Streambank Alteration Measurement and Implementation
Bridger-Teton National Forest
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INTRODUCTION

Importance of bank alteration in the context of channel function

It is widely known that bank alteration by trampling, shearing, and exposure of bare soil can be an important source of stream channel and riparian degradation (e.g., Clary and Webster, 1989, 1990; Overton et al., 1994; Belsky et al., 1999). Impacts may include channel widening (and loss of ability of flood flows to access floodplains), loss of riparian vegetation (which then makes banks more vulnerable to further erosion), localized lowering of water tables in riparian areas (and loss of water storage in floodplains and stream channels), and changes in sediment transport capacity of stream channels.

Researchers have also reported that channel degradation from alteration may occur before utilization or stubble height requirements are met. In a personal communication to Ronna Simon on 1/31/08, Tim Burton (Idaho BLM State Office Fisheries Biologist and co-developer of MIM—see references to MIM that follow) stated that a test site that had received less than 5% streambank alteration for several years in a row had 47% bank alteration in 2007; this was accompanied by a decrease in bank stability from 86% to 30%, while a stubble height standard of 4 inches was still met. As a result, his office will be replacing the stubble height trigger for moving livestock with one for bank alteration. Bengeyfield (2006) also reported that trampling limits were exceeded before stubble height requirements were met.

Channel recovery is often slower than vegetative recovery. Kondolf (1993) found that channels in California that had been excluded from grazing for 24 years had not returned to their pre-disturbance morphology despite the growth of lush streambank vegetation. Clary and Webster (1989) provided information from other studies in their paper. They stated that "[w]hile Skovlin (1984) suggested that vegetation recovery after release from excessive grazing generally can occur within 5 to 15 years, Platts and Raleigh (1984) pointed out that impacts on fishery environments go far beyond the riparian vegetation. Channel and bank morphology, instream cover, and water flow regimens are important factors. Little is known about the recovery time for these factors in different environments." Magilligan and McDowell (1997) described geomorphic channel adjustments after more than 14 years of grazing exclusion in eastern Oregon. They concluded that 14 years might not be sufficient time for all variables to adjust. They also cite other studies' findings that "…for exclosures less than approximately five to ten years old, little geomorphic difference exists despite noticeable differences in riparian vegetation".

Given this knowledge, it is evident that bank alteration is an important factor to consider when evaluating stream channel and riparian area conditions in grazing allotments. Some researchers have concluded that bank alteration, taking natural channel stability into account, is the most important factor to consider in evaluating physical stream channel conditions and impacts from land use (Bengeyfield, 2006).

This paper provides a method for determining if streambank alteration is at acceptable levels for maintaining or improving channel stability. The information in this paper is not meant to imply that riparian vegetation is not important in maintaining riparian and stream channel conditions. This paper is addressing just the physical streambank conditions: a broader evaluation that includes vegetation is beyond the scope of what is presented here.

DEFINITIONS

Bank Alteration: The change in streambank form resulting from large herbivores' walking along or crossing a stream during the current grazing season. Shearing and trampling by animals' hooves results in direct breakdown of the streambank, channel widening, exposure of bare soil, and may cause soil compaction. The definition of streambank alteration provided by Burton, Cowley, and Smith (2007) is used to determine what constitutes bank alteration.

Disturbance: Disruption or perturbation of normal or pre-existing conditions. In the context of this document, disturbance refers to disruption of channel form—mainly streambanks.

Greenline: "The first perennial vegetation that forms a lineal grouping of community types on or near the water's edge" (Burton et al., 2007). It can also consist of patches of vegetation on bars and other areas where vegetation is becoming established.

Recovery Potential: Ability of a stream channel to return to its pre-disturbance physical form and/or condition without external (e.g., structural) measures, once the cause of instability is corrected.

Sensitivity: Ease with which a channel's form may be altered in response to disturbance; susceptibility of a given channel type to disturbance.

Shearing: One form of bank alteration (see above). Deformation of a streambank where one portion of the bank is shifted downward in response to direct hoof pressure, parallel to the remaining section of bank (i.e., shear stress is applied). Shearing is recognized by a shear plane associated with hoof marks on the streambank.

Stability: The persistence of a physical system in its existing equilibrium form when undisturbed, or only slightly disturbed. A streambank is stable if it lacks fractures, slumps, or sloughs. A steep bank (within 10 degrees of vertical) that is actively eroding is unstable.

