



MILK RIVER RIPARIAN AREA MANAGEMENT OBJECTIVES

Discussion Paper for the Milk River Integrated Watershed Management Plan and State of the Watershed Report 2013

Note to Reader:

This is a working document. You will note that there are areas highlighted in red, some areas where question marks remain etc. or thoughts are not well developed. Your comments and feedback will be considered in the final version of this document.

Prepared by: Palliser Environmental Services Ltd.

Prepared for: Milk River Watershed Council Canada

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1.0 BACKGROUND

Riparian areas, including flowing (lotic) areas and non-flowing (lentic) areas (wetlands) are important components of the Milk River watershed. Functioning riparian areas reduce streambank erosion, reduce sediment transport, maintain water quality, store water to minimize the impacts of drought and to mitigate floods, and provide forage and shelter for wildlife and domestic livestock. All of these functions are important to maintain a healthy Milk River watershed and to preserve and/or increase biodiversity in the region.

The Milk River Watershed Council Canada (MRWCC) is a non-profit organization and provincially designated Watershed Planning and Advisory Council for the Milk River, Alberta. As such, the MRWCC is responsible for state of the watershed reporting and watershed management planning. Riparian condition is one component of the watershed that is of interest to its members and was reported in the 2008 Milk River State of the Watershed Report.

The MRWCC is currently developing an Integrated Watershed Management Plan (IWMP) to address a variety of concerns that landowners, community members, resource managers and stakeholders have expressed, including aspects of water supply, water quality, biodiversity and land use. Riparian area management will form an integral part of the Milk River IWMP as riparian areas occupy the important transition zone between land and water. This report summarizes available riparian health assessment data collected in the Milk River watershed, offers management recommendations to maintain or improve riparian function and establishes draft targets and thresholds for riparian area health as a measure of meeting riparian area management objectives.

Overall, the objective of this report is to:

- 1) provide a baseline riparian health score for each of the four river reaches and Eastern Tributaries in the Milk River watershed,
- 2) summarize the riparian issues for each of the four reaches and Eastern Tributaries,
- 3) develop riparian management objectives to address priority issues, and
- 4) identify riparian targets and thresholds for each of the four Milk River reaches and Eastern Tributaries.

2.0 METHODS

Riparian health assessment data for public and private land in the Milk River watershed was obtained from Cows and Fish and Alberta Conservation Association (ACA). The data was grouped according to year, geographical location (river mainstem site, tributary site or wetland) and by organization for each of five reaches delineated in the watershed. Four of the Milk River reaches were predefined in earlier studies (AMEC 2008) and the fifth reach represents the Eastern Tributaries (Figure 1). The Eastern Tributaries consist of streams located wholly in SE Alberta; streams which straddle the provincial boundary, and; streams which are wholly located within SW Saskatchewan – all of which drain into the Milk River. [In this document the Eastern Tributaries that are located within Alberta will only be addressed]. Average health ratings were calculated for each of the five Reaches and average scores for individual health parameters are presented in bar graphs. If a site was assessed more than once, a comparison of this data was made to determine if site conditions had changed.

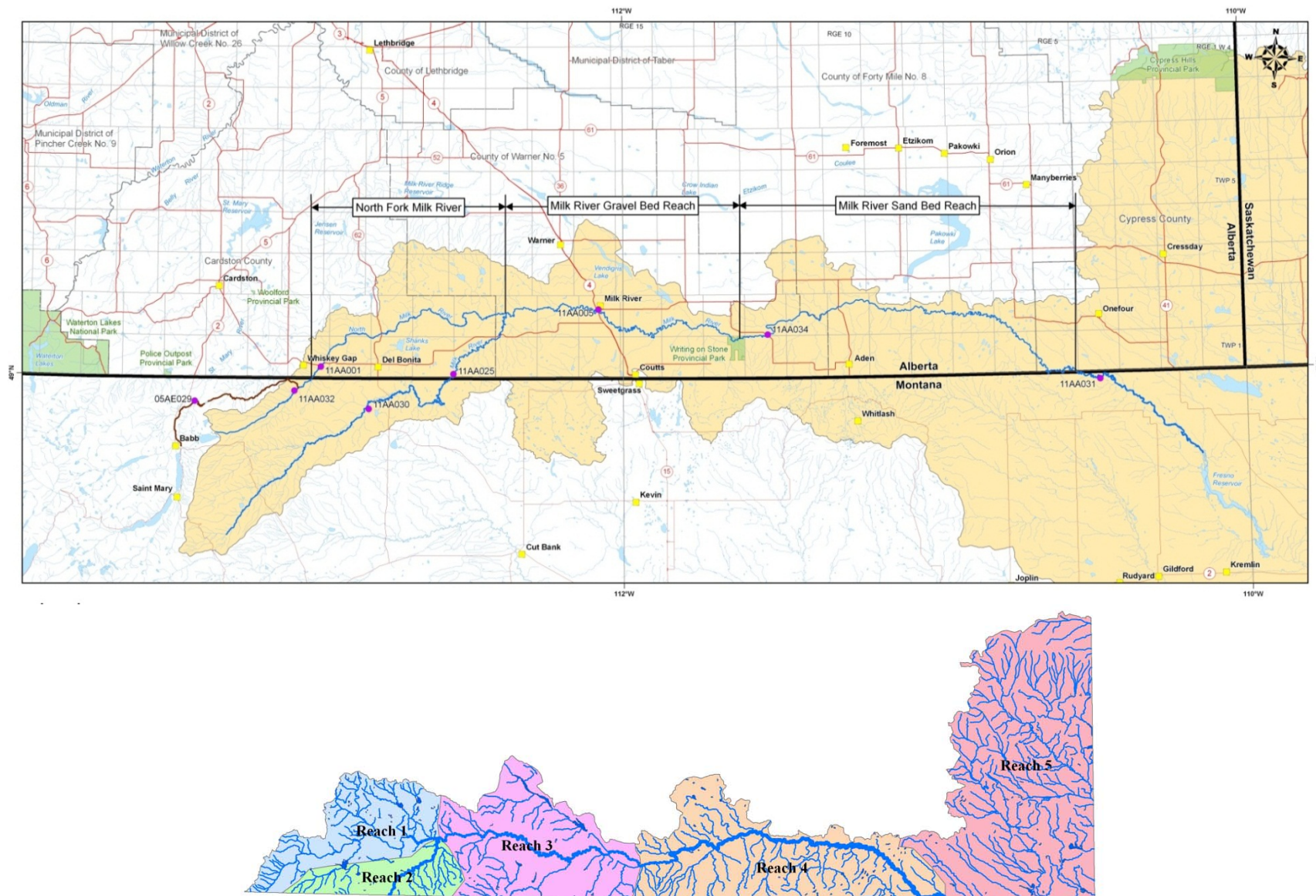


Figure 1. Map showing the five reaches used to group riparian health assessment data in the Milk River watershed.

Cows and Fish uses riparian health inventory and riparian health assessment methods to report on riparian function for lakes, sloughs and wetlands, streams and small rivers, and large rivers in the Milk River watershed. Each method evaluates riparian health using a variety of indicators related to ecological status, plant community structure and site stability. Indicators that are considered in each survey include vegetative cover, disturbance and invasive plants, tree and shrub establishment, regeneration and utilization, and human disturbance (refer to Table 1 for a list of all the parameters and their significance). These parameters are intended to indirectly evaluate the ability of a site to perform ecological functions.

The **riparian health inventory** is a more comprehensive riparian health survey than the riparian health assessment. The riparian health inventory thoroughly examines vegetation, soil parameters and hydrology through 79 questions or parameters related to health indicators, many of which require detailed measurements. This method is generally used by resource managers to capture benchmark data and examine details of the plant community and structure. The riparian health inventory is used for monitoring purposes and evaluation of the impacts of management changes through time. A computer model is used to derive riparian health scores for 9 indicators for lakes and wetlands, 11 indicators for streams and small rivers and 15 indicators for large rivers based on the inventory data collected (Appendix A, Appendix B and Appendix C).

The **riparian health assessment** is a more rapid method compared to the riparian health inventory. This tool is typically used by landowners and frequently serves as a training tool for resource managers. The riparian health assessment evaluates 9 questions for lakes and wetlands and 11 questions or parameters related to riparian condition for streams and small rivers. Alberta Conservation Association has used the riparian health assessment method in their evaluation of riparian condition in the Milk River watershed. Table 1 summarizes the number of riparian surveys completed in the Milk River basin using the inventory and assessment methods.

Table 1. Summary of methods used to conduct riparian health surveys in the Milk River watershed, 1997-2011.

Site	Large Rivers (Milk River Mainstem Sites)		Streams and Small Rivers (Milk River Tributary Sites)			Lakes and Wetlands		
	Inventories	Assessments	Inventories	Assessments		Inventories	Assessments	
	C&F	C&F	C&F	C&F	ACA	C&F	C&F	ACA
Reach 1 - North Fork Milk River	12	0	2	0	0	-	-	-
Reach 2 – South Fork Milk River	13	0	0	0	0	-	-	-
Reach 3 – Milk River Gravel-bed	42	0	2	0	0	-	-	-
Reach 4 – Milk River Sand-bed	49	6 ^a	24	0	5	-	-	-
Reach 5 – Eastern Tributaries	-	-	53	5	0	-	-	-

Site	Large Rivers (Milk River Mainstem Sites)		Streams and Small Rivers (Milk River Tributary Sites)			Lakes and Wetlands		
	Inventories	Assessments	Inventories	Assessments		Inventories	Assessments	
	C&F	C&F	C&F	C&F	ACA	C&F	C&F	ACA
Wetlands (Lentic Areas)	-	-	-	-	-	11	1	9

^aSix of the 55 inventories conducted at Reach 4 were completed using the Streams and Small Rivers Form.

Riparian health inventories and assessments rate riparian health by assigning scores to the appropriate list of indicators that contribute to system function. The main 11 health indicators, which appear in many of the figures that follow, are described in Table 2. A complete description of all riparian health indicators is provided in Appendix D. A score of 80 or above is achieved when the riparian area is Healthy (green condition, little or no impairment to riparian function), a score of 60 to 79 is achieved for riparian areas that are Healthy with Problems (yellow condition, some impairment to riparian functions due to human or natural causes) and scores of less than 60 denote Unhealthy riparian areas (red condition, impairment to many riparian functions due to human or natural causes).

Table 2. Summary of riparian health indicators and their significance to riparian function.

Riparian Health Indicators	Significance
Vegetative Cover of Floodplain and Streambanks	Native plants provide deep binding root mass to maintain streambanks, slow the flow of overland runoff to facilitate water quality improvements, provide summer and winter forage for wildlife and livestock.
Preferred Tree and Shrub Establishment and Regeneration	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Standing Decadent and Dead Woody Material	The amount of decadent and dead woody material may indicate a change in water flow due to human or natural causes, dewatering of a reach can change vegetation from riparian to upland species, flooding of a reach or persistent high water table can kill or eliminate some species, chronic overuse of browse, physical damage such as rubbing and trampling and climatic impacts.
Utilisation of Preferred Trees and Shrubs	The root systems of woody species provides streambank stability. Removal of this material reduces stability, causes loss of preferred woody species and leads to invasion of disturbance and weed species.
Occurrence of Invasive Plant Species	Invasive plants do not provide deep-binding root mass for bank protection and they provide minimal structural and habitat diversity when present in high densities. Weeds impact wildlife and livestock by replacing the vegetation they utilize for shelter and food.
Disturbance-Increaser Undesirable Herbaceous Species	Disturbance plants generally do not have deep binding root mass to protect streambanks and they provide minimal structural and habitat diversity when present in high densities. These plants are not as palatable to wildlife and livestock.
Streambank Root Mass Protection	Root mass provide by native vegetation acts similar to rebar and hold streambanks together, preventing erosion and limiting lateral cutting.
Human-Caused Bare Ground	Bare ground is void of plants, plant litter, woody material or large rocks and is more susceptible to erosion processes. Human-caused bare ground may be caused by livestock, recreationists and vehicle traffic. It provides an opportunity for disturbance or weed species.

Riparian Health Indicators	Significance
Streambanks Structurally Altered by Human Activity	Structural alterations of the streambanks (e.g., mechanically broken down by livestock activity or vehicle traffic) increase the potential for erosion while inhibiting the establishment of riparian vegetation.
Human Physical Alteration to the Rest of the Polygon	Stable streambanks maintain channel configuration and bank shape. Altered streambanks may increase erosion and mobilize channel and bank materials, water quality can deteriorate and instability can increase downstream.
Stream Channel Incisement (Vertical Stability)	Incisement can increase stream energy by reducing sinuosity, water retention and storage and increase erosion.

Appendix A, Appendix B and Appendix C provide a description of how health score categories are derived using the *Riparian Health Score Sheet Categories for Lakes and Wetlands*, *Riparian Health Score Sheet Categories for Streams and Small Rivers* and *Riparian Health Score Sheet Categories for Large Rivers*.

The data compiled for riparian health assessments and inventories in the Cows and Fish database spanned a 15-year period from 1997 to 2011. Within this time frame a number of modifications were made to the assessment methodology to reflect improved knowledge of riparian systems. To render the data comparable among years, a number of modifications were made to the original data sets. The changes made to field methodologies are documented in Appendix E.

