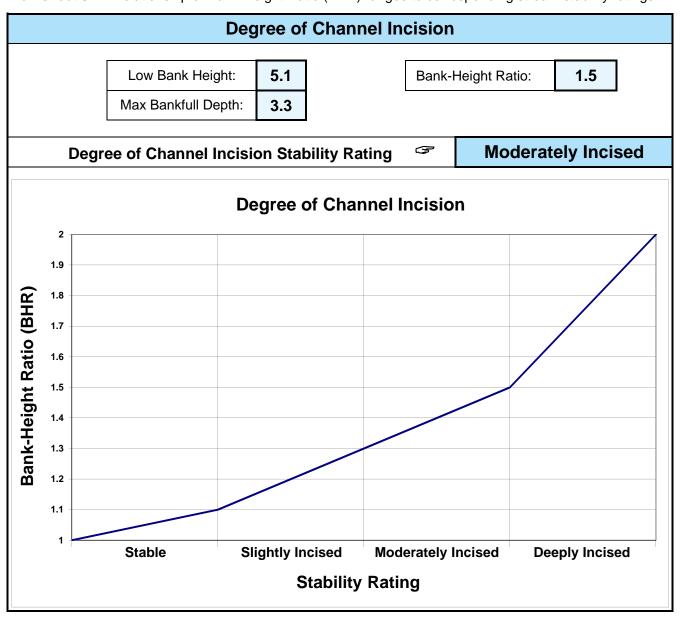
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



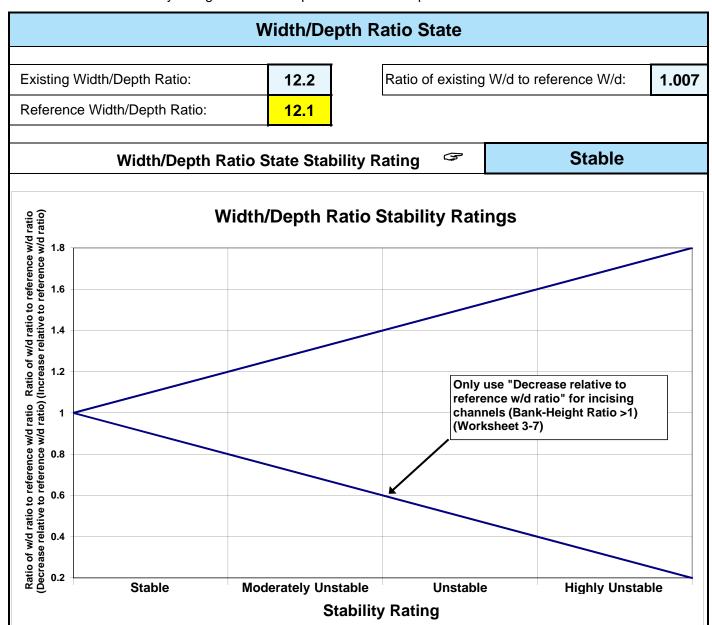
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

Channel Blockages			
Stream: Wolverton Creek		k Location: Wolverton Creek - 1 - 0.64	
Observers: KP, AL Date: 11/19/2010			
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.	Y
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.	>
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.	
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.	
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.	
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.	
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.	

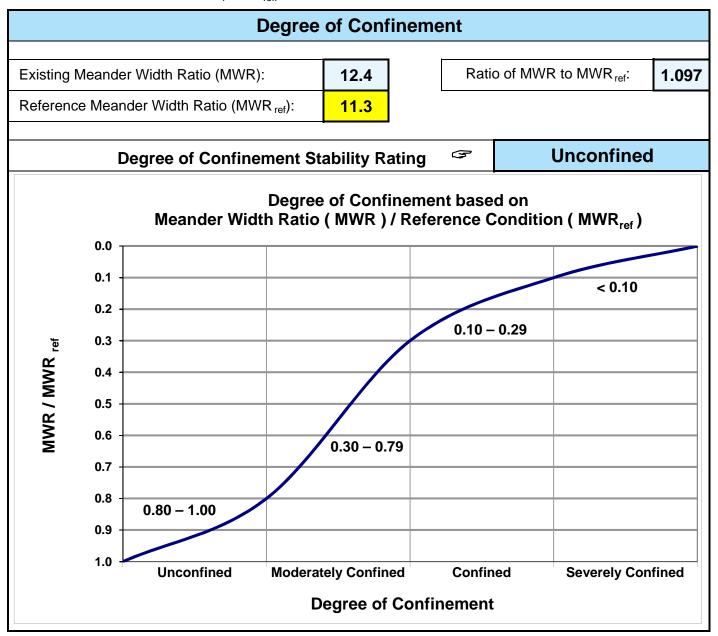
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



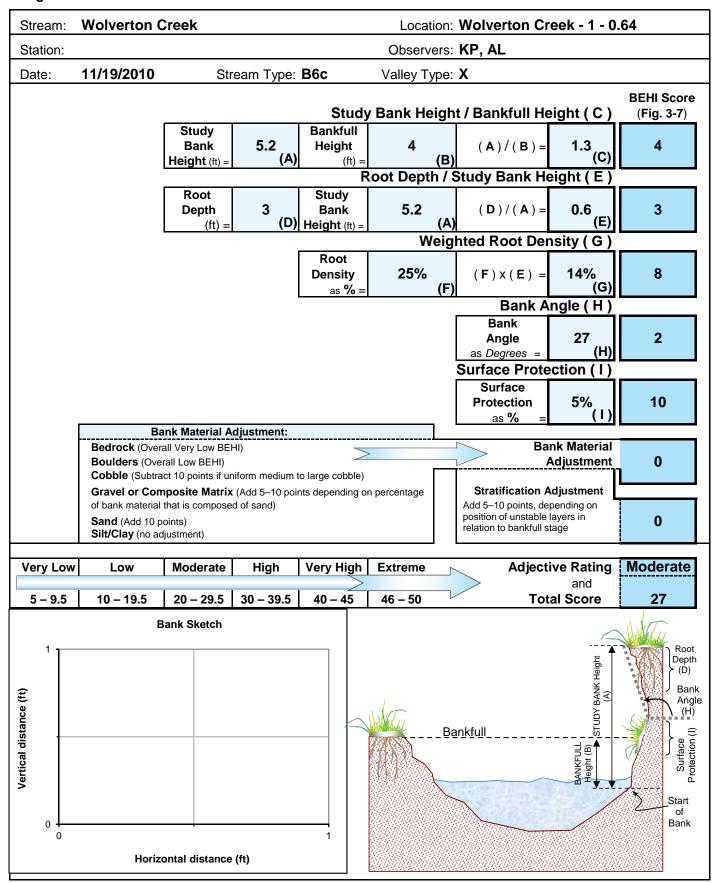
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Wolv	erton/	Cree	k			Loc	ation:	Wolve	erton	Creek	(- 1 - (Valley	Type:	Χ		Obse	ervers:	KP, A	۸L		Date: 11/19/2010				
Loca-	Key	Categ	iorv			Exce	llent					Go	od					Fa	air						Poor		
tion	Rey	Caleg	JOI y			Descriptio	n		Rating		D	Description	n		Rating		[Description	on		Rating			Descr	iption		Rating
6	1	Landform slope	n	Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope grad	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	- 60%.		6	Bank slo	ope gra	adient >	60%.		8
Upper banks	2	Mass ero	osion	No eviderosion.		past or	future m	ass	3	Infreque future p		stly heale	ed over.	Low	6		nt or larg		sing sed	iment	9				sing sediment not danger of same		12
pper	3	Debris ja potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	sizes.		ounts, m		6	Moderat predomi	inantly	larger s	sizes.		8
D	4	Vegetative bank protection			t a deep	nsity. Vi , dense			3		or sugg	y. Fewer est less			6	fewer s		rom a sl		ınd	9		dicating	poor,	ver species and l discontinuous an		12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	th ratio de th ratio = 1	ntained wit eparture fro 1.0-1.2. Ba	m referer	nce	2	Bankfull s ratio depa	stage is no arture from	t containe reference	d. Width/d	oth ratio	3	common v	vith flows rture fron	less than	ed; over-bank flows a bankfull. Width/dept ce width/depth ratio > 1.3.	n	4
nks	6	Bank roc content	:k	12"+ co	mmon.	je angula				40–65%. Mostly boulders and small cobbles 6–12".			small	4	20–40%. Most in the 3–6" diameter class.			6	or less.			of gravel sizes,	-3"	8			
Lower banks	7	Obstructi to flow	ions		w/o cutt	firmly in			2	currents fewer an	and mind d less firr		ing. Obs	tructions	4		th high flo		able obst sing bank		6	cause b	ank er	osion ye	and deflectors earlong. Sediment ration occurring.	it	8
Low	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks				ently at o aw bank			6				l" high. I ughing (12				s, some over 24 angs frequent.		16
	9	Depositio	on	Little or point ba		irgemen	t of char	nnel or	4	Some n		increase	, mostly	/ from	8	Modera and coa new ba	arse san		new gra		12				redominantly fin bar developmen		16
	10	Rock angularity		surfaces	s rough.			е	1			rs and e th and fla	•		2	Corners dimens		lges we	ll rounde	ed in 2	3	Well rou smooth.		n all din	nensions, surfac	es	4
	11	Brightnes		General	lly not b				1	surface	S	may hav		6 bright	2	Mixture mixture		d bright,	i.e., 35-	-65%	3	Predom scoured			> 65%, exposed	or	4
E	12	Consolidate particles		overlap	ping.	tightly pa			2	overlap	oing.	ked with			4		loose as nt overla		nt with n	10	6	No pack easily m	-	dent. L	oose assortment	'	8
Bottom	13	Bottom s distribution		No size material	_	e evident 0%.	. Stable		4	50–80%	· .	t light. S		aterial	8	materia	ıls 20–50	0%.	zes. Stal		12	Marked material			ange. Stable		16
	14	Scouring depositio		<5% of depositi		affected	by scou	ır or	6	constric	tions an	I. Scour Id where depositi	grades		12	at obstr		constri			18				bottom in a state yearlong.	of	24
	15	Aquatic vegetatio			•	th moss I. In swif						e forms i Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a		wth	3				e or absent. Yellom may be prese		4
						Exc	ellent	total =	21				Good	total =	4				Fair	total =	21				Poor to	al =	32
Stream ty	ne	A1	A2	А3	A4	A5	A6	B1	B2	В3	В4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6	ī			
Good (Stabl	le)	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		Grand total	=	78
Fair (Mod. u Poor (Unsta	ble)	48+	44-47 48+	91-129 130+	96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+	86-105 106+	91-110	91-110	106+	133+	108-132	108-132 133+	99-125 126+		Existing stream type	=	В6с
Stream ty	_		DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6				*Potential		В6с
Good (Stabl			40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110		80-95	40-60	40-60	85-107							stream type		
Fair (Mod. u			64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105		111-125					61-78	108-120			108-120				Modified		
Poor (Unsta	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+ *Ra	121+ ting is a	121+ diusted	126+	121+ itial strea	ım tyne	not exi	sting	stability Fa) =
	*Rating is adjusted to potential stream type, not existing.														io poter	га											