Trampling: Treading heavily or destructively; beating down with hooves so as to adversely affect streambanks.

RATIONALE

Need for this protocol, including need for change

Current Forest Plan guidance on either streambank stability or alteration is contained in the Streambank Stability Guideline, which states that "[a]t least 90 percent of the natural bank stability of streams that support a fishery, particularly [TES] and all trout species, should be maintained. Streambank vegetation should be maintained to 80 percent of its potential natural condition or an HCI rating of 85 or greater. Streambank stability vegetation and fish numbers and biomass should be managed by streamtype." (p.126)

This guideline has proven difficult to interpret for field personnel; determining the natural stability of streams is difficult, especially given our limited database. The guideline mentions managing by stream type and this idea should be retained in the revised Forest Plan. Conducting surveys to determine stream type can be time-consuming, and has not been done on many streams across the Forest. This task is being emphasized in recent NEPA project work for a variety of projects, and more stream typing is continually being done by Hydrology personnel. The HCI is a Habitat Condition Index used by Fred Mangum of BYU to measure stream health using aquatic invertebrate assemblages.

Livestock permittees accompanied Forest personnel on one allotment in summer 2006, and during discussions of riparian conditions and the methods used to evaluate them it became evident that lack of clear direction on bank alteration was making it difficult for Rangeland Management Specialists and permittees to judge the point at which bank alteration by livestock – and wildlife – was a problem. Permittees and Range personnel have pointed out the need to recognize that wildlife can contribute to alteration levels, and in some areas their impact is sizable. The question of when to evaluate conditions, and annual variability in amounts of alteration, were also problematic. This paper—developed with input from Range personnel, hydrologists, and other resource specialists -- is intended to address these concerns.

The measures described in this document have been developed to provide for determination of allowable amounts of induced streambank alteration-- taking natural channel sensitivity (via channel type) into account-- that would still allow stream channels to function properly. Where stream channels are degraded, the allowable amount of disturbance would lead to an improvement in conditions. These measures also seek to take into account the ability of a stream to recover from disturbance. This would be used to assist livestock managers and Rangeland Management Specialists in managing livestock to protect or improve stream channel conditions. It may also be useful for evaluating impacts from other uses (e.g., recreation). This protocol would be incorporated by reference into the revised Bridger-Teton Forest Plan.

Desired Conditions
Alluvial stream channels (i.e., those not formed in bedrock) are considered to be physically functioning properly when they can adjust their form and gradient, over a period of time, to transport the water, wood, and sediment being delivered to them. They are resilient to disturbance. When desired conditions are achieved, channel form is generally maintained, even with lateral migration of the channel, i.e. channels have the stream type that would exist in the absence of grazing or other land use impacts.

For fisheries, the assumption is that if the desired conditions described above are met, fisheries habitat will also be in its desired condition. Fish are mobile in a stream system and, like riparian vegetation, may experience an initial increase in numbers as a stream recovers from disturbance.

DEVELOPMENT OF METHODOLOGY

Summary of other guidance
It is instructive to see what other Forests and Regions are using for allowable streambank alteration and streambank stability guidelines, and the basis for those guidelines. Following is a summary of what some other units are using.

Caribou-Targhee: Riparian Grazing Implementation Guide Version 1-2

- Stratify by stream type: damage potential, recovery potential, vegetation influence.
- It appears that inherent, undisturbed bank stability of channels functioning at full potential ranges from about 70 percent to 100 percent, depending on channel type and streamside vegetation.
- Finer-grained materials are more sensitive to disturbance. Depends on vegetation, too.
- Tables 5, 5A, 7: recommended guidelines by channel type

Channel types (Rosgen)	Bank Disturbance/Alteration	Bank Stability (cumulative)
A1, A2, A6, B1, B2, B3, C1, C2, F1, F2,G1, G2	15-25% (depends on PFC rating)	75-85% (depends on PFC rating)
A3, A4, A5, B4, B5, B6, F3	15-20% (ditto)	70-80% (ditto)
The rest	10-15% (ditto)	65-75% (ditto)

Region 2 (USFS R2, 1996): Standard says "Maintain the extent of stable banks in each stream reach at 80% or more of reference conditions. Limit cumulative stream bank alteration (soil trampled or exposed) at any time to 20-25 percent of any stream reach."