3.0 RESULTS

3.1 Wetlands (Lentic Sites)

Cows and Fish assessed 12 wetlands in the Milk River watershed from 1998 to 2008. Five of the sites were assessed in Reach 4 and 7 sites were assessed in Reach 5. The results showed that 25% of sites were rated as Healthy, 42% of sites were rated as Healthy with Problems and 33% were rated as Unhealthy (Figure 2).

Nine wetlands in the watershed were assessed in 2011 by the Alberta Conservation Association. All of the sites assessed were located in Reach 4. Overall, 11% of sites rated as Healthy, 11% of sites rated Healthy with Problems and 78% of sites rated Unhealthy (Figure 2).

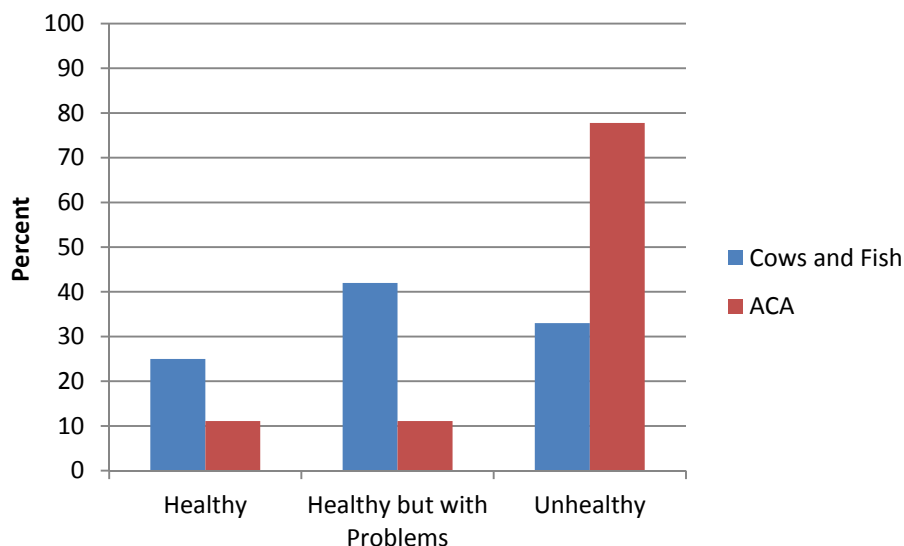


Figure 2. Summary of riparian health categories for wetlands in the Milk River watershed, 2011. Note N=12 for Cows and Fish data (1998-2008), N=9 for ACA data (2011).

Figure 3 summarizes the results for the various riparian health indicators representing wetlands in the Milk River watershed as reported by Cows and Fish. Indicators that rated Healthy were vegetative cover, preferred tree and shrub regeneration, woody vegetation removal other than browse and artificial water level change. Two indicators related to human influences were rated Healthy with Problems. These were human-caused alterations to vegetation and human-caused bare ground. Although the indicator “vegetative cover” rated Healthy, the indicators invasive and disturbance plants rated Unhealthy. Human-caused alterations to site and the severity of the human-caused alterations also rated Unhealthy.

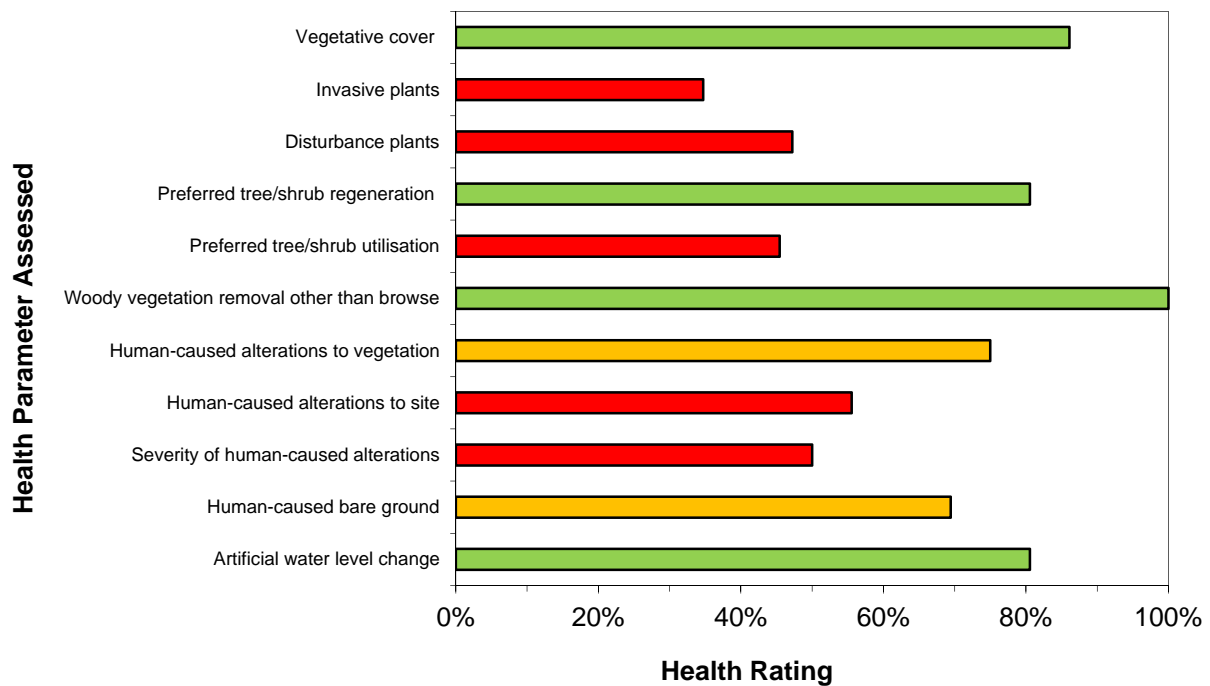


Figure 3. Summary of riparian health indicators for wetlands reported by Cows and Fish, 1998 to 2008 (N=12). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

Figure 4 summarizes the average score that was assigned to riparian health indicators as collected by the Alberta Conservation Association in 2011. There was no indicator rated Healthy in the 2011 assessment. Indicators that rated Healthy with Problems were vegetative cover and artificial water level change. Similar to the Cows and Fish assessment, indicators that were rated Unhealthy by ACA were invasive and disturbance plants, human-caused alteration to site and severity of human-caused alterations. In addition, human-caused alterations to vegetation and human-caused bare ground rated Unhealthy by ACA, compared to the Healthy with Problems rating assigned to these to indicators in the Cows and Fish assessment.

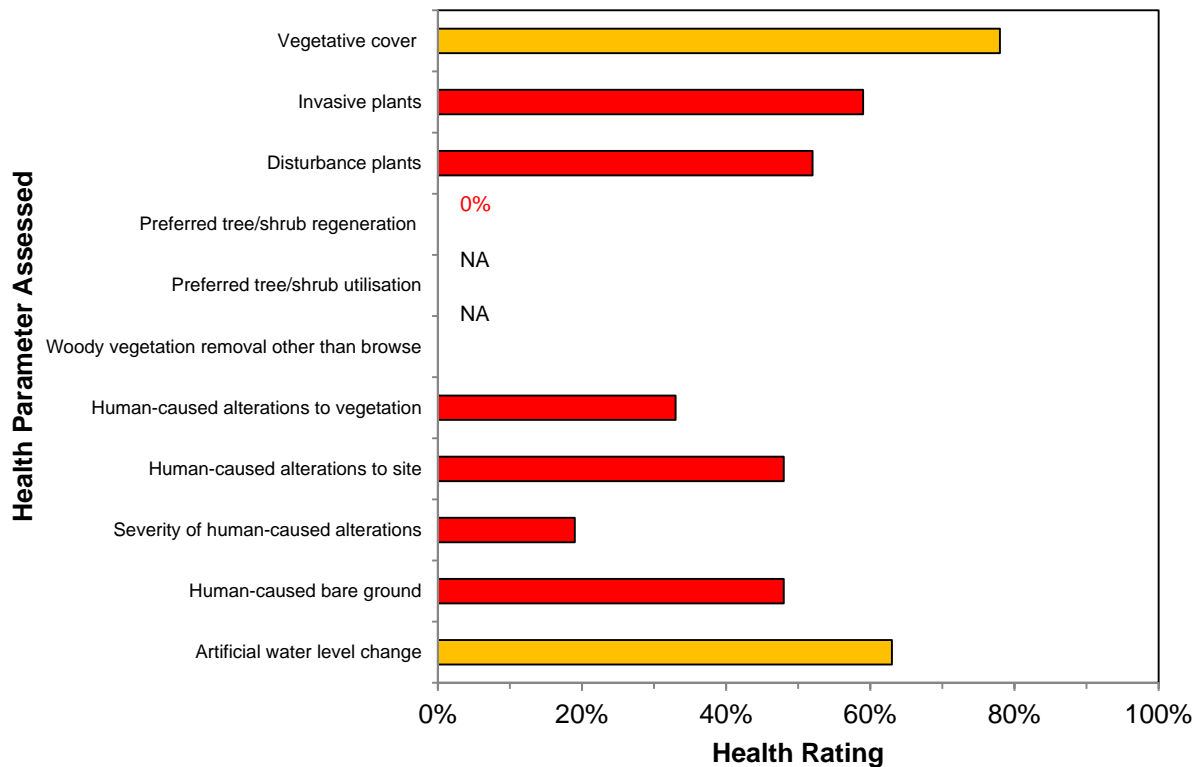


Figure 4. Summary of riparian health indicators for wetlands reported by Alberta Conservation Association, 2011 (N=9). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings. The letters “NA” represent “not applicable”.

3.2 Riparian Areas (Lotic Sites)

A total of 220 riparian sites have been inventoried or surveyed within the Milk River watershed by Cows and Fish from 1997 to 2011. Eighty-six of the 220 sites assessed were on tributaries, and of these, 58 (67%) of the sites were at Reach 5 – the Eastern Tributaries. Refer to Appendix F for a summary of the number of riparian health assessments completed by year. About 130 km of riparian lands were assessed in the past 15 years along the mainstem Milk River and 218 km assessed along tributaries (Table 3). Of the 55 mainstem sites originally assessed at Reach 4 in 1998 and 1999, 25 sites (46%) were re-visited, 15 sites in 2008 and 10 sites in 2011. In 2005, one site was revisited at Reach 3. Four sites on the same tributary and one lentic site have been re-assessed in Reach 5 in 2001 and 2003.

Table 3. Summary of total river kilometers assessed in the Milk River watershed.

Milk River Reach	Mainstem			Tributaries	
	Kilometers	Percent of Reach	Hectares	Kilometers	Hectares
Reach 1	11.5	12	105.3	1.0	0.6
Reach 2	15.3	38	140.7	-	-
Reach 3	46.2	44	541.0	2.0	2.0
Reach 4	56.6	40	926.3	18.6	41.4
Reach 5	-	-	-	190.3	46.9

Wetlands	-	-	-	5.9	11.1
Total	129.6	-	1,713.3	217.8	102.0

3.2.1 Reach 1 - North Fork Milk River

Tributaries

Two riparian sites were assessed in 2009 at one tributary in Reach 1, representing about 1 km of that tributary. Both sites rated in the Healthy with Problems category. Indicators that rated Healthy were vegetative cover, woody vegetation removal other than browse, dead and decadent woody material, root mass protection, human-caused bare ground and channel incisement (Figure 5). Indicators that rated Unhealthy were invasive and disturbance plants, preferred tree/shrub utilization and regeneration, human-caused alteration to banks and human caused alteration to polygon. No indicators rated in the Healthy with Problems category.

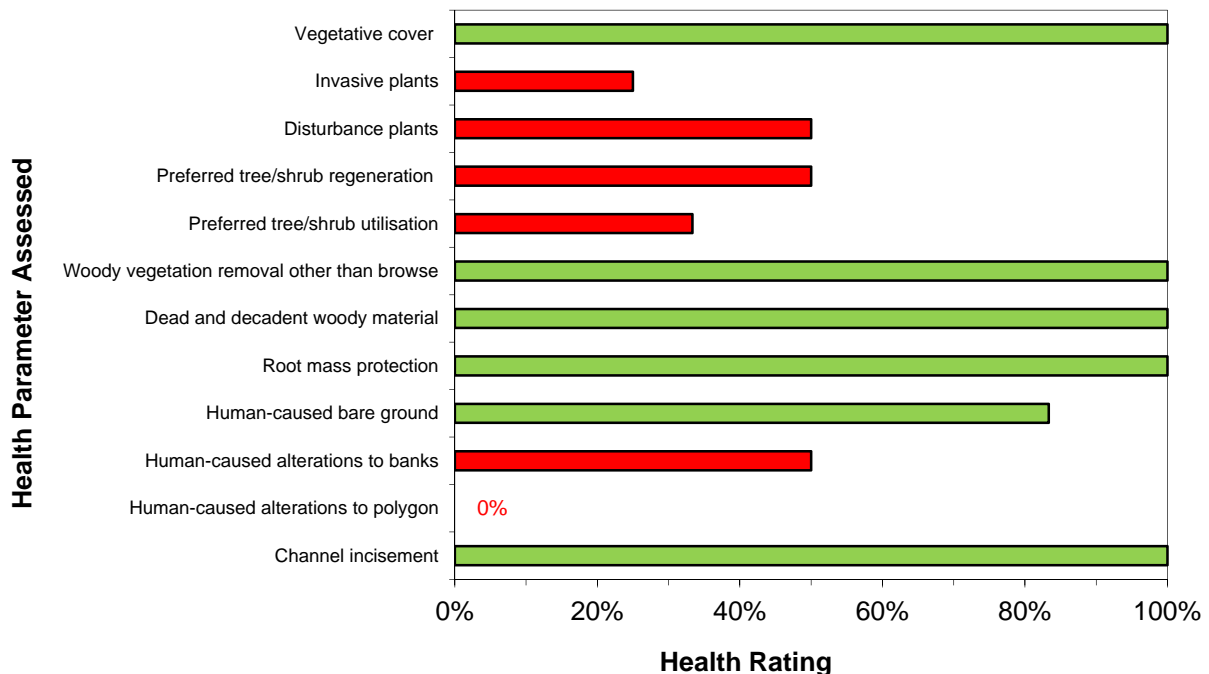


Figure 5. Summary of riparian health indicators at a tributary to the North Fork Milk River, reported by Cows and Fish, 2009 (N=2). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

Mainstem

Twelve riparian sites were assessed from 2000 to 2009 at Reach 1 – North Fork Milk River, representing about 11.5 km. No site was rated Healthy, 83% of sites rated in the Healthy with Problems category and 17% of sites rated Unhealthy. Indicators that rated Healthy were dead and decadent woody material, woody vegetation removal other than browse, human-caused bare ground, control of flood peak and timing by upstream dam(s), human-caused alterations to banks and floodplain accessibility (Figure 6). Indicators that rated in the Healthy with Problems category were total canopy cover of woody species and human-caused alterations to the

polygon. Indicators that rated Unhealthy were preferred shrub regeneration, preferred tree/shrub utilization, invasive and disturbance plants, riverbank root mass protection and removal or addition of water from/to the river system.