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	rate.									
			Estim	ating Nea	r-Bank St	ress (NB:	S)			
Stream:	Wolver	ton Creek			Location:	Wolvertor	Creek - 1	- 0.64		
Station:	0			S	tream Type:	B6c	\	√alley Type:	X	
Observe	rs:	KP, AL						Date:	11/19/10	
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)			
(1) Chanı	nel pattern	, transverse ba	r or split channe	el/central bar cr	eating NBS		Level I	Reconaissance		
(2) Ratio	of radius o	f curvature to b	ankfull width (I	R _c / W _{bkf})	Level II	General	prediction			
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)	Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction	
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction	
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ_{nb}	′ τ _{bkf})		Level III	Detailed	prediction	
(7) Veloc	ity profiles	/ Isovels / Velo	city gradient				Level IV	Valid	dation	
Levell	(1)									
				meander mig		ging now		INE	שט = ⊏xiieine	
		Radius of Curvature	Bankfull Width W _{bkf}	Ratio R _c /	Near-Bank Stress					
	(2)	R _c (ft)	(ft)	W _{bkf}	(NBS)					
_					Near-Bank					
ell	(3)	Pool Slope	Average		Stress			inant		
Level II	(3)	S _p	Slope S	Ratio S _p / S	(NBS)			nk Stress		
_							Very	Low		
					Near-Bank					
	(4)	Pool Slope	Riffle Slope	Ratio S _p /	Stress					
	()	S _p	S _{rif}	S _{rif}	(NBS)					
		Near-Bank								
		Max Depth	Mean Depth	Ratio d _{nb} /	Near-Bank Stress					
	(5)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)					
=										
Level III				Near-Bank			Bankfull			
Le		Near-Bank	Noor Ponk	Shear			Shear	Datia - /	Near-Bank	
	(6)	Max Depth	Near-Bank	Stress τ _{nb} (Mean Depth	Average	Stress τ _{bkf} (Ratio τ _{nb} /	Stress	
		d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)	
2		Velocity Grad	dient (ft/sec	Near-Bank Stress						
Level IV	(7)	/ f		(NBS)						
Ľ				Very Low						
		0	worting V	luga ta a l	Joor Pont	Ctross /NF	OC) Detine			
Near-B	ank Str	ess (NBS)	iverting Va	ilues to a f	Near-Bank	Stress (NE ethod numb				
146ai-B	rating		(1)	(2)	(3)	(4)	(5)	(6)	(7)	
	Very Lo		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	
	Modera		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 Hi		(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	
	Extrem	_	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40	
					ear-Bank S				Low	

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Wolverton Cree	ek		Location:	Wolverton C	Creek - 1 - 0.64	1	
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	2165.2		Date:	11/19/2010	
Observers:	KP, AL		Valley Type:			Stream Type:		
(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)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}	
1.	Moderate	Very Low	0.092	2165.2	5.2	1036	0.02	
2.						0	#DIV/0!	
3.						0	#DIV/0!	
4.						0	#DIV/0!	
5.						0	#DIV/0!	
6.						0	#DIV/0!	
7.						0	#DIV/0!	
8.						0	#DIV/0!	
9.						0	#DIV/0!	
10.						0	#DIV/0!	
11.						0	#DIV/0!	
12.						0	#DIV/0!	
13.						0	#DIV/0!	
14.						0	#DIV/0!	
15.						0	#DIV/0!	
Sum erosior	n subtotals in Colu	umn (7) for eac	ch BEHI/NBS	combination	Total Erosion (ft ³ /yr)	1036		
Convert erosion in ft ³ /yr to yds ³ /yr {divide Total Erosion (ft ³ /yr) by 27} Total Erosion (yds ³ /yr) 38								
Convert eros by 1.3}	sion in yds ³ /yr to t	tons/yr {multip	ly Total Erosi	on (yds ³ /yr)	Total Erosion (tons/yr)	50		
	osion per unit len total length of stre			Erosion	Total Erosion (tons/yr/ft)	0.02		

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

Stream:	Wolverton	Creek	St	ream Type:	B6c					
Location:	Wolverton	Creek - 1 - 0.64	\	/alley Type:	Х					
Observers:	KP, AL			Date:	11/19/2010	1				
Enter Req	uired Infor	mation for Existing Condition	on							
	D ₅₀	Riffle bed material D ₅₀ (mm)								
	D ₅₀	Bar sample D ₅₀ (mm)								
	D _{max}	Largest particle from bar samp	ole (ft)		(mm)	304.8 mm/ft				
	S	Existing bankfull water surface	e slope (ft/ft)							
	d	Existing bankfull mean depth (ft)							
1.65	γ_s	Submerged specific weight of	sediment							
Select the	Appropria	te Equation and Calculate C	Critical Dimensio	nless She	ar Stress					
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7 U	se EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}				
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0 U	se EQUATION 2:	$\tau^* = 0.038$	4 (D _{max} /D ₅	₀) ^{-0.887}				
#DIV/0!	τ*	Bankfull Dimensionless Shear	Stress	EQUATIO	ON USED:	#DIV/0!				
Calculate	Bankfull Me	an Depth Required for Entrai	nment of Largest	Particle in	Bar Sampl	е				
#DIV/0!	d	Required bankfull mean depth	(ft) $d = \frac{\tau}{}$	* $\gamma_s D_{max}$	- (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐								
Calculate Sample	Bankfull W	ater Surface Slope Require	d for Entrainmen	t of Large	st Particle	in Bar				
#DIV/0!	s	Required bankfull water surface	ce slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$) _{max} (use	D _{max} in ft)				
	Check:	☐ Stable ☐ Aggrading ☐	Degrading							
Sediment	Competen	ce Using Dimensional Shea	r Stress							
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (sub	ostitute hydraulic rad	dius, R, with	mean depth,	d)				
U	$\gamma = 62.4, c$	d = existing depth, S = existing start S = existi	ope							
	Predicted largest moveable particle size (mm) at bankfull shear stress τ (Figure 3-11)									
	Predicted shear stress required to initiate movement of measured D _{max} (mm) (Figure 3-11)									
#DIV/0!		mean depth required to initiate m		red D _{max} (mr	$d = \frac{7}{1}$	<u> </u>				
#DIV/0!	Predicted	ted shear stress, $\gamma = 62.4$, S = e. slope required to initiate movements	ent of measured D _m	_{ax} (mm)	$S = \frac{T}{2d}$	· •				
L	τ = predic	ted shear stress, γ = 62.4, d = ex	xisting depth		γ d					