Helena NF: Annual bank disturbance (percent) depends on resiliency of sites [can relate to channel types] and PFC (Functionality)/Similarity of site to conditions that are conducive to sustainable function. Simplified version of Table 4, Annual Bank Disturbance:

Resiliency	Functionality / Similarity		
	FAR/Mod	**FAR/Low**	**NF/Low**
High	30-40 / 20-25	20-30 / 15-20	15-20 / 10-15
Mod	25-30 / 15-20	15-25 / 10-15	10-15 / 5-10
Low	10-15	5-10	5-10

Tonto NF: (cited in Lewis and Clark NF, Sheep Creek Range analysis): Bank alteration standard limits physical impacts by livestock to 20% of alterable bank features or the greenline.

Beaverhead-Deerlodge NF: Based on PFC and still under development. SWCP 17 (17.05, in particular, dated 4/95) provides guidance, with "similarity" (how similar the existing reach conditions are to potential natural conditions), resiliency to impacts, and sensitivity to impacts taken into account. The Lewis and Clark Sheep Creek Range analysis states that the B-D's interim riparian guidelines allow between 19 and 51 percent total bank alteration (including natural) for inherent stabilities between 70 and 90 percent, and desired management levels between 70 and 90 percent of maximum.

Bengeyfield and Svoboda (1998) described four steps in the process of developing use levels for specific riparian areas on the B-D:

1. Set a Desired Future Condition (DFC) for a riparian area;
2. Choose a sensitivity level (I-III, based on IDT input and consideration of resource values in a watershed);
3. Determine the inherent stability of the stream channel type and vegetative communities present; and
4. Assess parameters important to attaining/maintaining DFC.

Acceptable amounts of streambank alteration were determined via comparison with reference reaches—i.e., streams that appear to be at, or near, DFC, and are relatively unaltered by land use.

Idaho Watersheds Project vs. Owyhee Resources (9th Circuit, 2002): The Court imposed an interim measure proposed by BLM of "Streambank damage attributable to grazing livestock will be less than 10% on a stream segment".

Lewis and Clark NF: 20% bank alteration is recommended as a starting point for developing a set of standards. Type of fisheries is used to vary from the 20% level:

Beneficial Use	Allowable Livestock Disturbance
Westslope CTT (where competing brook trout are also present)	10%
Fish (including streams where Westslope CTT are the only trout present)	20%
Non-fish	30%

These are regardless of similarity and resiliency: different rates of improvement would occur. Long-term trend monitoring is incorporated and adaptive management used to refine these.

Malheur NF: (Draft 5/16/2005) General starting points, to be adjusted as more site-specific information is gathered:

Desired Riparian Objectives: Mean bank stability: >80% (based on Kershner et al., 2004)
End-point indicators: Bank alteration: <5-20% (Cowley 2002, Bengeyfield and Svoboda, 1998)

Region 4 RO Guidance: Following is the text of an e-mail from Rick Hopson, Regional Hydrologist, in response to a request from the Bridger-Teton NF for input on the question of acceptable bank alteration. His response includes input from Cynthia Tait (Regional Aquatic Ecologist) and Rick Forsman (Regional Rangelands Program Lead):

> There is not any one scientifically valid criteria available. However, there is information available to help determine threshold values (see attached example from the BLM). Unless your Forest Plan provides specific direction, we recommend each Forest design criteria which best fit your specific resource conditions and needs. This should be done using an interdisciplinary team. Example - for PIBO streams on BLM lands in Idaho they are using a 10% threshold for streams with T&E listed species, and 20 value for all other streams. This latter 20% value can be adjusted based on site specific conditions. This is only one example and not to be considered direction from the Regional Office. What we do recommend is to use information which best fits your field conditions, determine in an interdisciplinary fashion specific threshold criteria, and document at the appropriate level (NEPA decision, AMP, etc.).

(Note: The referenced "attached example from the BLM" is the Cowley document, Guidelines for Establishing Allowable Levels of Streambank Alteration, dated March 2002).

As can be seen from the above information, there is no standard method for assigning allowable bank alteration. A number of Forests and BLM use PFC as their starting point, relating allowable bank alteration to some combination of similarity, functionality, and sensitivity. Others relate allowable alteration directly by Rosgen type, while the Tonto uses a straight 20%. Values for allowable bank alteration generally vary between 10% and 25%, with some outliers at both ends of the range.

Research summary

Research literature was also reviewed for information on bank alteration and channel stability; a summary of some literature found in a fairly brief search follows.