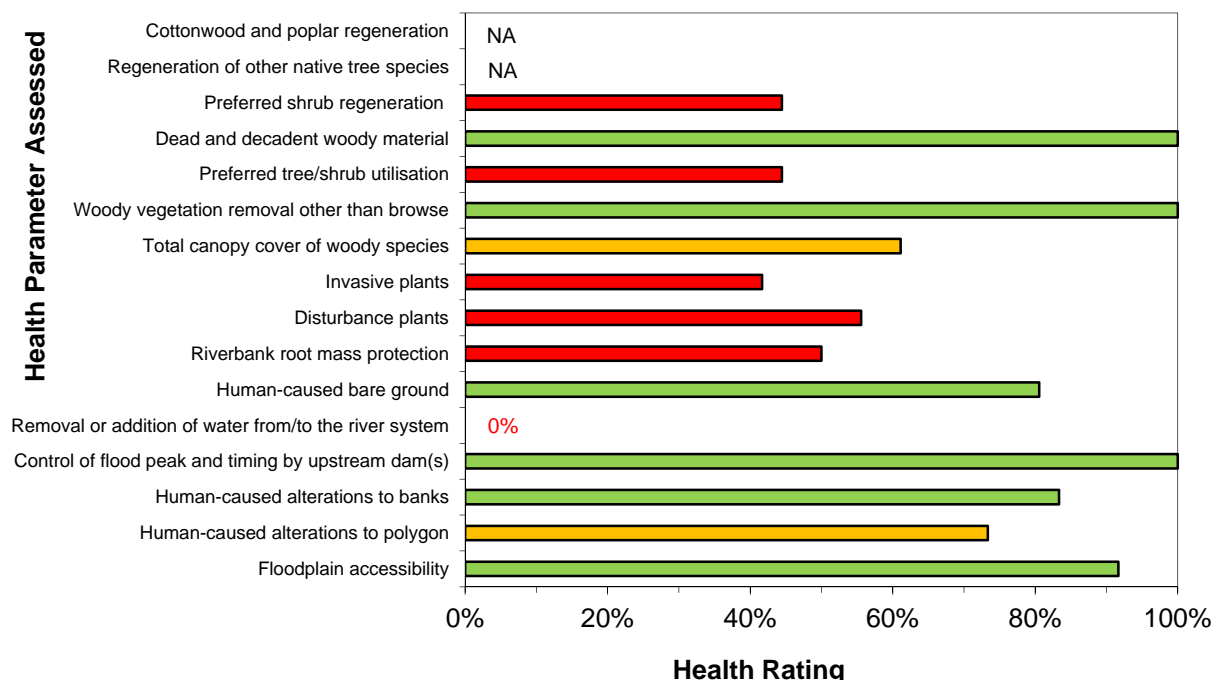


Figure 6. Summary of riparian health indicators at Reach 1 - North Fork Milk River, reported by Cows and Fish, 2000-2009 (N=12). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings. The letters “NA” represent “not applicable”.

3.2.2 Reach 2 – South Fork Milk River

Tributaries

No tributaries have been assessed in Reach 2.

Mainstem

Thirteen riparian sites were assessed at Reach 2 – South Fork Milk River, six in 2000 and seven in 2009. Fifty-four percent of sites rated in the Healthy category, 23% of sites rated Healthy with Problems and 23% of sites rated Unhealthy. Indicators that rated Healthy were preferred shrub regeneration, dead and decadent woody material, woody vegetation removal other than browse, human-caused bare ground, control of flood peak and timing by upstream dam(s), human-caused alterations to banks, human-caused alterations to polygon and floodplain accessibility (Figure 7). Indicators that rated Healthy with Problems were total canopy cover of woody species and removal or addition of water from/to the river system. Indicators that rated Unhealthy were preferred tree/shrub utilization, invasive and disturbance plants and riverbank root mass protection.

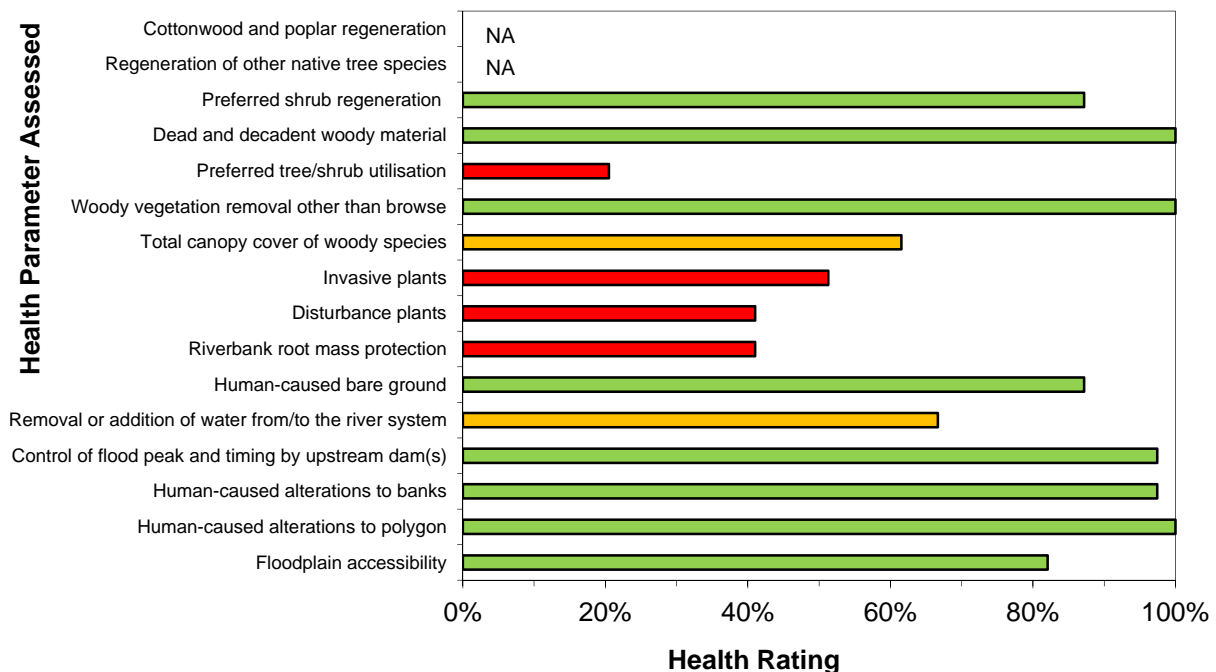


Figure 7. Summary of riparian health indicators at Reach 2 – South Fork Milk River, reported by Cows and Fish, 2000 and 2009 (N=13). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings. The letters “NA” represent “not applicable”.

3.2.3 Reach 3 – Milk River Gravel-bed Reach

Tributaries

In 2008, two riparian health assessments were conducted on one tributary at Reach 3 by Cows and Fish. Both sites rated in the Healthy with Problems category. Indicators that rated Healthy were vegetative cover, preferred tree/shrub utilization, woody vegetation removal other than browse, dead and decadent woody material, human-caused alterations to banks, human-caused alterations to polygon and channel incisement (Figure 8). Indicators that rated Healthy with Problems were root mass protection and human-caused bare ground. Indicators that rated Unhealthy were invasive and disturbance plants and preferred tree/shrub regeneration.

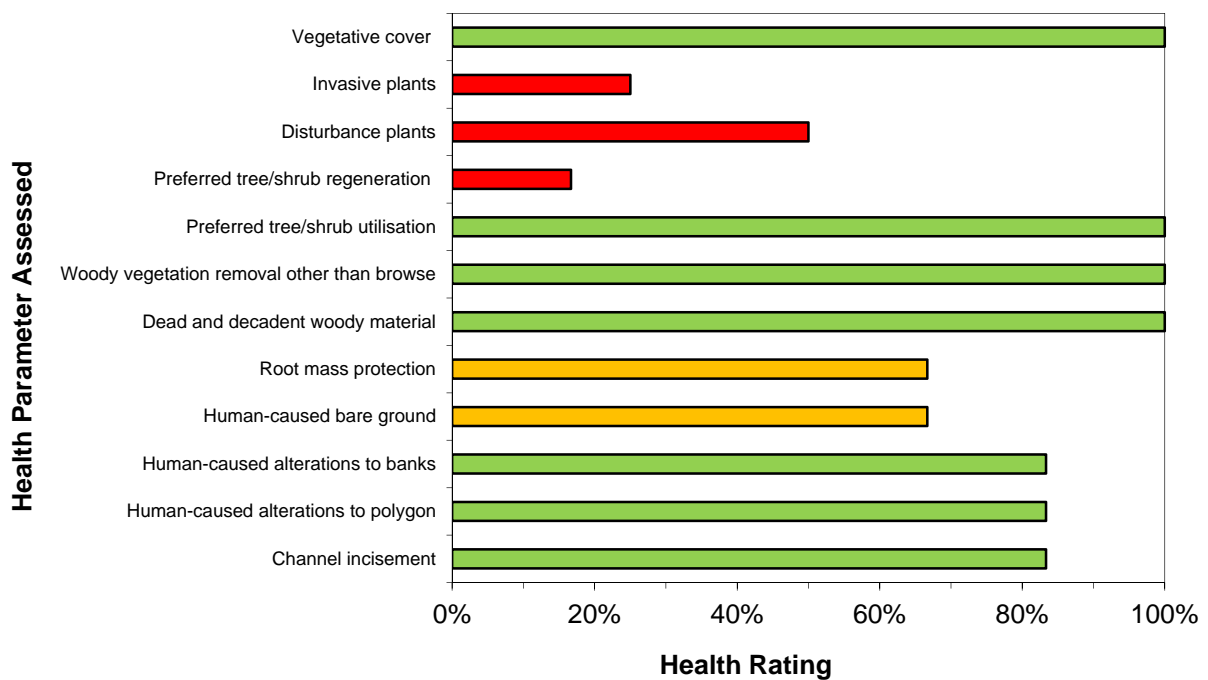


Figure 8. Summary of riparian health indicators at one tributary to Reach 3 – Milk River Gravel-bed Reach, reported by Cows and Fish, 2008 (N=2). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

Mainstem

Forty-two riparian sites were assessed at Reach 3 – Milk River Gravel-bed Reach, in 1999 and 2000. Two percent of sites rated in the Healthy category, 41% of sites rated Healthy with Problems and 57% of sites rated Unhealthy. Indicators that rated health were preferred shrub regeneration, dead and decadent woody material, total canopy cover of woody species, human-caused bare ground, control of flood peak and timing by upstream dam(s) and floodplain accessibility (Figure 9). The indicator that rated Healthy with Problems was human-caused alteration to banks. Indicators that rated Unhealthy were cottonwood and poplar regeneration, regeneration of other native tree species, preferred tree/shrub utilization, invasive and disturbance plants and riverbank root mass protection.

In 2005, one site at Reach 3 was re-assessed. This site rated Unhealthy in 2000 with a score of 52 and improved to rate Healthy with Problems in 2005 (score 70). Improvements at the site were mainly due to better scores assigned to the regeneration of preferred trees and shrubs, canopy cover of woody species and of invasive plants, riverbank rootmass protection, human-caused bare ground and floodplain accessibility.