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Point / Side BAR-BULK MATERIALS SAMP								E DATA: Size Distribution Analysis Observers: KP, AL												
u b	Strea	ım:	Wolve	erton C	reek				Loca	tion:	Wolve	erton C	reek -	1 - 0.6	64				Date: 11/	19/201	0
		⇒ (⇒ (⇒ (⇒ (⇒ (⇒(→ (→ (⇒ (
s a m		h Pan CKET	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE		SIZE	Sieve	SIZE	Sieve	SIZE mm	Sieve	SIZE mm	Sieve	SIZE			
p I	Tare v	veight	Tare v	veight	Tare	weight	Tare	weight	Tare \	veight	Tare	weight	Tare	weight	Tare	weight	Tare	weight		URFACI ATERIAI	
e s	Sample v	veights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	Sample	weights	(Two l	DATA argest pa	rticles)
	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net			
1																			No	Dia.	WT.
2																			1		
3																			2		
5																			Bucket + materials		
6																			weight		
7																			Bucket tare		
8																			weight		
9																			Materials		
10																			weight		0
11																			Materials less	3	
12																			than:		mm
13																				Be sure to separate n	
14 15																				weights to total	grand
Net wt	total	0		0		0		0		0		0		0		0		0	0	lUlai	
% Gra	ind total	#####		#####		#####		#####		#####		#####		#####		#####		#####		7	
Accum	. % =<	#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####		#####	\Longrightarrow	#####	\Longrightarrow	#####	\Longrightarrow	#####	\longrightarrow	100%		RAND TO	TAI
											'										
S	ample lo	cation no	otes				Sar	nple loca	ation sk	etch											

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

Stream:	Wolverton Creek	Stream Type: B6c
Location:	Wolverton Creek - 1 - 0.64	Valley Type: X
Observers:	KP, AL	Date: 11/19/2010
	ream type changes due to sional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)
	ream type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	▽ Stable
	(E→C), (C→High W/d C)	
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable
(C→D)), (B→G), (D→G), (C→G), (E→G)	☐ Highly unstable

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wolverton Creek			Stream Ty	_{/pe:} B6c	
Location: Wolverton Creek	- 1 - 0.64		Valley Ty	_{/pe:} X	
Observers: KP, AL			Da	ate: 11/19/2010	
Lateral stability criteria		Lateral Stabilit	ty Categories		Selected
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)
W/d ratio state (Worksheet 3-8)	< 1.2	1.2 – 1.4	1.4 – 1.6	> 1.6	2
	(2)	(4)	(6)	(8)	
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1
	(1)	(2)	(3)	(4)	
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1
	(1)		(3)		
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(6)	(8)	
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1
(Worksheet 3-9)	(1)	(2)	(3)	(4)	
				Total points	7
	La	inge			
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 3-18. Vertical stability prediction for excess deposition or aggradation.

Stream: Wolverton Creek Stream Type: B6c											
Location: Wolverton Cre	eek - 1 - 0.64		Valley Type:	X							
Observers: KP, AL			Date:	11/19/2010							
Vertical stability criteria	Vertical Stabil	lity Categories fo	r Excess Deposition	on / Aggradation	Selected						
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)						
Sediment 1 competence (Worksheet 3-14)	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)							
Sediment capacity (POWERSED)	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)							
W/d ratio state (Worksheet 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2						
	(2)	(4)	(6)	(8)							
Stream succession 4 states (Worksheet 3- 16)	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)							
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1						
3-5)	(1)	(2)	(3)	(4)							
6 Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	3						
	(1)	(2)	(3)	(4)							
				Total points	12						
	Vertical stat		int range for exces	s deposition /							
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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Wolverton Creek Stream Type: B6c												
Lo	cation: Wolverton Cr	eek - 1 - 0.64		Valley Type:	X							
Ob	oservers: KP, AL			Date:	11/19/2010							
	ertical stability	Vertical Stabil	ity Categories for	Channel Incision	n / Degradation	Selected						
s	criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)						
1	Sediment competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2						
		(2)	(4)	(6)	(8)							
2	Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2						
		(2)	(4)	(6)	(8)							
3	Degree of channel incision (BHR) (Worksheet 3-7)	1.00 – 1.10	1.11 – 1.30	1.31 – 1.50	> 1.50	6						
	(WOIRSHEEL 3-1)	(2)	(4)	(6)	(8)							
4	Stream succession states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	4						
		(2)	(4)	(6)	(8)							
5	Confinement (MWR / MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1						
	3-9)	(1)	(2)	(3)	(4)							
					Total points	15						
		Vertical stab	ility category poi degra	nt range for char dation	nel incision /							
d p	/ertical 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 3-20. Channel enlargement prediction summary.

Stream: Wolverton Creek Stream Type: B6c											
Location: Wolverton Cree	ek - 1 - 0.64		Valley Type:	Х							
Observers: KP, AL			Date:	11/19/2010							
Channel enlargement	Char	nel Enlargement	Prediction Categ	ories	Selected						
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)						
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2						
	(2)	(4)	(6)	(8)							
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2						
	(2)	(4)	(6)	(8)							
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2						
(Worksheet 3-18)	(2)	(4)	(6)	(8)							
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	4						
(Worksheet o 15)	(2)	(4)	(6)	(8)							
				Total points	10						
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Str	eam: Wolverton Creek	(Stream Type:	B6c
Lo	cation: Wolverton Creek	c - 1 - 0.64		Valley Type:	Х
Ob	servers: KP, AL			Date:	11/19/2010
O p	overall sediment supply rediction criteria (choose orresponding points for ach criterion 1–5)	Stability	y Rating	Points	Selected Points
		Stable		1	
1	Lateral stability	Mod. unstab	ole	2	1
'	(Worksheet 3-17)	Unstable		3	•
		Highly unsta	able	4	
	Vertical stability	No deposition	on	1	
2	excess deposition/	Mod. depos	ition	2	1
-	aggradation	Excess dep	osition	3	•
	(Worksheet 3-18)	Aggradation	1	4	
	Vertical stability	Not incised		1	
3	channel incision/	Slightly inci	sed	2	2
3	degradation	Mod. Incised	d	3	2
	(Worksheet 3-19)	Degradation	1	4	
	Channal anlargement	No increase		1	
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2	1
~	3-20)	Mod. increa	se	3	•
	3 20)	Extensive		4	
	Pfankuch channel	Good: stable	e	1	
5	stability (Worksheet 3-	Fair: mod ui	nstable	2	2
ľ	10)				2
	10)	Poor: unsta	ble	4	
				Total Points	7
L			Category p	ooint range	
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 ✓	High 11 – 15 □	Very High 16 – 20 □

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wolverton Creek			Location: V	Volverton Cre	ek - 1 - 0.6	54	
Observers:	KP, AL	Date:	11/19/2010	Stream 7	Туре: В6с	Valley	y Type: X	
Channel Dimension	Mean bankfull depth (ft): 2.09	Mean bankfull 25 width (ft):	Cross-section area (ft ²):	53.73 N	Vidth of flood- rone area (ft):	475	Entrenchment ratio:	1.9
Channel Pattern	Mean: Range: MWR:	12.4 Lm/W _b		Rc/W	/ _{bkf} :		,	1.73
	Check: Riffle/pool	☐ Step/pool ✓		Convergenc	e/divergence	<u></u> Dunes/a	antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool Depth i	ratio Riffle	Pool	Pool to Ratio		Slope	
Features	bankfull depth (ft):	(max/m	ean): 1.6		pool spacing:	Valley:	Average bankfull:	0.00124
	Nipanan	nt composition/density:	Potential composit	ion/density:	Remarks:	Condition, vigo	or and/or usage of existing	reach:
	vegetation							
	Flow P1, 2, Stream regime: 9 and or	N=4	Meander pattem(s):	p	epositional attern(s):	NONE	Debris/channel blockage(s):	D4, 5
Level III Stream Stability Indices	Degree of incision (Bank-Height Ratio):	1.5 Degree of stability rate			lodified Pfanku numeric and ad	•	· -	air
	Width/depth ratio (W/d):	Reference W/d ratio (W/d _{ref}):	12.1 Width/deptl (W/d) / (W/	n ratio state d _{ref}):	1.0	W/d rat stability	tio state rating:	able
	Meander Width Ratio (MWR):	Reference MWR _{ref} :	Degree of on (MWR / MV	confinement VR _{ref}):	1.1	MWR / stability	MWR _{ref} v rating:	nfined
Bank Erosion Summary	Length of reach studied (ft):	65	mbank erosion rate	s/yr/ft)	Curve used: Fig 3-9	Remarks:		
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient cap	acity Excess	capacity	Remarks	:		
Entrainment/ Competence	Largest particle from bar sample (mm):	$\tau =$		Existing depth _{bkf} :	Required depth _{bkf} :		sting Requi	
Successional Stage Shift	→ –	→	→	→	Existing streated state (type):	am Be	Potential stream state (type):	B6c
Lateral Stability	▼ Stable □	Mod. unstable Г	Unstable	☐ Highly	unstable Re	emarks/causes	s: None	
Vertical Stability (Aggradation)	✓ No deposition □	Mod. deposition	Ex. deposition	☐ Aggrad	dation	emarks/causes	s: None	
Vertical Stability (Degradation)	□ Not incised □	Slightly incised	Mod. incised	□ Degrad	dation	emarks/causes	s: None	
Channel Enlargement	▼ No increase □	Slight increase	☐ Mod. increase	☐ Extens	sive	emarks/causes	s: None	
Sediment Supply (Channel Source)	□ Low ☑	Moderate	High 🔲 Very hi	Remarks	s/causes: No	one		