Overton et al., 1995: Mean inherent stability for "A" channels = 97%, for "B" channels = 87%, for "C" channels =85%. This was in the Salmon River drainage, and geology was described. (cited in C-T GIG)

Geology in the drainage is mostly granitics. Bengeyfield and Hickenbottom (2005) found that there was little variation in particle size distributions among geologies under reference conditions in the Greater Yellowstone area. Granitics and volcanics were in the middle of the range of particle sizes of various geologies under reference conditions. The authors stated, however, that "as disturbance and the possibility of sediment delivery increases, it is likely geology becomes a more important factor in determining the particle size distribution in streams".

Overton et al., 1994: Bank stability and width/depth ratios were recommended as the indicators to be used for assessing habitat conditions in a study stream. Ungrazed banks for stream reaches in granitic geologies from Idaho "C" type channels had a combined mean of 90% stable. An interim DFC of greater than 80% stable was recommended for these streams. Bank stability and width/depth ratios appeared to be correlated.

Cowley, 2002: Overton (pers. comm.) found that over 2/3 of low-gradient meadow type stream reaches in Idaho had streambank stabilities greater than 95%. Four-fifths exceeded 80% stability. Eight percent had bank stabilities less than 50%.

Based on his literature review, "it appears that 70 percent unaltered streambanks (i.e., 30 percent altered streambanks) is the minimum level that would maintain stable conditions. All of [the] authors consider both natural and accelerated alteration in the totals".

Cowley suggested that 80% unaltered streambanks should allow for "making significant progress" toward stream channel improvement, and that this value should be the maximum allowable streambank alteration.

In a personal communication regarding this paper (1/31/08, to Ronna Simon), Tim Burton cautioned against using 10% as a criterion and suggested 15 or 20% as a starting point for bank alteration.

Hockett and Roscoe (1993): Maximum allowable bank disturbance of 10% or less for sensitive streams and 10-25 percent for moderate to low sensitivity streams. (cited in C-T GIG)

Platts, 1981: Past sheep driveway use, especially where meadows had been used for forage and bedding while awaiting shipment, was evaluated for impacts on a stream channel. Significant differences in channel morphology between a fenced area that experienced light grazing and the unfenced, heavily-grazed, meadow were reported. Natural streambank alteration was about the same for both areas (3.5% +/- 1.4 in the lightly grazed area; 5.8% +/-1.4 in the heavily grazed area). Alteration from streambank trampling was 86.1% (+/-4.2) in the heavily used portion of the meadow. The fenced area that experienced light grazing had 5.7% (+/-4.2) bank alteration.

Dallas, 1997: In southwestern Montana, stream channels narrowed and deepened when streambank disturbance from cattle did not exceed 30 feet per 100 feet of stream reach. (cited in Mosley et al., 1997)

Bridger-Teton National Forest

<u>Natural channel characteristics-- Rosgen</u>

It is important, first, to distinguish between natural stream *sensitivity/stability* and induced *bank alteration*: channel stability is a long-term characteristic of a stream while streambank alteration is a short-term impact to a channel that may induce changes in stability. A major question that arises in regard to stability is the following: what level of bank stability can realistically be achieved, given the natural characteristics of the stream? It is also important to think about the ability of the stream to recover from disturbance once there are impacts. This can be related directly back to Rosgen type (Rosgen, 1996). Rosgen types are assigned based on a number of measurable channel attributes (entrenchment, bankfull width/depth ratios, substrate, etc.). In his book, Rosgen provides information on various characteristics of the different stream types: sensitivity to disturbance, recovery potential, sediment supply, streambank erosion potential, and vegetation controlling influence (Table 8-1).

To stratify streams on the Bridger-Teton NF, a table/matrix was made of the first two characteristics – sensitivity to disturbance and recovery potential – with respect to different stream types. These two characteristics are the most important ones in assessing the impact of bank alteration on channel form and function: as stated in Rosgen (1996), "The greatest response in riparian and stream condition would come from placing the highest priority on developing grazing management strategies for those streams that are most sensitive to grazing disturbances and have the highest recovery potential." (p.8-10) The same categories as Rosgen's were used (i.e., sensitivity ranging from Extreme to Low; recovery potential ranging from Excellent to Very Poor) and stream types were assigned their respective place in the table (Table 1):