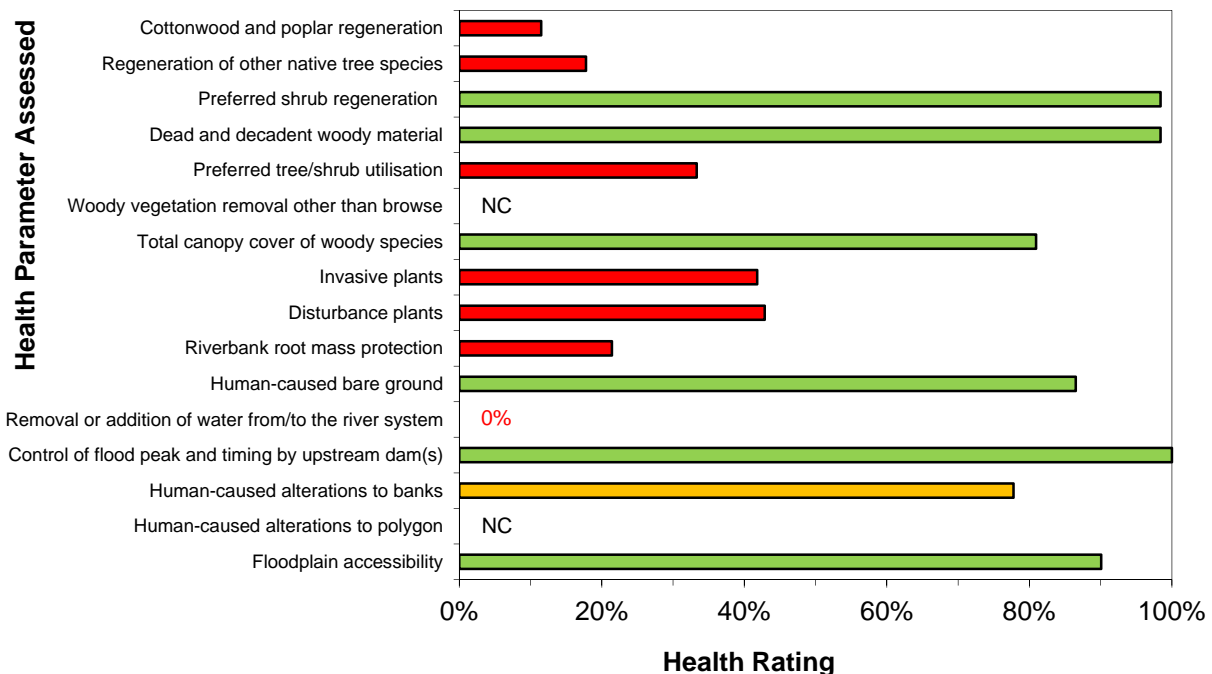


Figure 9. Summary of riparian health indicators at Reach 3 – Milk River Gravel-bed Reach, reported by Cows and Fish, 1999 and 2000 (N=42). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings. The letters “NC” represent “not collected”.

3.2.4 Reach 4 – Milk River Sand-bed Reach

Tributaries

Twenty-four riparian health assessments were conducted on tributaries at Reach 4 by Cows and Fish. Forty-six percent (46%) of sites rated Healthy and 54% of sites rated in the Healthy but with problem category. Indicators that rated Healthy were vegetative cover, woody vegetation removal other than browse, dead and decadent woody material, root mass protection, human-caused bare ground, human-caused alterations to banks, human-caused alterations to polygon and channel incisement (Figure 10). The indicators that rated Healthy with Problems was preferred trees/shrub regeneration. Indicators that rated Unhealthy were invasive and disturbance plants and preferred tree/shrub utilization.

In 2011, ACA assessed five sites at tributaries in Reach 4 (different from those assessed by Cows and Fish). Twenty percent (20%) of riparian sites assessed rated in the Healthy category, 60% of the sites rated Healthy with Problems and 20% of sites rated Unhealthy. Similar to the Cows and Fish data set, indicators that rated Healthy were vegetative cover, woody vegetation removal other than browse and dead and decadent woody material (Figure 11). In addition, preferred tree/shrub regeneration rated Healthy. Root mass protection, human-caused bare ground, human-caused alterations to polygon and channel incisement rated Healthy in the Cows and Fish data base, but ACA rated these parameters Healthy with Problems, as well as invasive plants. The indicators that rated Healthy with Problems by ACA were disturbance plants, human-caused alterations to banks and channel incisement.

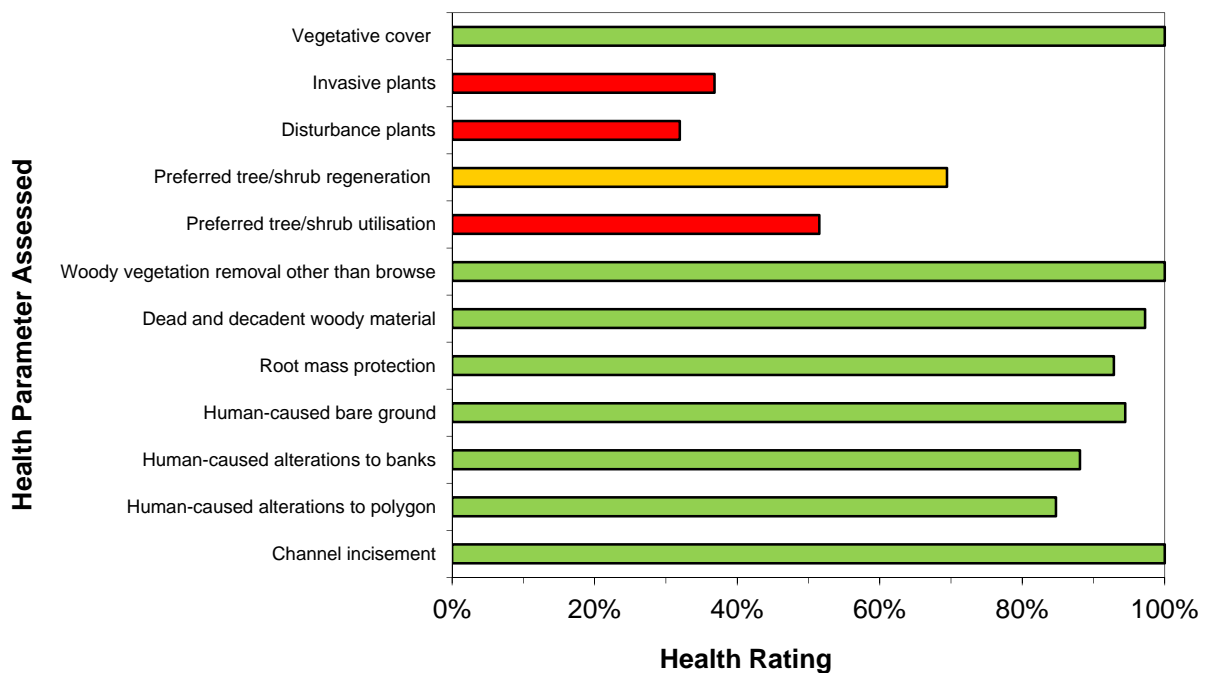


Figure 10. Summary of riparian health indicators for tributaries in Reach 4 – Milk River Sand-bed Reach, reported by Cows and Fish, 1997-2011 (N=24). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

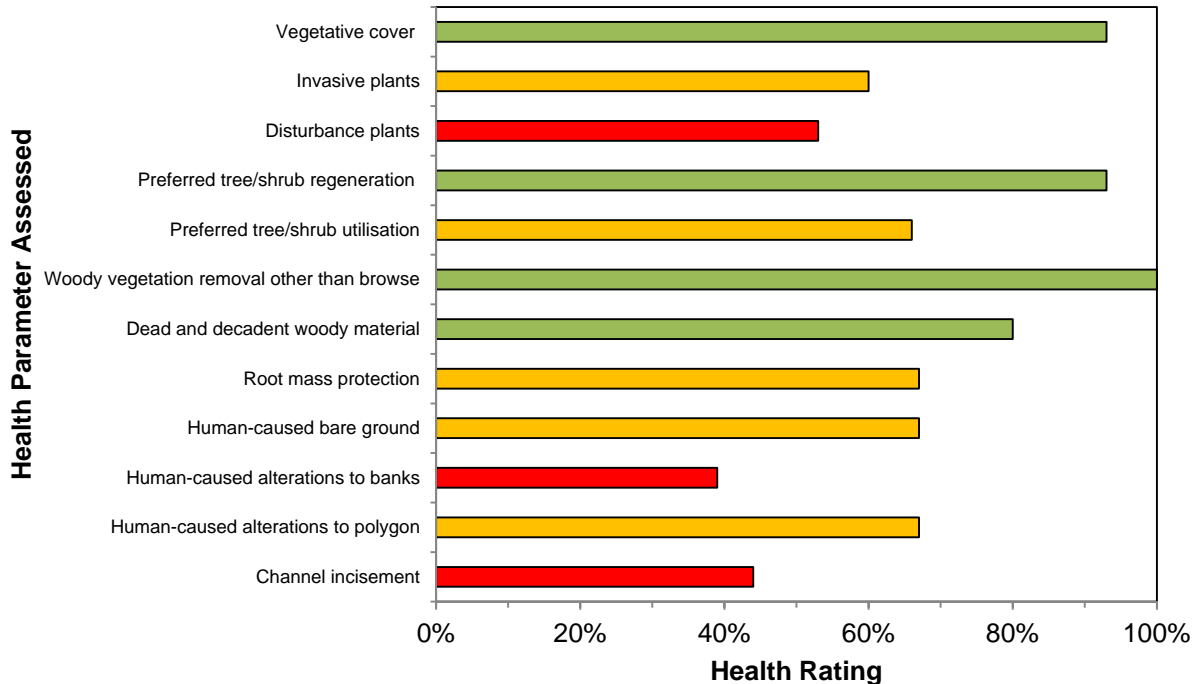


Figure 11. Summary of riparian health indicators for tributaries in Reach 4 – Milk River Sand-bed Reach, reported by Alberta Conservation Association, 2011 (N=5). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

Mainstem

Fifty-five riparian sites were assessed at Reach 4 – Milk River Sand-bed Reach, from 1999 to 2011, 49 of these sites were inventoried using the form for Large Rivers (15 questions/parameters) and the other six sites were inventoried using the form for Streams and Small Rivers (11 questions/parameters). For all sites combined, 4% of sites rated in the Healthy category, 56% of sites rated Healthy with Problems and 40% of sites rated Unhealthy.

For sites that were assessed using the form for Large Rivers, indicators that rated Healthy were preferred shrub regeneration, dead and decadent woody material, woody vegetation removal other than browse, control of flood peak and timing by upstream dam(s), human-caused alteration to polygon and floodplain accessibility (Figure 12). The indicators that rated Healthy with Problems were total canopy cover of woody species, human-caused bare ground and human-caused alterations to banks. Indicators that rated Unhealthy were cottonwood and poplar regeneration, regeneration of other native tree species, preferred tree/shrub utilization, invasive and disturbance plants, riverbank root mass protection and removal or addition of water from/to the river system.

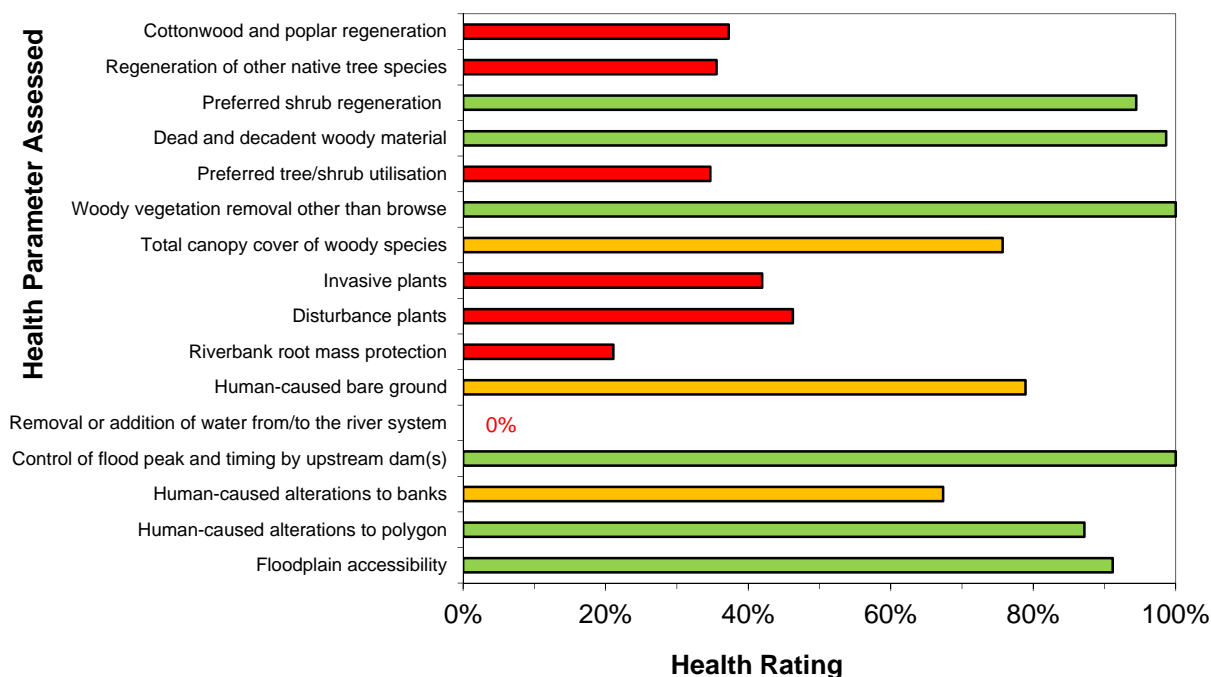


Figure 12. Summary of riparian health indicators (Large River form) at Reach 4 – Milk River Sand-bed Reach, reported by Cows and Fish, 1999 to 2011 (N=49). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

For sites that were assessed using the form for Streams and Small Rivers, indicators that rated in the Healthy category were vegetative cover, preferred tree/shrub regeneration, dead and decadent woody material, human-caused bare ground, human-caused alterations to banks, human-caused alterations to polygon and channel incisement (Figure 13). No indicators rated Healthy with Problems. Indicators that rate Unhealthy were invasive and disturbance plants, preferred tree/shrub utilization and root mass protection.