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

	Riparian Vegetation												
Stre	eam: Wolve	erton Creek		Location: Wovlerton Creek-2-2.02									
	servers: KP, A		Disturbed (impacted x reach) Date: 9/28/2011										
spe	sting cies nposition:			Potential species composition:									
R	iparian cover categories	Percent aerial cover*	Percent of site coverage**	Species composition Percent of total species composition									
1. Overstory	Canopy layer	1%	<1%										
	I			100%									
2. Understory	Shrub layer		13%										
				100%									
level	Herbaceous		15%										
3. Ground level			2%	Remarks: Condition, vigor and/or usage of existing reach:									
	Bare ground		70%										
	ed on crown closure. ed on basal area to s	surface area.	Column total = 100%										

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

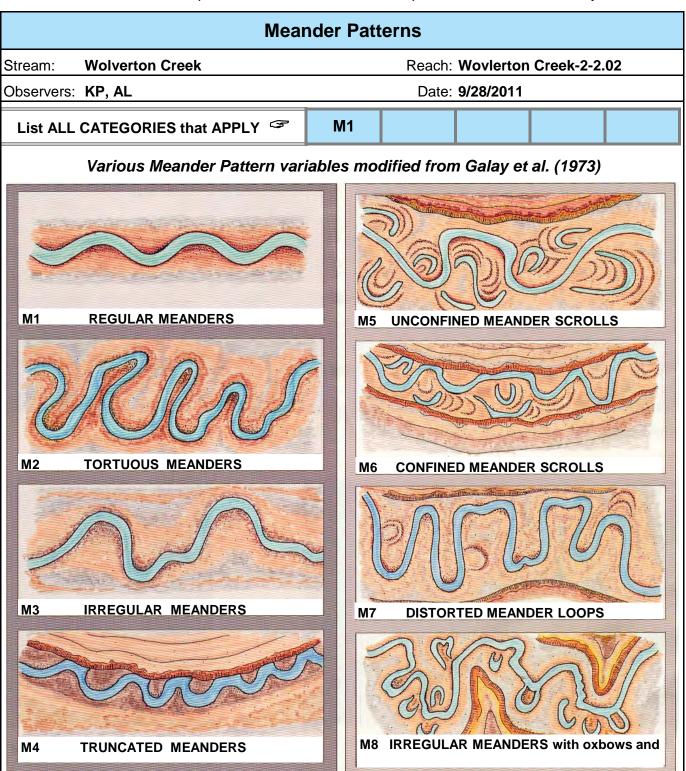
biological interpretations.												
FLOW REGIME												
Stream:	Wolverton Creek		Location:	Wovlerte	on Creek	-2-2.02						
Observers:	KP, AL						Date:	9/28/201	1			
List ALL	COMBINATIONS that	P1	P2	P9								
APF	PLY	PI	FZ	ГЭ								
General Category												
E	Ephemeral stream channels: Flows only in response to precipitation											
S	Subterranean stream channel: Flows parallel to and near the surface for various seasons - a subsurface flow that follows the stream bed.											
ı	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.											
Р	Perennial stream channels: Surface water persists yearlong.											
Specific (Category											
1	Seasonal variation in s	treamflow	dominated	d primaril	y by snow	melt runo	off.					
2	Seasonal variation in s	treamflow	dominated	d primaril	y by storn	nflow runc	off.					
3	Uniform stage and asso	ociated str	reamflow d	lue to spr	ing-fed co	ondition, b	ackwater	, etc.				
4	Streamflow regulated b	y glacial r	melt.									
5	Ice flows/ice torrents fro	om ice daı	m breache	s.								
6	Alternating flow/backwa	ater due to	o tidal influ	ence.								
7	Regulated streamflow	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 generate	ed runoff.										

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

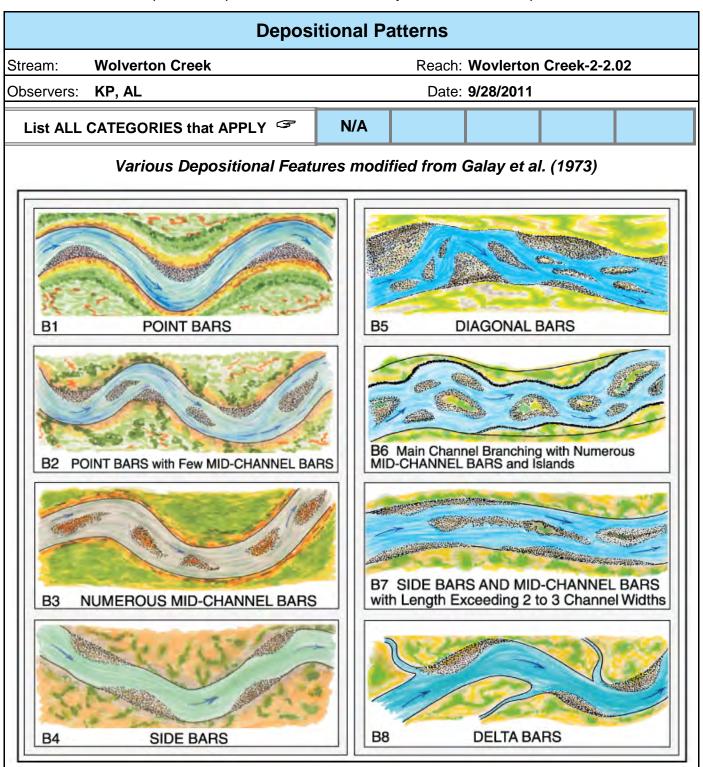
Stream Size and Order												
Stream:	Wolverton Cre	ek										
Location:	Wovlerton Cre	ek-2-2.02										
Observers:	KP, AL											
Date: 9/28/2011												
Stream Size Category and Order S-4												
STREAM SIZE: Bankfull Check (✓) Category width appropriate												
	meters	feet	category									
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 categoria	as in naranthasis	for enacific etras	m order of									

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

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



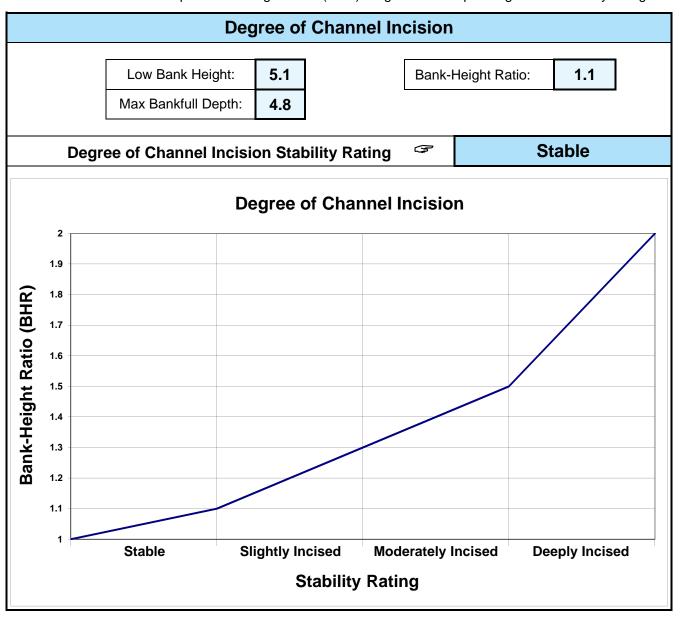
Worksheet 3-5. Depositional patterns used for stability assessment interpretations.