Table 1: Sensitivity and recovery potential for various stream types

	Recovery Potential	EXC	V.GOOD	GOOD	FAIR	POOR	V.POOR
Sensitivity to disturbance							
V. LOW		A1, A2, B1, B2					
LOW		B3	C1, C2,	G1	F1, F2		
MOD		B4, B5, B6		C3	G2	F3	
HIGH				E3		D6	A6
V. HIGH				C4,C6, E4, E5, E6	C5, F6	D3, D4, D5, F5, G3, G6	A3

EXTREME						F4	A4, A5, G4, G5

Heavy black lines were drawn in Table 1 to separate the various stream types into groups as a starting point for assessment. Those streams that are least sensitive and that have the highest recovery potential are in the upper left portion of the table. The most sensitive streams having the lowest recovery potential are in the lower right corner. The upper right corner contains stream types that are not especially sensitive to disturbance, but that have low potential for recovery once they are disturbed. The lower left corner contains stream types that are very sensitive, but that recover well (the highest priority for development of grazing strategies, according to Rosgen). In this table, moderately sensitive streams are included with the more sensitive streams. This was based on input from several hydrologists, and it makes sense given the data that are available. The position of stream types in the table may be adjusted later, if needed, as more information becomes available.

Streambank erosion potential is also shown in Rosgen's Table 8-1, as mentioned above. These ratings tend to closely follow the ratings for "sensitivity to disturbance", with occasional minor deviations (e.g., B4 streams are considered to have moderate sensitivity to disturbance, and low streambank erosion potential). Sensitivity is a reasonable surrogate for streambank erosion potential.

<u>Field Verification</u>
In summer 2006, Bridger-Teton National Forest staff evaluated a number of streams in grazing allotments to see if Categorical Exclusions were appropriate NEPA tools for reissuance of grazing permits. In evaluating riparian and stream channel conditions, Hydrology personnel measured or collected visual observations of the following parameters on representative reaches of channel:

- Channel and floodplain dimensions
- Stream gradient
- Substrate composition
- Vegetative composition, shrub use, and bank cover
- Streambank stability
- Recent bank shearing (alteration)
- Land use impacts

Streambank stability and bank alteration data were collected based on the Multiple Indicator Monitoring (MIM—Burton et al., 2007) and PACFISH/INFISH and the Biological Opinions (PIBO) protocols. Range specialists were consulted for information on channels and riparian areas before Hydrology crews went to the field; due to time and personnel constraints, priorities for field surveys were based on this information, along with information obtained from topographic maps and air photo interpretations. Survey channel reaches were chosen to be representative of overall channel types and conditions, in adjustable channels (i.e., not in bedrock- or boulder-dominated channel reaches): as much of the channel as could be accessed was walked before choosing a reach for survey. Fencelines and areas of isolated heavy impacts were avoided (although the latter were recorded in field notes where they were deemed important impacts to channel function). Other features that might have contributed to impacts on channel conditions were noted (e.g., roads), and beaver dams were evaluated for their effects on channel conditions. Reaches having beaver dams were generally not measured due to the dams' effects on channel features-- e.g., changes in water surface gradients and channel widths where there were active dams; changes in amount of exposed banks and headcutting where dams had blown out—but effects of livestock use were noted.

For this paper, field data from 2006 and 2007 were examined to see how observed conditions agreed with the information from Rosgen; results are summarized in Table 2. Where detailed channel surveys were conducted, measured channel parameters were compared with reference values and percent alteration was measured. Methods for assessing bank stability had been refined over the course of the field season, and values of "percent stable" are shown for the streams where this value was measured. Verbal descriptions of conditions from these streams (e.g., "good") are an overall impression, based on measured values or observed conditions. Where no formal channel survey was conducted, overall channel conditions were described based on ocular estimates of conditions by Hydrology personnel after having walked as much of the stream as possible. Degree of bank alteration, amount of unstable banks, riparian vegetation condition, and general channel characteristics were used as the basis of the description: detailed descriptions in field notes took the place of in-depth surveys due to time and personnel limitations.

Data gathered on "reference" reaches were also examined. These are reaches of streams that were surveyed in 2002 by a crew that worked throughout the Greater Yellowstone Ecosystem (GYE) They appeared to be at "proper functioning condition" (PFC) and did not have significant management impacts to them. Channel stability was evaluated on the reference streams using the Pfankuch method, which provides a qualitative assessment of channel stability; no channel alteration data were collected. Table 2 summarizes these results as well.