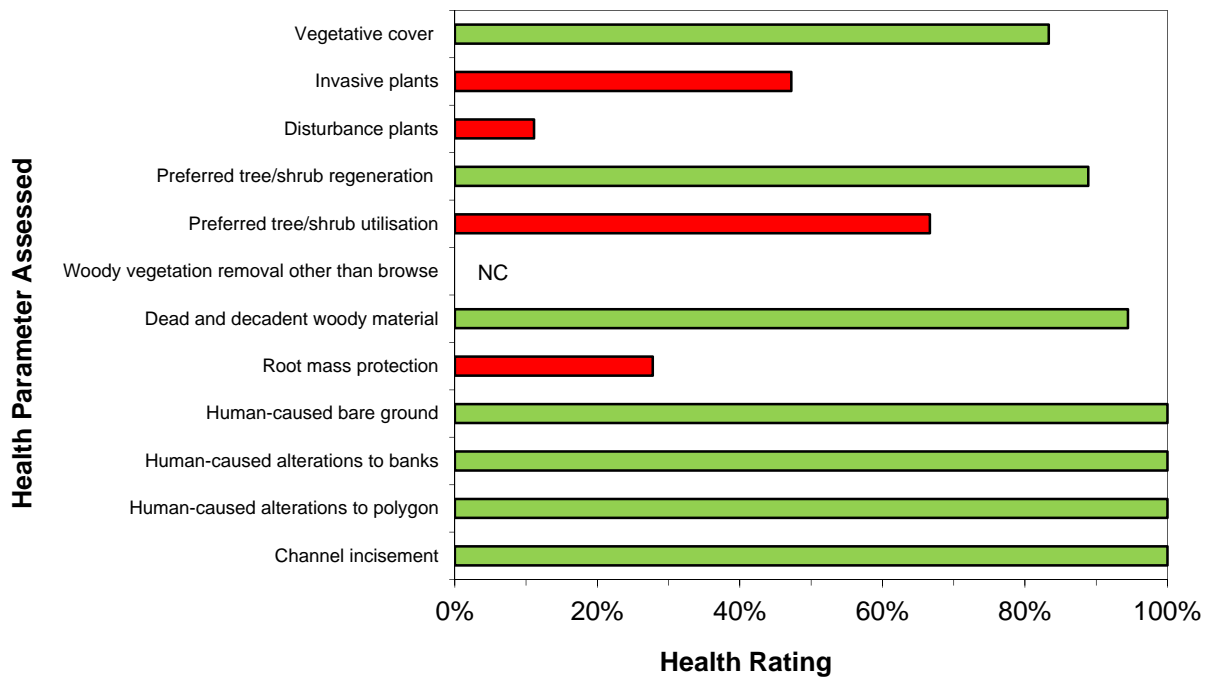


Figure 13. Summary of riparian health indicators (Streams and Small Rivers form) at Reach 4 – Milk River Sand-bed Reach, reported by Cows and Fish, 1997, 2007 (N=6). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

At Reach 4, 25 sites that were assessed in 1998 and 1999 were re-assessed in 2008 and 2011. For the first assessments (1998 and 1999), the average score was 56, rating riparian areas in this reach Unhealthy. In the re-assessment, the average score was slightly improved (62) rating riparian areas at the lower end of the Healthy with Problems category. Similar to Reach 3 findings, there was great improvement in the indicator tree and shrub regeneration that improved from an Unhealthy rating in the first assessment to a Healthy rating in the re-assessment (Figure 14). The scores for indicators “total canopy cover of woody species” and “human-caused alterations to banks” also improved in the re-assessment. Scores were lower in the re-assessment for indicators associated with invasive and disturbance plants (Figure 15).

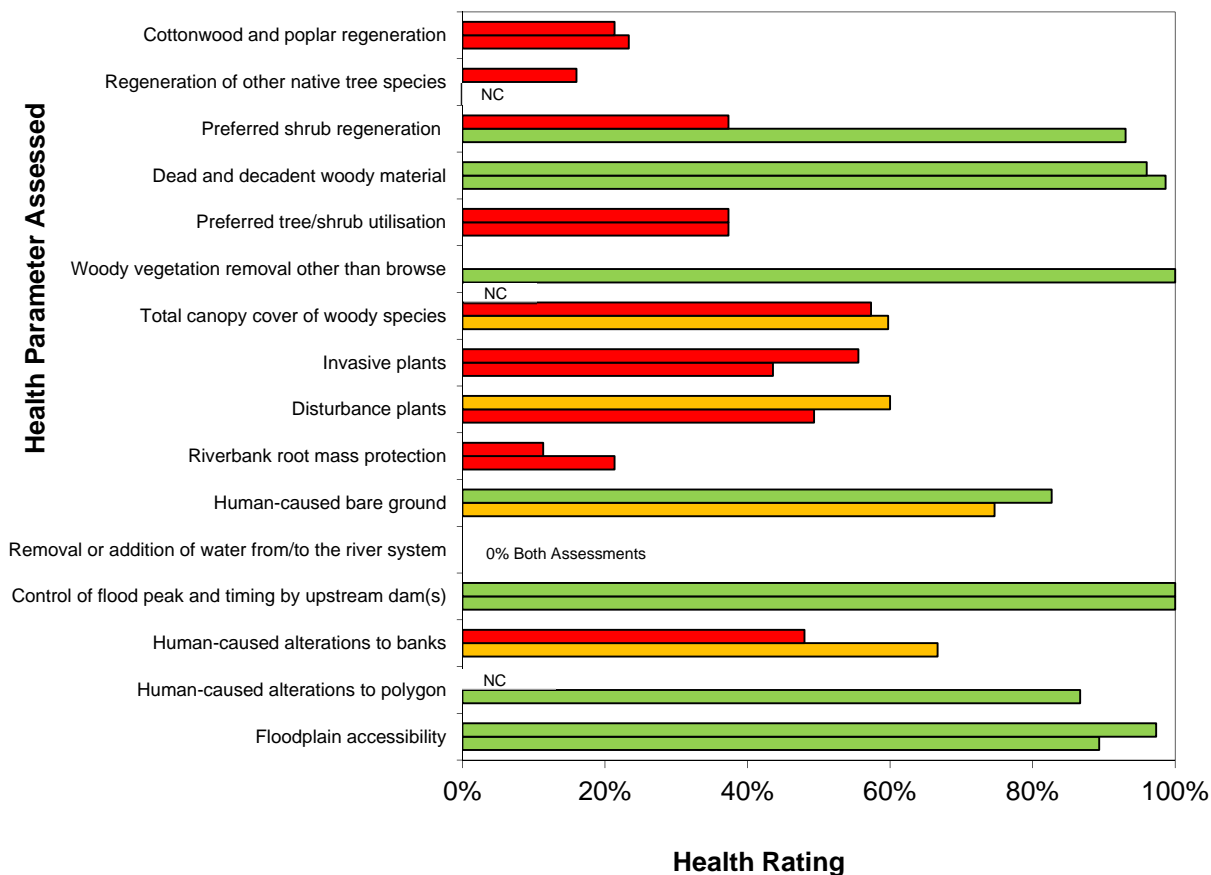


Figure 14. Comparison of riparian health indicators (Large River form) at Reach 4 – Milk River Sand-bed Reach, reported by Cows and Fish, 1998/1999 (top bar) and 2008/2011 re-visits (bottom bar) (N=25). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

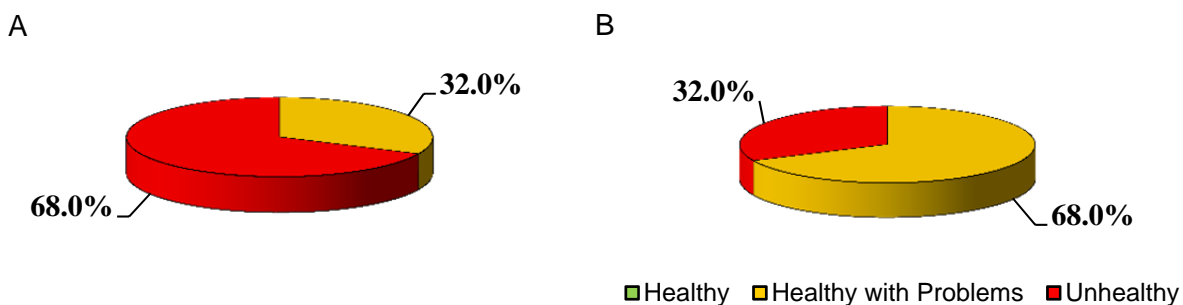


Figure 15. Average health assessment ratings for Reach 4 for the A) 1998/1999 assessments and B) 2008/2011 re-assessments.

3.2.5 Reach 5 - Eastern Tributaries

Fifty-eight riparian sites were assessed at Reach 5 – Eastern Tributaries, from 2000 to 2003, 53 of these sites were assessed using the more comprehensive inventory and the other five sites were assessed using the rapid assessment method. Twenty-one percent (21%) of sites rated in the Healthy category, 57% of sites rated Healthy with Problems and 22% of sites rated Unhealthy.

Indicators that rated Healthy were vegetative cover, preferred shrub regeneration, dead and decadent woody material, human-caused bare ground and channel incisement (Figure 16). The indicators that rated Healthy with Problems were root mass protection and human-caused alterations to polygon. Indicators that rated Unhealthy were invasive and disturbance plants, preferred tree/shrub utilization and human-caused alterations to banks.

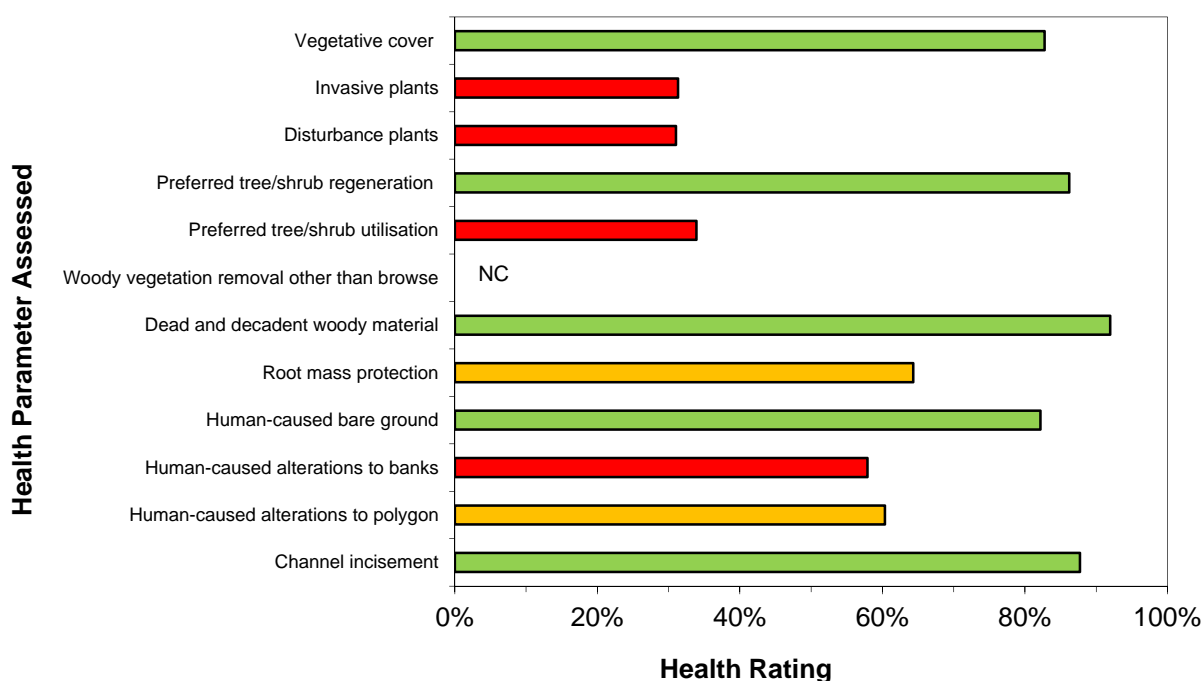


Figure 16. Summary of riparian health indicators for tributaries in Reach 5 – Eastern Tributaries, reported by Cows and Fish, 2000-2003 (N=58). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

At Reach 5, 4 tributary sites that were assessed in 2001 were re-assessed in 2003. For the first assessments (2001), the average score was 50.8, rating riparian areas in this reach Unhealthy. In the re-assessment, the average score was slightly improved (63.8) rating riparian areas in the lower end of the Healthy with Problems category. Similar to Reach 3 and 4 findings, there was great improvement in the indicator tree and shrub regeneration that improved from an Unhealthy rating in the first assessment to a Healthy rating in the re-assessment (Figure 17). The scores were also higher in the re-assessment for indicators associated with invasive and disturbance plants (Figure 17).