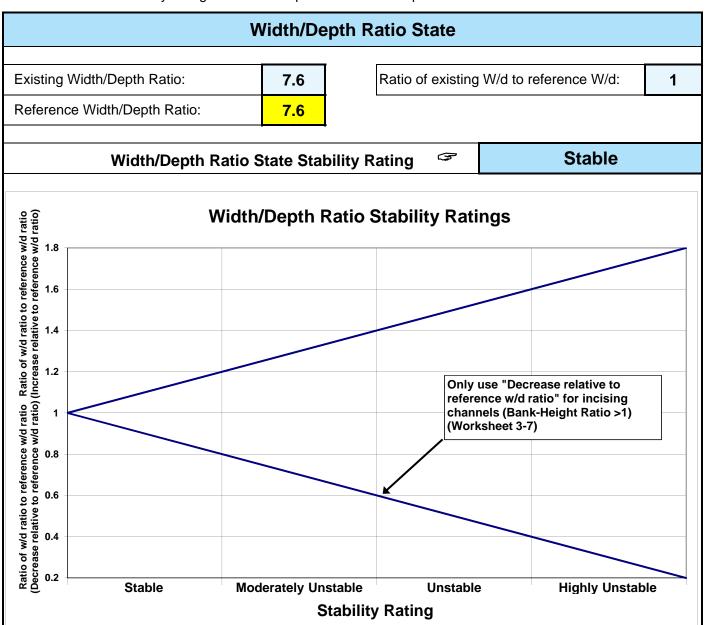
Worksheet 3-6. Various categories of in-channel debris, dams and channel blockages used to evaluate channel stability.

	Channel Blockages										
Stream	m: Wolverton	Creek Location: Wovlerton Creek-2-2.02									
Obser	rvers: KP, AL	Date: 9/28/2011									
Desc	ription/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.									
D1	None	Minor amounts of small, floatable material.	7								
D2	Infrequent	Debris consists of small, easily moved, floatable material, e.g., leaves, needles, small limbs and twigs.									
D3	Moderate	Increasing frequency of small- to medium-sized material, such as large limbs, branches and small logs, that when accumulated, affect 10% or less of the active channel cross-section area.									
D4	Numerous	Significant build-up of medium- to large-sized materials, e.g., large limbs, branches, small logs or portions of trees that may occupy 10–30% of the active channel cross-section area.									
D5	Extensive	Debris "dams" of predominantly larger materials, e.g., branches, logs and trees, occupying 30–50% of the active channel cross-section area, often extending across the width of the active channel.									
D6	Dominating	Large, somewhat continuous debris "dams," extensive in nature and occupying over 50% of the active channel cross-section area. Such accumulations may divert water into the flood-prone areas and form fish migration barriers, even when flows are at less than bankfull.									
D7	Beaver dams: Few	An infrequent number of dams spaced such that normal streamflow and expected channel conditions exist in the reaches between dams.									
D8	Beaver dams: Frequent	Frequency of dams is such that backwater conditions exist for channel reaches between structures where streamflow velocities are reduced and channel dimensions or conditions are influenced.									
D9	Beaver dams: Abandoned	Numerous abandoned dams, many of which have filled with sediment and/or breached, initiating a series of channel adjustments, such as bank erosion, lateral migration, avulsion, aggradation and degradation.									
D10	Human influences	Structures, facilities or materials related to land uses or development located within the flood-prone area, such as diversions or low-head dams, controlled by-pass channels, velocity control structures and various transportation encroachments that have an influence on the existing flow regime, such that significant channel adjustments occur.									

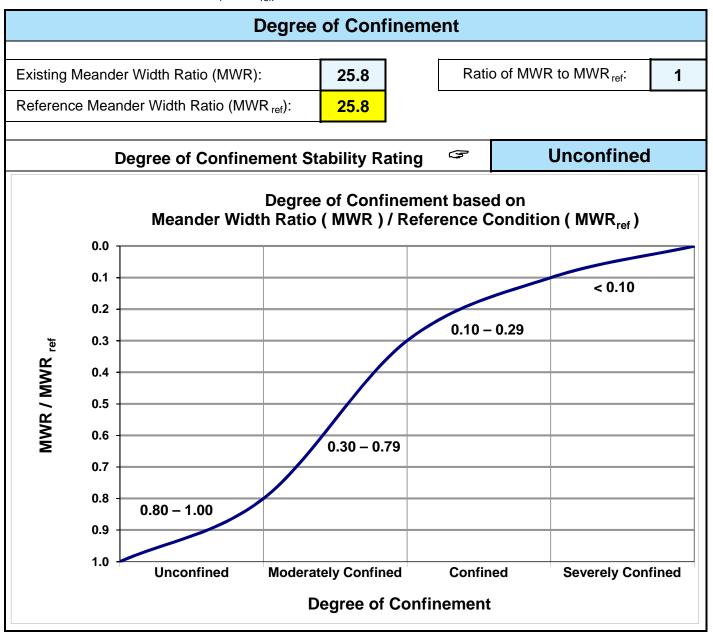
Worksheet 3-7. Relationship of Bank-Height Ratio (BHR) ranges to corresponding stream stability ratings.



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



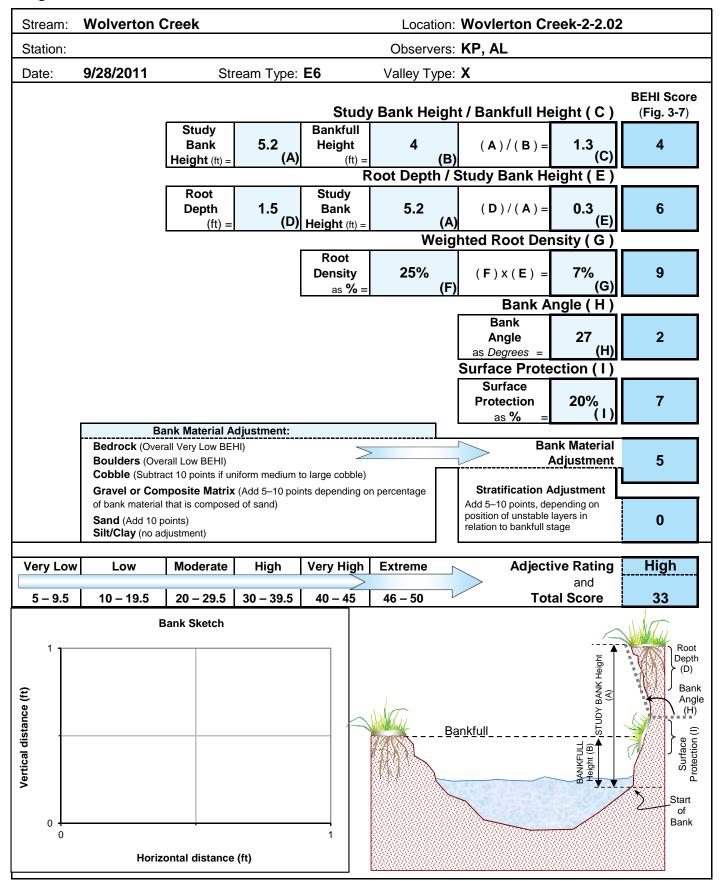
Worksheet 3-9. Degree of confinement based on Meander Width Ratio (MWR) divided by reference condition Meander Width Ratio (MWR_{ref}).



Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2001c, 2006b).