Table 2: Summary of 2006 and 2007 field data, and GYE-wide averages (reference reaches are in gold)

Stream	District	Type	Current Condition/ Bank Stability	% alteration (where measured)
Sheep	3	B3	good	
Sweeney	7	B3c	good to v. good (98% stable)	12
Indian Cr	1	B3 or B4	good	
Devils Hole	1	B3 or B4	fair to good	

NF Elk	1	B3 or B4	fair to good	
W. Fk. Hams Fk	1	B3 or B4	good	
Little Cliff	2	B4c	v. good (87% stable)	6
Willow	7	B4c	Good (80% stable)	33-38
Stewart	3	B4c	40-98% stable (fair overall)	0-4
S. Fk. Little Greys	3	B4	78-82% stable (good overall)	6-10%
Box (reference strm)		B3	poor stab	
Clear (reference strm)		B4a	poor stab	
GYE-wide Average (reference strms)		B3	fair stab	
GYE-wide Average (reference strms)		B4	fair stab	
Greys River (portions)	3	C3	fair to good	
Cliff (lower)	2	C3, C4	fair	
Sheffield (reference strm)		C3b	poor stab	
S.Fk Buffalo Fk (reference strm)		C3	good stab	
GYE-wide Average (reference strms)		C3	good stab	
Hams Fk nr CG	1	C4	good	
Hams Fk nr CG	1	C4	good	
Little Sweetwater	7	C4	fair	
E. Squaw (portions)	7	C4?	good	
Dutch Joe	7	C4c-	Unsure (48-80% stable)	10-34
Clear (reference strm)		C4	good stab	
Slate (reference strm)		C4	fair stab	
GYE-wide Average (reference strms)		C4	good stab	

E.Sweetwater	7	C5	fair to good (82% stable)	17
Irish Canyon	7	C5 or C6	fair to poor	high
Moose (reference strm)		E3a	good stab	
GYE-wide Average (reference strms)		E3	good stab	
Spruce	1	E4	v. good	
Middle Fk Squaw	7	E4	good to fair (85% stable)	22
Spring-fed stream, Patrol Cabin elk feedground	State land	E4	72 – 80% stable (fair)	8 - 20
Tepee (reference strm)		E4	good stab	
Horsetail (reference strm)		E4b	good stab	
Mill (reference strm)		E4b	good stab	
GYE-wide Average (reference strms)		E4	good stab	
GYE-wide Average		E5	ref	fair stab
Muddy	2	Likely F4, F5, or F6	Poor (50-52% stable)	56-80
Clark Draw	2	F4?	fair to poor	

Referencing the field information in Table 2 to the sensitivity and recovery potential information in Table 1 results in the following observations:

<u>B3 and B4 streams</u>: Including the GYE-wide reference streams, there is quite a bit of scatter in conditions, so it is reasonable to move the B4 streams to below the dark line in Table 1. It is not known why the two reference streams from the B-T rated out as "poor"; no information is provided on the field data forms. B3 streams may need to be moved down, but they can be left where they are for now and reassessed when more information is available.

<u>C3 streams:</u> These are quite variable, so it was decided to move the horizontal dark line up in Table 1, which would incorporate more streams in the "intermediate" category (vs.

the category with low sensitivity to disturbance). This was also suggested by Rick Hopson and several of the Greater Yellowstone hydrologists.

C4 streams: These are also somewhat variable, so their position on the table is appropriate.

C5 and C6 streams: Only two of these streams have been found on the Forest thus far, so they will be left in their current position in Table 1. There is only one C5 reference stream in the GYE dataset, and it rated as "good" (it is a spring-fed stream, which acts differently than snowmelt-dominated streams).

E3 streams: There was only one on the B-T, and it was a reference stream (and was not a "pure" E3), so it is left in its current position in Table 1. GYE E3 reference streams were also generally in good condition.

E4 streams: These appear to generally be in good condition, but they are sensitive to disturbance, which is reasonable with respect to their position on Table 1.

E5 streams: No E5 streams have been surveyed to date on the Bridger-Teton NF. GYE surveys averaged out as "fair" for this type so it will remain in its current position.

F streams: These streams definitely all belong in the lower right hand corner of Table 1. They are entrenched, highly sinuous streams that are very dynamic.

Other stream types have not been sampled on the Forest, and other types were not sampled in the GYE-wide reference stream surveys, so their position on Table 1 cannot be assessed at this time.