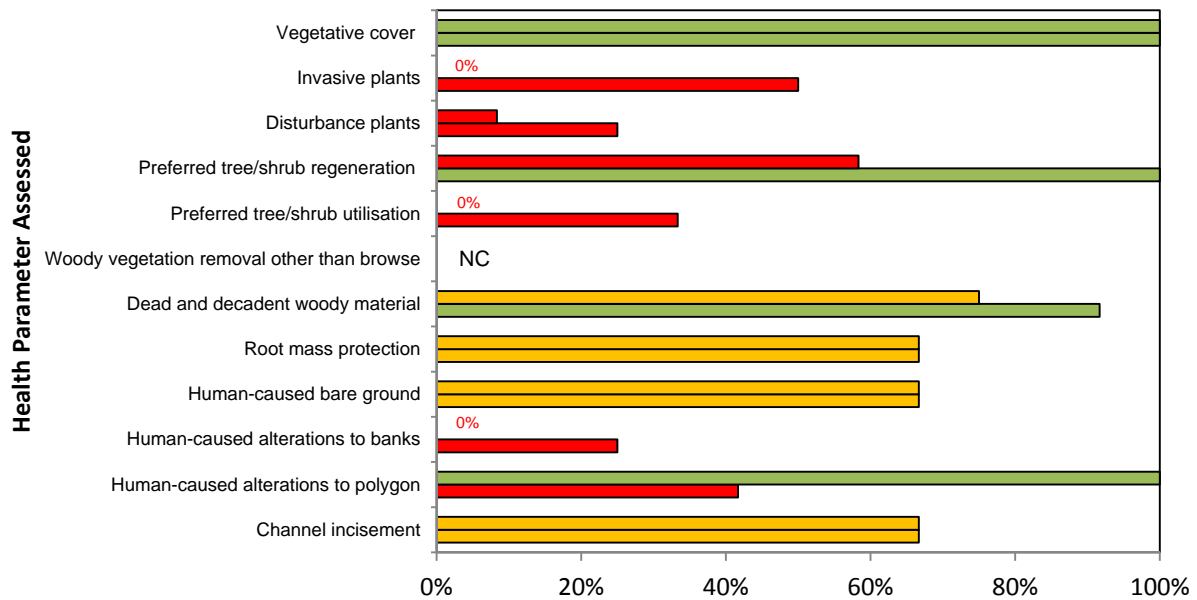


Figure 17. Comparison of riparian health indicators (Streams and Small Rivers form) at Reach 5 – Eastern Tributaries, reported by Cows and Fish, 2001 (top bar) and 2003 re-visits (bottom bar) (N=4). Green indicates Healthy, yellow indicates Healthy with Problems and red indicates Unhealthy ratings.

4.0 SUMMARY AND DISCUSSION

Figure 18 summarizes the riparian health assessment and inventory data by health category for tributary sites and mainstem sites. For tributaries at Reach 1 – North Fork Milk River and Reach 3 – Milk River Gravel-bed Reach, all sites rated in the Healthy with Problems categories. At Reach 4 – Milk River Sand-bed Reach, about half the tributary sites rated in the Healthy category and half rated in the Healthy with Problems category. At Reach 5 – Eastern Tributaries, the site ratings were distributed among all categories, 21% in the Healthy category, 57% in the Healthy with Problems category and 22% of sites in the Unhealthy category.

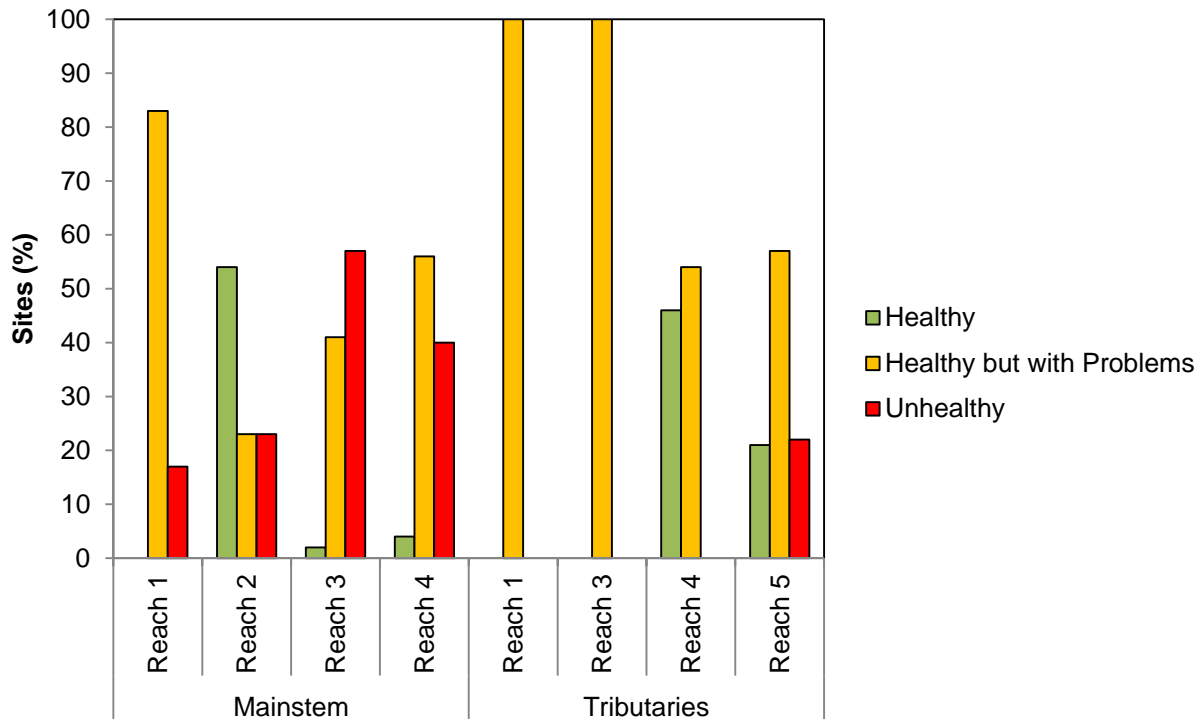


Figure 18. Comparison of average riparian health ratings by Milk River reach and site type.

For riparian health assessments completed at mainstem Milk River sites, no site rated Healthy at Reach 1 – North Fork Milk River, and 83% of sites rated in the Healthy with Problems category. Reach 2 - South Fork Milk River had the highest percentage of sites that rated in the Healthy category 54% of sites) (Figure 15). Reach 3 – Milk River Gravel-bed Reach had the highest percentage of sites that rated Unhealthy (57% of sites), followed closely by Reach 4 – Milk River Sand-bed Reach (40% of sites).

Priority Areas

A comparison of all sites assessed on Milk River tributaries and the mainstem was completed to identify the critical indicators that need to be addressed through management to improve riparian function. At tributary sites, management priorities are made clear in Table 4. Unhealthy ratings for invasive and disturbance plants are common among all reaches and should be considered the first priority to be addressed through management actions. Invasive plants do not provide deep-binding root mass for streambank protection and they provide minimal structural and habitat diversity when present in high densities. Weeds impact wildlife and livestock by replacing the vegetation they utilize for shelter and food.

Unhealthy ratings for preferred tree/shrub utilization (Reach 1, 4 and 5) and preferred tree/shrub regeneration (Reach 1, 3 and 4) are also common to tributaries and should be considered in the short-term. If improved conditions exist for these two parameters, root mass protection can be expected to improve (Reaches 3, 4 and 5). Preferred tree/shrub utilization occurs from wildlife and also domestic livestock. Trees and shrubs are vulnerable to increased browse when forage material, such as grasses and forbs, is reduced either due to drought conditions, overgrazing by livestock and wildlife, or when the forage becomes less palatable in the fall and

trees and shrubs are preferred. Heavy browse can deplete root reserves, inhibit establishment and regeneration, cause the loss of preferred woody species, lead to replacement by less desirable wood species and lead to invasion by disturbance or weed species.

Table 4. Summary of the condition of riparian health indicators at the various tributary reaches.

Riparian Health Indicator	Tributaries				
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
Channel incisement		-			
Human-caused alterations to polygon		-			
Human-caused alterations to banks		-			
Human-caused bare ground		-			
Root mass protection		-			
Disturbance plants		-			
Invasive plants		-			
Woody vegetation removal other than browse		-			NC
Preferred tree/shrub utilisation		-			
Dead and decadent woody material		-			
Preferred tree/shrub regeneration		-			
Vegetative cover		-			

For those riparian sites that were assessed on the mainstem Milk River, priority management areas are made clear in Table 5. All mainstem sites were impacted by the St. Mary/Milk River Diversion that increases flows above natural from generally March through September each year. Thus, all sites received an Unhealthy rating (except Reach 2 – South Fork Milk River) for the indicator “removal or addition of water to or from the river system”. The diversion has been operational since 1917 and will continue to operate to meet the terms outlined in the Boundary Waters Treaty 1909 and the IJC Order of 1921. Emphasis was placed on the equal sharing of water in these early documents and flows that may be required for environmental function was not considered. Altering the timing and duration of augmented flows to the Milk River may reduce the occurrence of frequent scouring of riverbanks by high flows and ice, and allow point bars to form and thus improve conditions for tree and shrub regeneration.

Current flow management generates a flow regime with very little within-year seasonal variability. Based on the recruitment box model, the river stage that would provide improved riparian recruitment after a major flow event (i.e., the 1 in 5 year flood event or greater) corresponds to flows between 30 m³/s and 3.5 m³/s. Managing flow recession and providing seasonal flow variability within this range of flows will likely result in improved riparian conditions on the Milk River (Golder Associates 2010).

Similar to tributary sites, an Unhealthy rating for invasive and disturbance plants should be considered the first management priority to improve riparian conditions as it is common to all reaches. Invasive and disturbance plants do not have deep binding roots to hold riverbanks together. In addition, weed species are generally less palatable to wildlife and livestock compared to native plants.

In addition to invasive and disturbance plants, Unhealthy ratings for root mass protection and preferred tree/shrub utilization was common among the reaches. By reducing utilization of preferred trees and shrubs and improving the regeneration of trees, including cottonwoods,

poplars, other native trees and shrubs, improved root mass protection of riverbanks in the Milk River watershed will be achieved (particularly at Reach 3 and Reach 4). Riverbank root mass protection will provide stability to riverbanks and reduce erosion that may be caused by irregular flow patterns.

Table 5. Summary of the condition of riparian health indicators at the four Milk River mainstem reaches.

Riparian Health Indicator	Mainstem			
	Reach 1	Reach 2	Reach 3	Reach 4
Floodplain accessibility				
Human-caused alterations to polygon			NC	
Human-caused alterations to banks				
Control of flood peak and timing by upstream dam(s)				
Removal or addition of water from/to the river system				
Human-caused bare ground				
Root mass protection				
Disturbance plants				
Invasive plants				
Total canopy cover of woody species				
Woody vegetation removal other than browse			NC	
Preferred tree/shrub utilisation				
Dead and decadent woody material				
Preferred shrub regeneration				
Regeneration of other native tree species	NA	NA		
Cottonwood and poplar regeneration	NA	NA		

5.0 RECOMMENDATIONS

- a) Adopt the following recommended targets and thresholds to provide a measurable indication of success in achieving riparian management objectives:

Riparian Health Target: Riparian health scores should range within the “Healthy” category of equal to or greater than 80 for all reaches.

Riparian Health Threshold: Riparian health scores should not be less than 70 in all reaches. (Table 6)

Rationale. Targets and thresholds are numerical or written statements that provide a measurable indication of success in achieving watershed management objectives. They can be used to see how riparian areas rate in the watershed compared to acceptable ratings. Targets and thresholds identify when additional management is required to improve riparian conditions to a functioning state. Scores less than the threshold require additional management action.

Table 6. Draft Target and threshold for riparian health by Milk River reach.

Reaches	Dominant Land Use	Target (Score)	Threshold (Score)	Actual Average Score (as of 2011)		
				Mainstem Score	Tributary Score	Wetlands Score
Lotic						
Reach 1: North Fork	Agricultural	≥ 80	70	65	66	
Reach 2: South Fork Milk River	Agricultural	≥ 80	70	75	-	
Reach 3: Gravel Bed Reach	Agricultural	≥ 80	70	58	70	
Reach 4: Sand Bed Reach	Agricultural	≥ 80	70	62	77 71	
Reach 5: Eastern Tributaries	Agricultural	≥ 80	70	-	68	
Lentic						
Wetlands (Entire Watershed)	Agricultural	≥ 80	70	-	-	66 52

Notes: Riparian health score categories: Healthy (Score ≥ 80), Healthy with Problems (Score 60-79), Unhealthy (Score < 60).

- b) Riparian management strategies should be adopted to address those health indicators that rated in the Healthy with Problems or Unhealthy categories, with top priority assigned to those indicators commonly rating in the Unhealthy category. Strategies might include:
- i. **Vegetative cover of streambanks and floodplain.** Provide rest from grazing or other disturbances during the growing season to allow for regrowth, to reduce the amount of bare ground and enable native vegetation to out-compete disturbance-caused and invasive plants for nutrients and water. Manage other human activity (e.g., recreation, transportation and industrial development) to preserve native plant communities.
 - ii. **Invasive and disturbance-caused plants.** Livestock grazing strategies should consider distribution, timing and stocking rates that fall within the carrying capacity of each pasture. Provide maximum rest during the growing season and use strategies such as skim grazing and time-controlled grazing to maintain an abundance of native species. Other landuse management plans (e.g., industrial development, road construction, sand and gravel extraction) should have reclamation plans and sites should be monitored until reclamation is complete.
 - iii. **Tree/shrub establishment and regeneration.** Maintain existing preferred tree and shrub communities (e.g., poplars, buffaloberry, willows) and prevent the increase of browsing resistant shrub communities (e.g., snowberry, rose,

silverberry) resulting from excessive livestock browsing. Provide adequate rest from continuous browsing pressure to promote regeneration of existing preferred trees and shrub communities and improve future reproduction and establishment. Manage distribution, timing, rotation and stocking rate to maintain and increase preferred trees and shrubs.