Stream:	Wolv	erton (Cree	k			Loc	ation:	Wovl	erton	Creek	(-2-2.0		Valley	Type:	Χ		Obse	ervers:	KP, A	\L				Date: 9/28/2	2011	
Loca-	Key	Catego	orv			Exce	llent					Go	od					Fa	air						Poor		
tion	Ney	Calego	OI y			Descriptio	n		Rating			Descriptio	n		Rating		[Description	n		Rating			Descri	otion		Rating
(0	1	Landform slope		Bank slo	ope gra	dient <3	0%.		2	Bank sl	ope gra	dient 30-	-40%.		4	Bank sl	ope gra	dient 40	-60%.		6	Bank slo	pe gradi	ent >	60%.		8
banks	2	Mass eros	SION	No evide erosion.		past or	future m	ass	3		ent. Mos otential	stly heale	ed over.	Low	6		nt or larg	•	ing sedi	ment	9				sing sediment nearly danger of same.		12
Upper	3	Debris jar potential		channel	l area.	ent from			2	limbs.		ostly sma			4	larger s	sizes.	-	ounts, m	•	6	Moderat predomi	nantly lai	rger si	sizes.		
) 	4	Vegetative bank protection			t a deep	nsity. Vi , dense	_	-	3		or sugg	y. Fewer est less			6	fewer s		rom a sl		nd	9		icating p	oor, d	er species and l iscontinuous an		12
	5	Channel capacity		stage. Wid	dth/depth width/dep	ent to cont ratio depar oth ratio = 1	ture from		1	Width/dep	oth ratio de th ratio = 1	ntained wite parture fro 1.0-1.2. Ba	om referer	nce	2	Bankfull s	stage is no arture from	t containe reference	d. Width/dep width/dep (BHR) = 1	th ratio	3	common w	ith flows les ture from re	ss than eference	d; over-bank flows a bankfull. Width/dept e width/depth ratio > .3.	n	4
nks	6	Bank rock content		12"+ co	mmon.	je angula			2		6. Mostly 6–12".	y boulde	rs and	small	4	20–40% class.	6. Most	in the 3-	-6" diam	eter	6	or less.			of gravel sizes,	-3"	8
Lower banks	7	Obstruction to flow	ons		w/o cutt	firmly ir ting or d			2	currents fewer an	and mind d less fir		ing. Obs	tructions	4		th high flo		able obstr ing bank		6	cause ba	ank erosi	on ye	and deflectors arlong. Sedimer ation occurring.	nt	8
Lov	8	Cutting		Little or <6".	none. I	nfrequer	nt raw ba	anks	4			ently at a			6	U			" high. F ughing e		12				s, some over 24 ngs frequent.	'	16
	9	Deposition	n	Little or point ba		irgemen	t of char	nnel or	4	Some r coarse		increase	e, mostly	/ from	8		arse san		new gra I and so		12	·			Extensive deposit of predominantly fine particles. Accelerated bar development.		16
	10	Rock angularity		Sharp e surfaces	-	nd corne	rs. Plan	е	1			rs and e th and fl	•		2	Corners dimens		lges we	l rounde	ed in 2	3	Well rounded in all dime smooth.					4
	11	Brightnes	s	General	lly not b				1	surface	s.	may ha		6 bright	2	mixture	range.		i.e., 35-		3	scoured	surfaces	5.	• 65%, exposed		4
Ē	12	Consolidati particles		overlapp	ping.	tightly p			2	overlap	ping.	ked with			4	appare	nt overla	ар.	nt with n		6	No packing evident. Lo easily moved.				,	8
Bottom	13	Bottom siz distributio		No size material	_	e evident 0%.	. Stable		4	50-80%	6.	t light. S		aterial	8	materia	ls 20–50	0%.	es. Stat		12	Marked of materials			ange. Stable		16
	14	Scouring deposition		<5% of deposition		affected	by scou	ır or	6	constric	tions ar	d. Scour nd where deposit	grades		12	at obstr	uctions,	affected. Deposits and scour ctions, constrictions and come filling of pools.		ns and 18		More that			oottom in a state earlong.	of	24
	15	Aquatic vegetation			•	th moss I. In swif			1			e forms i . Moss h			2	backwa	t but spo iter. Sea rocks sl	sonal a	stly in Igae gro	wth	3				or absent. Yellon m may be prese		4
						Exc	ellent	total =	28				Good	total =	0				Fair	total =	21				Poor to	al =	12
Stream typ	pe	A1	A2	А3	A4	A5	A6	B1	B2	В3	B4	B5	В6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6				
Good (Stable			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		67-98		Grand total	=	61
Fair (Mod. ui	nstable	44-47			96-132 133+	96-142 143+	81-110 111+	46-58 59+	46-58 59+	61-78 79+	65-84 85+	69-88 89+	61-78 79+	51-61 62+	51-61 62+							32 108-132 99-125 Existing		Existing stream type	· =	E6	
Stream typ			DA4	DA5	DA6	E3	E4	E5	E6	F1	F2	F3	F4	F5	F6	G1	G2	G3	G4	G5	G6		1		*Potential		EG
Good (Stable	e)	40-63 4	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				stream type	e =	E6
Fair (Mod. u	nstable	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				Modified		
Poor (Unstal	ble)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+				stability	ating	j =
*Rating is adjusted to potential stream type, not existing.										God	od																

Worksheet 3-11. Form to calculate Bank Erosion Hazard Index (BEHI) variables and an overall BEHI rating. Use **Figure 3-7** with BEHI variables to determine BEHI score.



Worksheet 3-12. Various field methods of estimating Near-Bank Stress (NBS) risk ratings to calculate erosion rate.

	erosion rate.											
	Estimating Near-Bank Stress (NBS)											
		ton Creek			Location:	Wovlertor	Creek-2-2	2.02				
Station:	0			S	tream Type:	E6	\	/alley Type:	Х			
Observe	rs:	KP, AL						Date:	9/28/11			
			Methods fo	or Estimati	ng Near-Ba	ank Stress	(NBS)					
(1) Chanr	nel pattern	transverse ba	or split channe	el/central bar cr	eating NBS		Level I	Recona	aissance			
(2) Ratio	of radius o	f curvature to b	ankfull width (F	R _c / W _{bkf})	Level II	General prediction						
(3) Ratio	of pool slo	pe to average v	vater surface sl	ope (S _p / S)			Level II	General	prediction			
(4) Ratio	of pool slo	pe to riffle slope	e (S _p / S _{rif})				Level II	General	prediction			
(5) Ratio	of near-ba	nk maximum de	epth to bankfull	mean depth (d _{nb} / d _{bkf})		Level III	Detailed	prediction			
(6) Ratio	of near-ba	nk shear stress	to bankfull she	ar stress (τ_{nb}	′ τ _{bkf})		Level III	Detailed	prediction			
(7) Veloci	ty profiles						Level IV		dation			
_	(4)											
Levell	(1)											
		Radius of	Bankfull	meander mig	Near-Bank	girig now			JO - EXTORIO			
	(0)	Curvature	Width W _{bkf}	Ratio R _c /	Stress							
	(2)	R _c (ft)	(ft)	W_{bkf}	(NBS)	i						
=					Near-Bank				7			
Level II	(3)	Pool Slope	Average Slope S	Potio S / S	Stress (NBS)			inant nk Stress				
Le	` ,	S _p	Slope 3	Ratio S _p / S	(INDO)			Low				
					N D 1		V C I y	LOW	L			
		Pool Slope	Riffle Slope	Ratio S _p /	Near-Bank Stress							
	(4)	S _p	S _{rif}	S _{rif}	(NBS)							
		Near-Bank			Near-Bank	•						
	(5)	Max Depth	Mean Depth	Ratio d _{nb} /	Stress							
_	(-)	d _{nb} (ft)	d _{bkf} (ft)	d _{bkf}	(NBS)							
Level III				Near-Bank			Bankfull		1			
Le v		Near-Bank		Shear			Shear		Near-Bank			
_	(6)	Max Depth	Near-Bank	Stress τ_{nb} (Mean Depth	Average	Stress τ_{bkf} (Ratio τ_{nb} /	Stress			
	` ,	d _{nb} (ft)	Slope S _{nb}	lb/ft ²)	d _{bkf} (ft)	Slope S	lb/ft ²)	$ au_{bkf}$	(NBS)			
≥				Near-Bank								
Level IV	(7)	Velocity Grad / f	lient (ft / sec	Stress (NBS)								
Le		/ 1	.)	Very Low								
					J							
News	and Of		verting Va	lues to a l	Near-Bank							
Near-B	ank Stro	ess (NBS)	(1)	(2)	(3)	ethod numb (4)	oer (5)	(6)	(7)			
	Very Lo		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			
	Modera	ate	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 Hi		(1)	1.50 – 1.80	0.81 – 1.00	1.01 – 1.20	2.51 – 3.00					
	Extren	-	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.40			
				Overall N	ear-Bank S	Stress (NB	S) rating	Very	Low			

Worksheet 3-13. Summary form of annual streambank erosion estimates for various study reaches.