IMPLEMENTATION

Several people, including Pete Bengeyfield (B-D Hydrologist, retired) and Tim Burton caution against using 10% as a criterion for allowable streambank alteration because it is unrealistically low (Pete). In a recent e-mail, Tim suggested using 15 or 20% as a starting point: this conflicts with information in Ervin Cowley's 2002 paper, but is based on more recent MIM results.

For the above reasons, and based on information described in the "Summary of other guidance" and "Research summary" sections of this paper, the following percentages are the allowable amounts of streambank alteration for the current season of use:

Table 3. Allowable bank alteration by channel type

LOCATION IN TABLE 1	ALLOWABLE PERCENT BANK ALTERATION
Upper left corner	25
Upper right and lower left corners	20
Lower right corner	15

Where stream types have not been assigned	20

These amounts of bank alteration—at least initially-- would address physical channel impacts, and using Rosgen as a basis also takes channel sensitivity and recovery potential into account. Values are to be adjusted if field data show that adjustments are needed. Guidance from other Forests seems difficult to implement; the method presented in this paper is a straightforward way to start measuring impacts to channels, to keep management impacts in line with Forest Plan guidance, and to start speaking with permittees about amounts of bank alteration that are acceptable.

Field methods

MIM direction for evaluation of streambank alteration and channel stability will be followed. At the time the initial drafts of this document were prepared, the 2007 version of Burton et al. was in use, but this version has already been superseded by an April 2008 version of MIM. The most recent version should be used.

1. Selection of survey reach:

MIM guidance for selecting sample reaches (called Designated Monitoring Areas, or DMAs) is as follows: (Burton et al., 2007)

> • DMAs represent riparian areas **used** by livestock (or other use). Select the site based on the premise that if proper management occurs on the DMA, the remainder of the riparian areas within a pasture or use area will also be managed within requirements.
> • Select sites that are representative of use, not an average for the stream within the pasture or allotment. For example, if livestock use one-half mile of a stream reach in the pasture and one mile is not used because it is protected by vegetation, rock, debris, or topography, the DMA location should represent the stream reach that livestock actually use.
> • Monitoring sites should have the potential to respond to and demonstrate measurable trends in condition resulting from changes in grazing management. Livestock trails associated with livestock use of the riparian area may be included in the DMA.
> • Avoid selecting sites where vegetation is not a controlling factor, such as cobble, boulder, and bedrock-armored channels.
> • Do not place DMAs in streams over four percent gradient unless they have distinctly developed flood plains and vegetation heavily influences channel stability.
> • Avoid putting DMAs at water gaps or locations intended for livestock concentration, or areas where riparian vegetation and streambank impacts are the result of site specific conditions (such as along fences where livestock grazing use is not representative of the riparian area). These local areas of concentration may be monitored to address highly localized issues, but they should not be considered

as representative of livestock grazing management over the entire riparian area within the grazing unit, and are therefore not generally chosen as DMAs.

DMA selection is meant to occur in an interdisciplinary team setting. If this is not possible, locations of DMAs are to be shared with ID team members who have a vested interest in their selection.

2. Stability and alteration assessments:
Channel stability reflects long-term channel conditions while bank alteration reflects short-term impacts that may lead to long-term changes in stability. The MIM stability assessment protocol includes a procedure for assessing streambank stability that incorporates observations of both bank cover and stability (Burton et al., 2007). The PIBO procedure for assessing streambank stability is identical to the MIM method, except that a sampling frame is not used with PIBO (Kershner et al., 2004). MIM includes a procedure for measuring bank alteration, while PIBO does not, for two reasons: (1) PIBO crews may be onsite before livestock have come onto a given pasture, and (2) PIBO is more interested in long-term channel conditions than annual conditions.

Channel stability

Protocol

1. Evaluation is conducted along the entire study reach, which is approximately 110m in length. Pacing is used to establish sample site spacing within the study reach; figure out the number of paces between observations sites needed to provide at least 40 observation points along each bank to cover the entire reach (observation spacing is 2.75m—this usually requires 4 or 5 steps between observation sites). Avoid fence boundaries where livestock tend to congregate. Begin pacing at the downstream left end of the reach (looking upstream), work upstream along that bank, cross over, and work downstream along the other bank.
2. At each site, determine if the bank is depositional (e.g., point bar on the inside of a channel bend) or erosional.
3. Evaluate stability within a rectangle defined laterally by the width of the measuring frame (50 cm). The lower limit of the rectangle is the scour line, and the upper limit is the elevation defined by the top of the point bar or, on erosional banks, the lowest terrace. The scour line is defined as the elevation of the ceiling of undercut banks or, on depositional banks, the lower limit of sod-forming or perennial vegetation.
4. A "covered" bank is one that has at least 50% of the area within the rectangle covered by any of the following:
   - perennial vegetation
   - cobbles (greater than 6 inches in diameter)
   - anchored large wood (diameter at least 4 inches)
   - a combination of the above.
5. A "stable" bank lacks fractures, slumps, or sloughing within the rectangle. A steep or bare/eroding bank is considered to be unstable, as is a depositional site that is bare of vegetation. If any of the signs of instability are present within the rectangle, the site is considered unstable.