- iv. **Streambanks: Root mass protection and alterations.** Rotational grazing, off-stream water developments and other distribution techniques should be used to disperse livestock over large areas of rangeland and prevent cattle from loitering adjacent to the river. Develop riparian pastures, with complementary off-stream watering systems, allow seasonal skim grazing in riparian areas to increase tree and shrub cover and improve streambank stability.
 - v. **Bare ground and physical alterations to entire riparian area.** Improvements to industrial reclamation standards and monitoring of disturbed areas should be encouraged and mandated by provincial, municipal and industrial regulators. Maintain livestock distribution throughout the rangeland, provide effective rest during the growing season and avoid vulnerable periods. Avoid use of riparian pastures as wintering areas, rather skim graze these pastures during the summer months.
 - vi. **Stream channel incisement and stability.** Maintain and increase native trees and shrubs with deep binding root mass along the river banks. Water management should consider the erosive potential of excessive flows in the Milk River and the timing of these flows at different times of the year.
- c) The timing and duration of flows should be managed to promote the regeneration of preferred native tree species, including cottonwoods and poplars. Based on the recruitment box model, the river stage that would provide improved riparian recruitment after a major flow event (i.e., the 1 in 5 year flood event or greater) corresponds to flows between 30 m³/s and 3.5 m³/s. Managing flow recession and providing seasonal flow variability within this range of flows will likely result in improved riparian conditions on the Milk River (Golder Associates 2010) (Appendix G).
- d) Re-establishment of preferred native tree and shrub species should be undertaken at certain sites, considering species, density and survivability of plants (Refer to Owings and Marlow 2012).
- e) Riparian setbacks, greater than the minimum 6 m setback specified in the *Municipal Government Act*, should be applied to the Milk River and its tributaries according to Table 7¹.

¹ Currently the *Municipal Government Act* specifies a minimum 6 m setback from waterways.

Table 7. Draft riparian setback recommendations for the Milk River and its tributaries. NOTE THIS IS DRAFT FOR DISCUSSION AND SCOPING PURPOSES...ACTUAL SETBACKS MAY DIFFER IN WIDTHS. APPROPRIATE MAPPING TO ACCOMPANY THIS FOR DISCUSSION _ IN PROGRESS.

Reach	Management Objective	Setback	Notes
Reach 1 – North Fork	Floodplain Protection, Erosion Control, Biodiversity	50 m In cases where the coarse or fine fluvial sediment is greater than 50 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	Refer to surficial geology map for location of fluvial deposits (Appendix H). Erodible stream banks influenced by St. Mary River Diversion.
Reach 2 – South Fork	Floodplain Protection, Biodiversity	50 m In cases where the coarse or fine fluvial sediment is greater than 50 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	
Reach 3 – Gravel Bed Reach	Floodplain Protection, Erosion Control, Biodiversity	100 m In cases where the coarse or fine fluvial sediment is greater than 100 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	Highly erodible stream banks influenced by St. Mary River Diversion. Stream meander belt width should be considered.
Reach 4 – Sand Bed Reach	Floodplain Protection, Erosion Control, Water Quality, Biodiversity	100 m In cases where the coarse or fine fluvial sediment is greater than 100 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	Highly erodible stream banks. Stream meander belt width should be considered. Consider including the stream and slopewash eroded deposits within the flood fringe calculation.
Reach 5 – Eastern Tributaries	Floodplain Protection, Water Quality, Biodiversity	20 m In cases where the coarse or fine fluvial sediment is greater than 20 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	
Ephemeral and Intermittent Streams and Gullies	Floodplain Protection, Water Quality, Biodiversity	20 m In cases where the coarse or fine fluvial sediment is greater than 20 m, the additional width of the fluvial sediment will be considered flood fringe and included in the setback calculation.	Consider including the stream and slopewash eroded deposits within the flood fringe calculation in Reach 4 (e.g., Verdigris Coulee)

- f) Permitted and restricted activities in the riparian setback and flood fringe zones should be adopted according to **Table 8**.

Table 8. Permitted and restricted activities in the riparian setback and flood fringe zones (taken from Jumpingpound Creek IWMP (PESL 2012) as starting place for discussion – DRAFT Only!)

Activity	Riparian Setback	Flood Fringe
Permitted	<ul style="list-style-type: none"> Existing buildings and structures Existing public and private roads Existing and new public and private linear utilities (mitigation to reduce impacts) Existing public and private non-linear utilities Maintenance and repair of infrastructure Livestock grazing (where BMPs are applied) Passive recreation (depending on wildlife sensitivities) Existing pathways and trails (mitigation to reduce impacts) New pervious pathways and trails (i.e., no concrete) discouraged, but may be considered Public education 	<ul style="list-style-type: none"> Existing buildings and structures Existing public and private roads Existing public and private linear utilities New public and private non-linear utilities (discretionary) Cultivation (using appropriate BMPs) Livestock grazing (where BMPs are applied) Passive recreation (depending on wildlife sensitivities) Recreation infrastructure (discretionary) Pathways and Trails (with mitigation to reduce impacts) Public education
Restricted	<ul style="list-style-type: none"> New buildings and structures New public and private roads New public and private non-linear utilities Stormwater management infrastructure Cultivation Recreation infrastructure Resource extraction Damage to native vegetation 	<ul style="list-style-type: none"> New buildings and structures New public and private roads Stormwater management infrastructure Resource extraction Damage to native vegetation

- g) Only native vegetation should be used to reclaim disturbed areas.
- h) Best management practices should be used by the agricultural industry to promote the regeneration of preferred trees and shrubs within riparian areas. These BMPs include:
- i. Off-stream watering
 - ii. Rotational grazing and riparian pastures
 - iii. Appropriate timing and stocking rates
- i) A monitoring program should be developed to re-assess riparian areas on a 5 to 7 year rotational basis in order to identify trends in riparian health.
- j) Increase understanding of sedimentation rates, erosion rates and plains cottonwood survival.

6.0 LITERATURE CITED

Alberta Environment. 2011 . STEPPING BACK FROM THE WATER: A Beneficial Management Practices Guide for New Development Adjacent to Water Bodies in Alberta's Settled Region. Queen's Printer for Alberta, Calgary, AB. 52 pp. + Appendices.

Cows and Fish. 2012. Riparian Health Score Sheets. Provided March 2012.

Golder Associates. 2010. Milk River Instream Flow Needs Study. Milk River Watershed Council Canada, Milk River, AB. 72 pp. + Appendix.

MRWCC. 2008. Milk River State of the Watershed Report 2008. Milk River Watershed Council Canada. Milk River, Alberta 155 pp.

Owings, G. and C.B. Marlow. 2012. Landowner's Guide For Re-Establishing Riparian Gallery Forests Along Montana's Milk River Corridor. Animal and Range Sciences, Montana State University. 26 pp.

APPENDIX A. Riparian Health Score Sheet Categories for Lakes and Wetlands (Cows and Fish 2012)

Some factors on the evaluation will not apply on all sites. For example, sites without potential for woody species are not rated on factors concerning trees and shrubs. Vegetative site potential can be determined by using a key to site type. On severely disturbed sites, vegetation potential can be difficult to determine. On other sites, clues to potential may be sought on nearby sites with similar landscape position.

Most of the factors in this evaluation are based on ocular estimations. Such estimation may be difficult on large, brushy sites where visibility is limited, but extreme precision is not necessary. While the rating categories are broad, evaluators do need to calibrate their eye with practice. It is important to remember that a health rating is not an absolute value. The factor breakout groupings and point weighting in the evaluation are somewhat subjective and are not grounded in quantitative science so much as in the collective experience of an array of riparian scientists, range professionals and land managers.

Each factor below will be rated according to conditions observed on the sites. The evaluator will estimate the scoring category and enter the value on the score sheet. It is important to **remember that a health rating is not an absolute value**. Each factor is rated according to conditions observed on the site at the time of evaluation.

1. Vegetative Cover of Site

- 6** = More than 95% of the site area is covered by plant growth.
- 4** = 85% to 95% of the site area is covered by plant growth.
- 2** = 75% to 85% of the site area is covered by plant growth.
- 0** = Less than 75% of the site area is covered by plant growth.

2a. Total Canopy Cover of Invasive Plant Species

- 3** = No invasive plants (weeds) on site.
- 2** = Invasive plants present with total canopy cover less than 1% of the site area.
- 1** = Invasive plants present with total canopy cover between 1 and 15% of the site area.
- 0** = Invasive plants present with total canopy cover more than 15% of the site area.

2b. Density/Distribution of Invasive Plant Species (Table 1)

- 3** = No invasive plants (weeds) on site.
- 2** = Invasive plants present with density/distribution in categories 1, 2 or 3.
- 1** = Invasive plants present with density/distribution in categories 4, 5, 6 or 7.
- 0** = Invasive plants present with density distribution in categories 8 or higher.

3. Disturbance-Caused Undesirable Herbaceous Species

- 3** = Less than 5% of the site covered by disturbance-caused undesirable herbaceous species.
- 2** = 5% to 25% of the site covered by disturbance-caused undesirable herbaceous species.
- 1** = 25% to 50% of the site covered by disturbance-caused undesirable herbaceous species.
- 0** = More than 50% of the site covered by disturbance-caused undesirable herbaceous species.

7. Preferred Tree and Shrub Establishment and Regeneration

(N/A will appear in the Riparian Health Score Table if the site lacks potential for preferred trees or shrubs)

- 6** = More than 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 4** = 5% to 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 2** = Less than 5% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 0** = Preferred tree/shrub seedlings and saplings absent.

Table 1. Density/distribution of invasive plant species.

CLASS	DESCRIPTION OF ABUNDANCE	DISTRIBUTION PATTERN
0	No invasive plants on the site	
1	Rare occurrence	.
2	A few sporadically occurring individual plants
3	A single patch	•••
4	A single patch plus a few sporadically occurring plants	••• . . .
5	Several sporadically occurring plants
6	A single patch plus several sporadically occurring plants	. . . ••• . .
7	A few patches	••• ••• •••
8	A few patches plus several sporadically occurring plants	••• ••• . . •••
9	Several well spaced patches	••• ••• •••
10	Continuous uniform occurrence of well spaced plants
11	Continuous occurrence of plants with a few gaps in the distribution	••••••••••
12	Continuous dense occurrence of plants	••••••••••
13	Continuous occurrence of plants associated with a wetter or drier zone within the site	••••••••••

5a. Browse Utilisation of Available Preferred Trees and Shrubs

(N/A will appear in the Riparian Health Score Table if the site lacks potential for preferred trees or shrubs)

- 3** = None (0% to 5% of available 2nd year and older leaders of preferred species are browsed).
2 = Light (5% to 25% of available 2nd year and older leaders of preferred species are browsed).
1 = Moderate (25% to 50% of available 2nd year and older leaders of preferred species are browsed).
0 = Heavy (More than 50% of available 2nd year and older leaders of preferred species are browsed).

5b. Live Woody Vegetation Removal by Other than Browsing

(N/A will appear in the Riparian Health Score Table if the site lacks potential for trees or shrubs)

- 3** = None (0% to 5% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
2 = Light (5% to 25% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
1 = Moderate (25% to 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
0 = Heavy (More than 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).

6. Human Alteration of Site Vegetation

- 6** = Less than 5% of site vegetation is altered by human activity.
4 = 5% to 15% of site vegetation is altered by human activity.
2 = 15% to 35% of site vegetation is altered by human activity.

0 = More than 35% of site vegetation is altered by human activity.

7a. Human Alteration of Site Physical Structure

12 = Less than 5% of the site is physically altered by human activity.

8 = 5% to 15% of the site is physically altered by human activity.

4 = 15% to 35% of the site is physically altered by human activity.

0 = More than 35% of the site is physically altered by human activity.

7b. Severity of Human-Caused Alteration of Site Physical Structure

3 = *No physical alterations* to the site by human activity.

2 = Human alterations to the physical site are *slight* in effect.

1 = Human alterations to the physical site are *moderate* in effect.

0 = Human alterations to the physical site are *severe* in effect.

8. Human-Caused Bare Ground

6 = Less than 1% of the sites is human-caused bare ground.

4 = 1% to 5% of the site is human-caused bare ground.

2 = 5% to 15% of the site is human-caused bare ground.

0 = More than 15% of the site is human-caused bare ground.

9. Degree of Artificial Removal/Addition of Water (Table 2)

9 = The Waterbody is 'Not Subjected' to artificial water removal/addition.

6 = Degree of artificial water removal/addition is 'Minor'.

3 = Degree of artificial water removal/addition is 'Moderate'.

0 = Degree of artificial water removal/addition is 'Extreme'.

Table 2. Categories of Lentic Water Removal Severity.