Stream:	Wolverton Cre	ek	Wovlerton C	Creek-2-2.02					
Graph Used:	Fig 3-9	Total Bar	nk Length (ft):	3095.6		Date:	9/28/2011		
Observers:	KP, AL		Valley Type:	Χ		Stream Type: E6			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
Station (ft)	BEHI rating (Worksheet 3-11) (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.	High	Very Low	0.165	3095.6	5.2	2656	0.04		
2.						0	#DIV/0!		
3.						0	#DIV/0!		
4.						0	#DIV/0!		
5.						0	#DIV/0!		
6.						0	#DIV/0!		
7.						0	#DIV/0!		
8.						0	#DIV/0!		
9.						0	#DIV/0!		
10.						0	#DIV/0!		
11.						0	#DIV/0!		
12.						0	#DIV/0!		
13.						0	#DIV/0!		
14.						0	#DIV/0!		
15.						0	#DIV/0!		
Sum erosion	n subtotals in Col	Total Erosion (ft ³ /yr)	2656						
Convert eros	sion in ft ³ /yr to yo	ds ³ /yr {divide T	ft ³ /yr) by 27}	Total Erosion (yds ³ /yr)	98				
Convert eros by 1.3}	sion in yds ³ /yr to	Total Erosion (tons/yr)	128						
Calculate erosion per unit length of channel {divide Total Erosion (tons/yr) by total length of stream (ft) surveyed} Total Erosion (tons/yr/ft) 0.04									

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

Stream:	Wolverton	Creek	S	tream Type:	E6							
Location:	Wovlerton	Creek-2-2.02	,	Valley Type:	Х							
Observers:	KP, AL			Date:	9/28/2011							
Enter Req	uired Infor	mation for Existing Cond	ition									
	D ₅₀	Riffle bed material D ₅₀ (mm)									
	D ₅₀	Bar sample D ₅₀ (mm)										
0	D _{max}	Largest particle from bar sa	ample (ft)		(mm)	304.8 mm/ft						
	s	Existing bankfull water surf	ace slope (ft/ft)									
	d	Existing bankfull mean dep	th (ft)									
1.65 γ_s Submerged specific weight of sediment												
Select the Appropriate Equation and Calculate Critical Dimensionless Shear Stress												
#DIV/0!	D ₅₀ /D ₅₀	Range: 3 – 7	Use EQUATION 1:	$\tau^* = 0.083$	4 (D ₅₀ /D	^ ₅₀) ^{-0.872}						
#DIV/0!	D _{max} /D ₅₀	Range: 1.3 – 3.0	Use EQUATION 2:	$\tau^* = 0.038$	34 (D _{max} /D ₅	₀) ^{-0.887}						
#DIV/0!	τ*	Bankfull Dimensionless Sho	ear Stress	EQUATIO	ON USED:	#DIV/0!						
Calculate Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample												
#DIV/0!	d	Required bankfull mean de	pth (ft) $d = \frac{\tau}{2}$	· * γ _s D _{max}	use (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading										
Calculate Sample	Bankfull W	ater Surface Slope Requ	ired for Entrainmer	nt of Large	st Particle	in Bar						
#DIV/0!	s	Required bankfull water sur	rface slope (ft/ft) S =	$= \frac{\tau * \gamma_s L}{d}$	D _{max} (use	D _{max} in ft)						
	Check:	☐ Stable ☐ Aggrading	□ Degrading									
Sediment	Competen	ce Using Dimensional Sh	ear Stress									
0	Bankfull sl	near stress $\tau = \gamma dS$ (lbs/ft ²) (substitute hydraulic ra	dius, R, with	mean depth,	d)						
	$\gamma = 62.4, c$	d = existing depth, S = existing	g slope									
	Predicted	largest moveable particle size	(mm) at bankfull shea	ar stress τ (F	igure 3-11)							
	Predicted	shear stress required to initiat	e movement of measu	ıred D _{max} (m	m) (Figure 3	-11)						
#DIV/0!	Predicted mean depth required to initiate movement of measured D_{max} (mm) $\mathbf{d} = \frac{\tau}{v\mathbf{s}}$											
#DIV/0!	$τ$ = predicted shear stress, $γ$ = 62.4, S = existing slope Predicted slope required to initiate movement of measured D_{max} (mm) $S = \frac{τ}{m}$											
L	τ = predic	ted shear stress, γ = 62.4, d =	existing depth		γd							

Worksheet 3-15. Bar sample data collection and sieve analysis form.

S	Poir	Point / Side BAR-BULK MATERIALS SAMPLE DATA: Size Distribution Analysis Observers: KP, AL																				
u b	Strea	m:	Wolve	erton C	reek				Loca	tion:	Wovle	erton C	reek-2	2-2.02					Date: 9	9/28	/2011	
		⇒ (⇒ (⇒(⇒ (⇒ (<u> </u>	⇒ (⇒ (→ (⇒ (
s a		h Pan CKET	Sieve	SIZE	Sieve	SIZE	Sieve		Sieve		Sieve		Sieve		Sieve	SIZE	Sieve	SIZE	nm SUDEACE			
m p	Tare		Tare	mm weight	Tare	mm weight	Tare	mm weight	Tare v	mm veight	Tare	mm weight	Tare v	mm veight	Tare	mm weight	Tare	weight				
1	14101	volgili	Taio	oigint	Turo (grit	Taio i	grit	10.0	voigin.	Taro	worgin	Taio (Taio	.roigin	- 1410	oigint				S
e s	Sample		Sample		Sample		Sample		Sample		Sample		Sample		Sample	_	Sample		(Tw		rgest par	ticles)
1	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net	Total	Net		No.	Dia.	WT.
2																			-	1 1	Dia.	VVI.
3																				2		
4																			Bucket	+	<u> </u>	
5																			materia weight			
6																						
7																			Bucket ta weight			
9																			Materia	ls		
10																			weight	t	()
11																			Materials	less		
12																			than:			mm
14																				se	e sure to a eparate m	aterial
15																			1		eights to g tal	grand
Net wt	. total	0		0		0		0		0		0		0		0		0	0	L	1	
	and total	#####		#####		#####		#####		#####		#####		#####		#####		#####		<u></u>		
Accum	1. % =<	#####	\longrightarrow	#####	\longrightarrow	#####	\longrightarrow	#####	\rightarrow	#####	\longrightarrow	#####		#####	\longrightarrow	#####	\longrightarrow	100%	1	GRA	AND TO	TAL
<u> </u>	amnle lo	cation no	ntes				Sar	nple loca	ation ske	etch												
	ипріс іс	oation no	, , , , , , , , , , , , , , , , , , ,				- Gai	npio ioo	ation on	31011												

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

Stream:	Wolverton Creek	Stream Type: E6						
Location:	Wovlerton Creek-2-2.02	Valley Type: X						
Observers:	KP, AL	Date: 9/28/2011						
	ream type changes due to ional stage shifts (Figure 3-14)	Stability rating (check appropriate rating)						
	eam type at potential, $(C \rightarrow E)$,), $(G \rightarrow B)$, $(F \rightarrow B_c)$, $(F \rightarrow C)$, $(D \rightarrow C)$	☑ Stable						
	(E→C), (C→High W/d C)							
	$(G \rightarrow F)$, $(F \rightarrow D)$, $(C \rightarrow F)$	☐ Unstable						
(C→D)	, (B \rightarrow G), (D \rightarrow G), (C \rightarrow G), (E \rightarrow G)	☐ Highly unstable						

Worksheet 3-17. Lateral stability prediction summary.

Stream: Wolverton Creek			Stream Ty	_{/pe:} E6						
Location: Wovlerton Creek	-2-2.02		Valley Ty	_{/pe:} X						
Observers: KP, AL			Da	ate: 9/28/2011						
Lateral stability criteria		Selected								
(choose one stability category for each criterion 1–5)	Stable	Moderately unstable	Unstable	Highly unstable	points (from each row)					
W/d ratio state 1 (Worksheet 3-8)	< 1.2	1.2 – 1.4 1.4 – 1.6		> 1.6	2					
	(2)	(4)	(6)	(8)						
Depositional pattern (Worksheet 3-5)	B1, B2	B4, B8	ВЗ	B5, B6, B7	1					
	(1)	(2)	(3)	(4)						
Meander pattern (Worksheet 3-4)	M1, M3, M4		M2, M5, M6, M7, M8		1					
	(1)		(3)							
Dominant BEHI / NBS (Worksheet 3-13)	L/VL, L/L, L/M, L/H, L/VH, M/VL		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)	(4)	(6)	(8)						
Degree of confinement 5 (MWR / MWR _{ref})	0.8 – 1.0	0.3 – 0.79	0.1 – 0.29	< 0.1	1					
(Worksheet 3-9)	(1)	(2)	(3)	(4)						
				Total points	9					
Lateral stability category point range										
Overall lateral stability category (use total points and check stability rating)	Stable 7 − 9 <mark>▽</mark>	Moderately unstable 10 − 12	Unstable 13 – 21 □	Highly unstable > 21 □						

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

Stream: Wolverton Creek Stream Type: E6										
Location: Wovlerton Cre	eek-2-2.02		Valley Type:	Χ						
Observers: KP , AL			Date:	9/28/2011						
Vertical stability criteria	Vertical Stabi	ity Categories fo	r Excess Deposition	n / Aggradation	Selected					
(choose one stability category for each criterion 1–6)	No deposition	Moderate deposition	Excess deposition	Aggradation	points (from each row)					
Sediment 1 competence (Worksheet 3-14)	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)						
Sediment capacity (POWERSED)	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 3-8)	1.0 – 1.2	1.2 – 1.4	1.4 – 1.6	>1.6	2					
	(2)	(4)	(6)	(8)						
Stream succession 4 states (Worksheet 3- 16)	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)						
Depositional 5 patterns (Worksheet	B1	B2, B4	B3, B5	B6, B7, B8	1					
3-5)	(1)	(2)	(3)	(4)						
Debris / blockages (Worksheet 3-6)	D1, D2, D3	D4, D7	D5, D8	D6, D9, D10	1					
	(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 3-19. Vertical stability prediction for channel incision or degradation.