6. Record each observation in one of the following 6 categories. Categories are various combinations of stability and cover, with added categories for "false" banks and unclassified features, following MIM (and PIBO) guidelines:

* Covered, stable
* Covered, unstable
* Uncovered, stable
* Uncovered, unstable
* False bank (past slumped banks, now stabilized)
* Unclassified (side channels, tribs, springs, etc.)

Tally left and right banks separately, keeping track of each observation; a suggested data sheet is provided separately (Excel spreadsheet).

Because channel stability reflects long-term conditions, these assessments would be done approximately every 5 years, on average.

<u>Streambank alteration</u>
According to MIM, impacts must be the obvious result of current season use and are considered streambank alteration when:

• Streambanks are covered with vegetation and have hoof prints that expose at least 12 mm (about ½ inch) of bare soil (include both the depression and soil pushed up as a direct result of hoof action);
• Streambanks exhibit broken vegetation cover resulting from large herbivores walking along the streambank and have a hoof print at least 12 mm (½ inch) deep. Measure the total depression from the top of the displaced soil to the bottom of the hoof impression; and/or
• Streambanks have compacted soil caused by large herbivores repeatedly walking over the same area even though the animal's hoofs sink into and/or displace the soil less than 12 mm (½ inch). Animal trails are included; roads are NOT included.

Protocol

1. Observations are made at each of the observation points described under #1, under the channel stability protocol.
2. Place the centerline of the sampling frame beginning at the toe of the boot, along the ***greenline.*** Evaluate the presence of streambank alteration within the entire 42 x 50 cm plot of the sampling frame. Determine the number of lines on the frame (zero to 5) that intersect areas of streambank alteration within the plot (if there are multiple shears along a given line, count them as one intersection). The first and last lines are the inside of the sampling frame bars. Record the number (0 to 5): a suggested format for a datasheet is available, separately (Excel spreadsheet).

3. When the greenline is on the top of a high steep bank, record shearing on the face of the bank and trampling within the frame along the edge of the stream. Do NOT count trampling on the top of a high terrace above the active floodplain that is upslope from the greenline.
4. When the greenline is more than about 6m or 20 feet away from the stream channel or terrace wall, streambank alteration is read along the edge of the terrace wall or along the top of the streambank. If there is not a visible terrace, alteration is read 6m from the water's edge.

Channel alteration should be evaluated annually, if possible, when it is deemed near time to move livestock. It may also be advisable to evaluate alteration before livestock come onto a pasture if wildlife use (or another type of use) is high, or if there is a desire to evaluate changes over the grazing season.

For streambank alteration, the **greenline** is to be used instead of bankfull level as an index of impacts, even though it is not a good indicator of true channel function: bankfull should be used to assess stream channels. Greenline, however, is easier to identify than bankfull and, as a result, measurements are more easily replicated; this is the reason that greenline is used in MIM. Bankfull-based measurements will be used for long-term monitoring by Hydrology crews to evaluate channel conditions.

Channel morphology surveys, pebble counts, channel typing:
This will be done by Hydrology personnel. Relevant work will include assessment of bankfull channel dimensions and gathering of other channel information that will allow for assessment of long-term channel conditions and trends (in addition to channel stability, although this information may also be gathered).

CONCLUSION

This document provides a method for measuring streambank alteration and channel stability on streams in the Bridger-Teton National Forest. It also provides implementation direction for determining if alteration is exceeding amounts that allow for maintenance, or reestablishment, of channel stability. To be an effective tool, these assessments will need to be conducted at the appropriate time on grazing allotments. The question of who conducts the assessments needs to be discussed among Forest staff and personnel, and it may vary across the Forest. This method is also useful for evaluating the impacts of other Forest activities on stream channels, and should be used as a tool for this purpose.

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