Stream: Wolverton Creek Stream Type: E6						
Location: Wovlerton Creek-2-2.02 Valley Type: X						
Observers: KP, AL Date: 9/28/2011						
Vertical stability	Vertical Stabil	ity Categories for	r Channel Incision	n / Degradation	Selected	
criteria (choose one stability category for each criterion 1–5)	Not incised	Slightly incised	Moderately incised	Degradation	points (from each row)	
Sediment 1 competence (Worksheet 3-14)	Does not indicate excess competence	Trend to move larger sizes than D ₁₀₀ of bar or > D ₈₄ of bed	D ₁₀₀ of bed moved	Particles much larger than D ₁₀₀ of bed moved	2	
	(2)	(4)	(6)	(8)		
Sediment capacity (POWERSED)	Does not indicate excess capacity	Slight excess energy: up to 10% increase above reference	Excess energy sufficient to increase load up to 50% of annual load	Excess energy transporting more than 50% of annual load	2	
	(2)	(4)	(6)	(8)		
Degree of channel 3 incision (BHR)	1.00 – 1.10	1.11 – 1.30	11 – 1.30 1.31 – 1.50 > 1.50		2	
(worksneet 3-7)	sion (BHR) rksheet 3-7) (2) (4) (6) (8)					
Stream succession 4 states (Worksheets 3-16 and 3-7)	Does not indicate incision or degradation	If BHR > 1.1 and stream type has w/d between 5–10	If BHR > 1.1 and stream type has w/d less than 5	$(B\rightarrow G), (C\rightarrow G),$ $(E\rightarrow G), (D\rightarrow G)$	2	
	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 $(B\rightarrow G)$, $(C\rightarrow G)$, $(E\rightarrow G)$, $(D\rightarrow G)$					
Confinement (MWR / 5 MWR _{ref}) (Worksheet	0.80 – 1.00	0.30 – 0.79	0.10 – 0.29	< 0.10	1	
3-9)	(1)	(2)	(2) (3)			
Total points						
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 3-20. Channel enlargement prediction summary.

Stream: Wolverton Creek Stream Type: E6						
Location: Wovlerton Creek-2-2.02 Valley Type: X						
Observers: KP, AL Date: 9/28/2011						
Channel enlargement	Char	Selected				
prediction criteria (choose one stability category for each criterion 1–4)	No increase	Slight increase	Moderate increase	Extensive	points (from each row)	
Successional stage shift (Worksheet 3-16)	Stream type at potential, $(C \rightarrow E)$, $(F_b \rightarrow B)$, $(G \rightarrow B)$, $(F \rightarrow C)$, $(D \rightarrow C)$	(C→High W/d C), (E→C)	(G→F), (F→D)	$(C \rightarrow D), (B \rightarrow G),$ $(D \rightarrow G), (C \rightarrow G),$ $(E \rightarrow G), (C \rightarrow F)$	2	
	(2)	(4)	(6)	(8)		
Lateral stability (Worksheet 3-17)	Stable	Moderately unstable	Unstable	Highly unstable	2	
	(2)	(4)	(6)	(8)		
Vertical stability excess deposition/ aggradation	No deposition	Moderate deposition	Excess deposition	Aggradation	2	
(Worksheet 3-18)	√ No denosition I Lycess denosition I ∆aaradation I					
Vertical stability 4 incision/ degradation (Worksheet 3-19)	Not incised	Slightly incised	Moderately incised	Degradation	2	
(Worksheet 3-13)	(2)	(4)	(6)	(8)		
Total points						
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 3-21. Overall sediment supply rating determined from individual stability rating categories.

Stream: Wolverton Creek Stream Type:					E6	
Lo	Location: Wovlerton Creek-2-2.02 Valley Type:					
Ob	servers: KP, AL			Date:	9/28/2011	
Overall sediment supply prediction criteria (choose corresponding points for each criterion 1–5)		Stability	y Rating	Points	Selected Points	
		Stable		1		
1	Lateral stability	Mod. unstab	ole	2	1	
! '	(Worksheet 3-17)	Unstable		3		
		Highly unsta	able	4		
	Vertical stability	No deposition	on	1		
2	excess deposition/	Mod. deposi	ition	2	1	
-	aggradation	Excess depo	osition	3		
	(Worksheet 3-18)	Aggradation	1	4		
	Vertical stability	Not incised		1	1	
3	channel incision/	Slightly inci	sed	2		
٦	degradation	Mod. Incised	d	3		
	(Worksheet 3-19)	Degradation	1	4		
	Channal anlargement	No increase		1	1	
4	Channel enlargement prediction (Worksheet	Slight increa	ase	2		
"	3-20)	Mod. increas	se	3		
	<i>3 23)</i>	Extensive	Extensive			
	Pfankuch channel	Good: stable	e	1	1	
5	stability (Worksheet 3-	Fair: mod ur	nstable	2		
ľ	10)				•	
	10)	Poor: unsta	ble	4		
				Total Points	5	
		Category point range				
ra	overall sediment supply ating (use total points and heck stability rating)	Low 5	Moderate 6 – 10 □	High 11 – 15 □	Very High 16 – 20 □	

Worksheet 3-22. Summary of stability condition categories.

Stream:	Wolverton Creek			Location:	Wovlerton Cr	eek-2-2.02		
Observers:	Observers: KP, AL		Date: 9/28/2011		Stream Type: E6		Valley Type: X	
Channel Dimension	Mean bankfull depth (ft): 3.17	Mean bankfull width (ft):	Cross-secti area (ft²):	73.13	Width of flood- prone area (ft):	129	Entrenchment ratio:	5.3
Channel Pattern	Mean: Range: MWR:	25.8 Lm/V	V _{bkf} : 25.8	Rc/\	W _{bkf} :	7.1	Sinuosity:	1.26
	Check: Riffle/pool	☐ Step/pool	Plane bed	Convergen	nce/divergence	✓ Dunes/	antidunes/smooth be	d
River Profile and Bed	Max Riffle	Pool	n ratio Riffle	Pool	Pool to Ratio		Slope	
Features	bankfull depth (ft): 4.8	(max/r	mean): 1.5		pool spacing:	Valley:	Average bankfull:	0.0011
	Tapanan	nt composition/density:	Potential compo	sition/density:		: Condition, vig	or and/or usage of existing	reach:
	vegetation 0		0		0			
Level III Stream Stability Indices	Flow P1, 2, Strear regime: 9 and or	N=4	Meander pattern(s):	IVIT	Depositional pattern(s):	NONE	Debris/channel blockage(s):	D1
	Degree of incision (Bank-Height Ratio):	1.1 Degree of stability r	of incision rating:	atable	Modified Pfanku (numeric and ac	•	· (4/	ood
	Width/depth 7.6 ratio (W/d):	Reference W/d ratio (W/d _{ref}):	7.6 Width/de (W/d) / (V	oth ratio state V/d _{ref}):	^{te} 1.0		tio state y rating:	able
	Meander Width Ratio (MWR):	25.8 Reference MWR _{ref} :	25.8 Degree o (MWR / N	f confinemen IWR _{ref}):	nt 1.0	I	MWR _{ref} unco y rating:	nfined
Bank Erosion Summary	Length of reach studied (ft): Annual streambank erosion rate: Curve used: Remarks: 128 (tons/yr) 0.04 (tons/yr/ft) Fig 3-9							
Sediment Capacity (POWERSED)	✓ Sufficient capacity	☐ Insufficient ca	apacity Exces	s capacity	Remarks	S:		
Entrainment/ Competence	Largest particle from bar sample (mm):	τ=	τ*=	Existing depth _{bkf} :	Required depth _{bkf} :		sting Requi pe _{bkf} : slope _b	
Successional Stage Shift	→ -	→		→	Existing stre state (type):	am E	Potential stream state (type):	E 6
Lateral Stability	▼ Stable □	Mod. unstable	☐ Unstable	☐ Highly	y unstable R	emarks/cause	es:	
Vertical Stability (Aggradation)	✓ No deposition	Mod. deposition	☐ Ex. deposition	☐ Aggra	adation	emarks/cause	es:	
Vertical Stability (Degradation)	✓ Not incised	Slightly incised	☐ Mod. incised	☐ Degra	adation	emarks/cause	es:	
Channel Enlargement	✓ No increase	Slight increase	☐ Mod. increase	☐ Exten	nsive	emarks/cause	es:	
Sediment Supply (Channel Source)	✓ Low	Moderate	High Very	nigh	ks/causes:			