CATEGORY	DEFINITION
Not Subjected	The waterbody is not subjected to artificial drawdown.
Minor	The waterbody is subject to no more than minor artificial water level change. The shore area remains vegetated and withdrawal of water is limited or slow enough that vegetation is able to maintain growth and prevent exposed soil. A relatively narrow band affected by the water level fluctuation may support only annual plants.
Moderate	The waterbody is subject to moderate quantities, speed and/or frequency of artificial water level change. Where water is removed, it is done in a way that allows pioneer plants to vegetate at least half of the exposed area resulting from drawdown. Where water is added, some flooding may occur at levels or times not typical to the area/season.
Extreme	The waterbody is subjected to extreme changes in water level due to volume (extent), speed and/or frequency of artificial water addition or removal. Frequent or unnatural levels of flooding occur where water is added, including extensive flooding into riparian and/or upland areas; or no natural annual drawdown is allowed to occur. In extreme artificial drawdown situations, a wide band of exposed bottom remains unvegetated.

APPENDIX B. Riparian Health Score Sheet Categories for Streams and Small Rivers (Cows and Fish 2012)

Each riparian health parameter is rated according to conditions observed on the site at the time of evaluation. Parameters are assessed using ocular estimates by trained practitioners. The parameter breakout groupings and point weightings were developed by a collaboration of riparian scientists, fisheries biologists, range professionals and land managers. Some riparian health parameters will not apply on all sites. For example, sites without potential for woody species are not rated on questions concerning trees and shrubs. On severely disturbed sites, vegetation potential can be difficult to determine. On these sites, clues to potential may be sought on nearby sites with similar landscape position.

1. Vegetative Cover of Floodplain and Streambanks

6 = More than 95% of the polygon area is covered by plant growth.

4 = 85% to 95% of the polygon area is covered by plant growth.

2 = 75% to 85% of the polygon area is covered by plant growth.

0 = Less than 75% of the polygon area is covered by plant growth.

2a. Total Canopy Cover of Invasive Plant Species

3 = No invasive plants (weeds) on site.

2 = Invasive plants present with total canopy cover less than 1% of the polygon area.

1 = Invasive plants present with total canopy cover between 1 and 15% of the polygon area.

0 = Invasive plants present with total canopy cover more than 15% of the polygon area.

2b. Density/Distribution of Invasive Plant Species (Table 1)

3 = No invasive plants (weeds) on site.

2 = Invasive plants present with density/distribution in categories 1, 2 or 3.

1 = Invasive plants present with density/distribution in categories 4, 5, 6 or 7.

0 = Invasive plants present with density distribution in categories 8 or higher.

CLASS	DESCRIPTION OF ABUNDANCE	DISTRIBUTION PATTERN
0	No invasive plants on the polygon	
1	Rare occurrence	
2	A few sporadically occurring individual plants	
3	A single patch	
4	A single patch plus a few sporadically occurring plants	
5	Several sporadically occurring plants	
6	A single patch plus several sporadically occurring plants	
7	A few patches	
8	A few patches plus several sporadically occurring plants	
9	Several well spaced patches	
10	Continuous uniform occurrence of well spaced plants	
11	Continuous occurrence of plants with a few gaps in the distribution	
12	Continuous dense occurrence of plants	


13	Continuous occurrence of plants associated with a wetter or drier zone within the polygon	
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Table 1. Density/distribution of invasive plant species.

10. Disturbance-Caused Undesirable Herbaceous Species

- 3 = Less than 5% of the site covered by disturbance-caused undesirable herbaceous species.
- 2 = 5% to 25% of the site covered by disturbance-caused undesirable herbaceous species.
- 1 = 25% to 50% of the site covered by disturbance-caused undesirable herbaceous species.
- 0 = More than 50% of the site covered by disturbance-caused undesirable herbaceous species.

11. Preferred Tree and Shrub Establishment and Regeneration

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for preferred trees or shrubs)

- 6 = More than 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 4 = 5% to 15% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 2 = Less than 5% of the total canopy cover of preferred trees/shrubs is seedlings and saplings.
- 0 = Preferred tree/shrub seedlings and saplings absent.

5a. Utilisation of Preferred Trees and Shrubs

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for preferred trees or shrubs)

- 3 = None (0% to 5% of available 2nd year and older leaders of preferred species are browsed).
- 2 = Light (5% to 25% of available 2nd year and older leaders of preferred species are browsed).
- 1 = Moderate (25% to 50% of available 2nd year and older leaders of preferred species are browsed).
- 0 = Heavy (More than 50% of available 2nd year and older leaders of preferred species are browsed).

5b. Live Woody Vegetation Removal by Other than Browsing

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for trees or shrubs)

- 3 = None (0% to 5% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 2 = Light (5% to 25% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 1 = Moderate (25% to 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 0 = Heavy (More than 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).

12. Standing Decadent and Dead Woody Material

- 3 = Less than 5% of the total canopy of woody species is decadent or dead.
- 2 = 5% to 25% of the total canopy of woody species is decadent or dead.
- 1 = 25% to 45% of the total canopy cover of woody species is decadent or dead.
- 0 = More than 45% of the total canopy cover of woody species is decadent or dead.

13. Streambank Root Mass Protection

- 6 = More than 85% of the streambank has deep, binding root mass.
- 4 = 65% to 85% of the streambank has deep, binding root mass.
- 2 = 35% to 65% of the streambank has deep, binding root mass.
- 0 = Less than 35% of the streambank has deep, binding root mass.

14. Human-Caused Bare Ground

- 6 = Less than 1% of the sites is human-caused bare ground.
- 4 = 1% to 5% of the site is human-caused bare ground.
- 2 = 5% to 15% of the site is human-caused bare ground.
- 0 = More than 15% of the site is human-caused bare ground.

15. Streambank Structurally Altered by Human Activity

- 6** = Less than 5% of the bank is structurally altered by human activity.
4 = 5% to 15% of the bank is structurally altered by human activity.
2 = 15% to 35% of the bank is structurally altered by human activity.
0 = More than 35% of the bank is structurally altered by human activity.

16. Human Physical Alteration to the Rest of the Polygon

- 3** = Less than 5% of the polygon is affected by human causes.
2 = 5% to 15% of the polygon is affected by human causes.
1 = 15% to 25% of the polygon is affected by human causes.
0 = More than 25% of the polygon is affected by human causes.

17. Stream Channel Incisement (Vertical Stability) (Figure 1)

- 9** = Not incised
6 = Slightly incised
3 = Moderately incised
0 = Severely incised

Incisement Severity	Channel Development Stage	Rosgen Types	Included	Description of Incisement Situation
Not Incised flows (9 points)	A	A, B, C, E		Channel is vertically stable and not incised; 1-2 year high can begin to access a floodplain appropriate to the stream type. Active downcutting is not evident. Any old incisement is characterized by a broad floodplain inside which perennial riparian plant communities are well established. This category includes a variety of stream types in all land forms and substrates. The floodplain may be narrow or wide, depending on the type of stream, but the key factor is vertical stability. The system may have once cut down, and later become healed and is now stable again, with a new floodplain appropriate to its stream type. In this case, the erosion of the old gully side walls will have ceased and stabilised. A mature, or nearly mature, vegetation community will occupy much of the new valley bottom.
Slightly Incised (6 points)	B/D	C, F, G		This category contains both degrading and healing stages. either case, the extent of incisement is minimal. In Stage B, the channel is just beginning to degrade, and a 2 year flood event may still access some floodplain, either partially or in spots. Downcutting is likely progressing. In Stage D, the system is healing. Downcutting should have ceased at this stage. A new floodplain should be well established with perennial vegetation, although it may not yet be as wide as the stream type needs. This is indicated by continuing lateral erosion of the high side walls of the original incisement, as the system continues to widen itself at its new grade level.
Moderately incised stages. (3 points)	B/D	C, F, G		This category also contains both degrading and healing stages. In both cases, the extent of incisement is significant. In Stage B, the channel has downcut to a level that floods of the 1-5 year magnitude cannot reach a floodplain.

Severely
(0 points)

C

F, G

Downcutting is likely still progressing, but the channel may already have the appearance of a gully. In Stage D, the system has only just begun to heal. A small floodplain along the new meanders within the gully is forming, and perennial vegetation is starting to colonize the new sediment features. The high side walls of the gully are being actively eroded as the system widens, and much of the fallen material is being incorporated along the bottom. This is the worst case category, where the system has no floodplain in the bottom of a deep entrenchment, and small-to-moderate floods cannot reach the original floodplain level. Downcutting may, or may not, still be in progress. High side wall banks may have begun to collapse and erode into the bottom, but high flows typically just wash this material directly through the system, with none of it being trapped to build a new floodplain. At this stage, the system has lost practically all of its riparian function and habitat value.

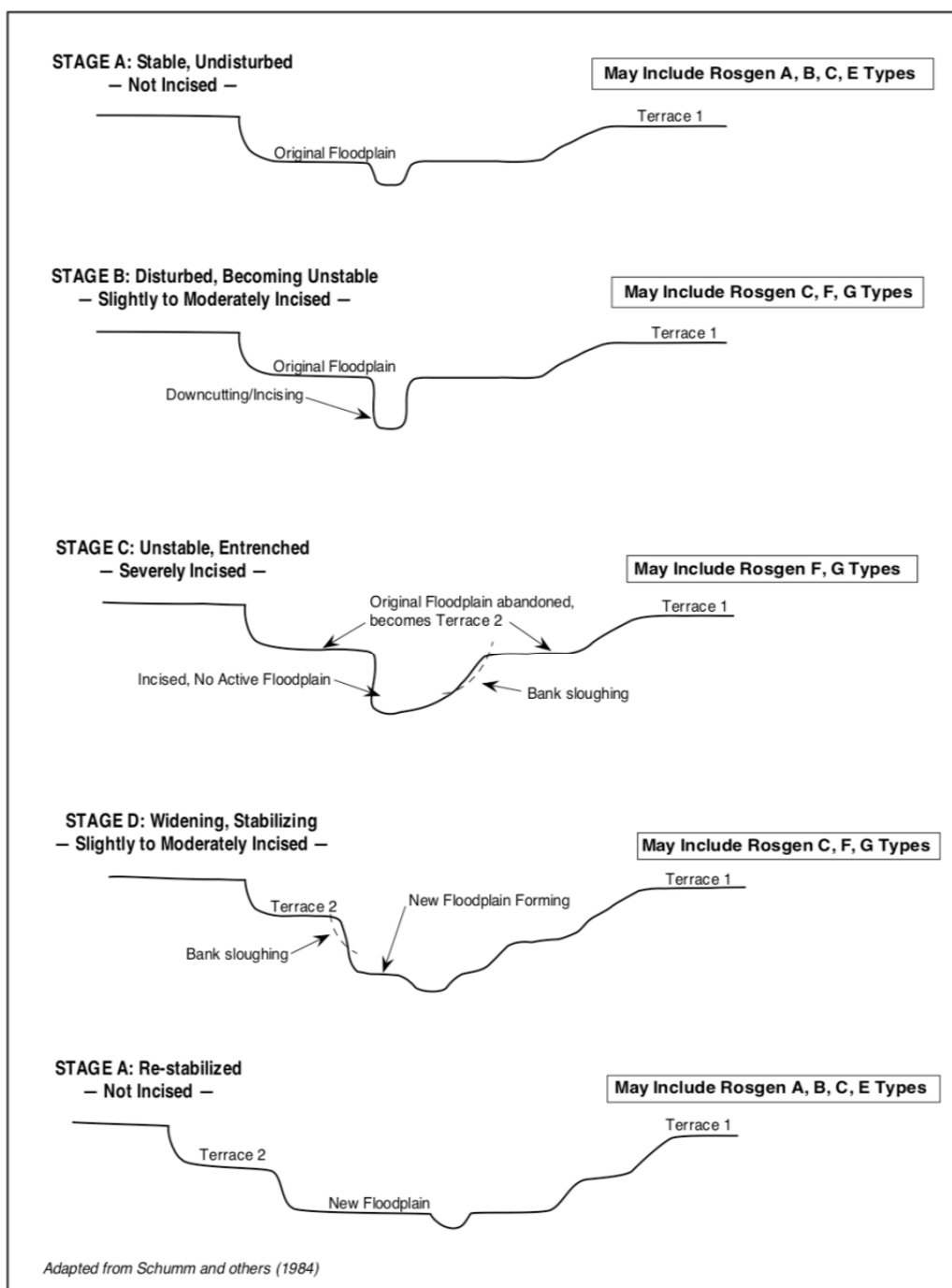


Figure 1. Guide for estimating channel incisement stage.

APPENDIX C. Riparian Health Score Sheet Categories for Large Rivers (Cows and Fish 2012)

Some factors on the evaluation will not apply on all sites. For example, sites without potential for woody species are not rated on factors concerning trees and shrubs. Vegetative site potential can be determined by using a key to site type. On severely disturbed sites, vegetation potential can be difficult to determine. On other sites, clues to potential may be sought on nearby sites with similar landscape position.

Most of the factors in this evaluation are based on ocular estimations. Such estimation may be difficult on large, brushy sites where visibility is limited, but extreme precision is not necessary. While the rating categories are broad, evaluators do need to calibrate their eye with practice. It is important to remember that a health rating is not an absolute value. The factor breakout groupings and point weighting in the evaluation are somewhat subjective and are not grounded in quantitative science so much as in the collective experience of an array of riparian scientists, range professionals and land managers.

Each factor below will be rated according to conditions observed on the sites. The evaluator will estimate the scoring category and enter the value on the score sheet. It is important to **remember that a health rating is not an absolute value**. Each factor is rated according to conditions observed on the site at the time of evaluation.

1. Cottonwood and Balsam Poplar Regeneration

6 = More than 15% of the cottonwood and/or balsam poplar cover is established seedlings and/or saplings.

4 = 5% to 15% of the cottonwood and/or balsam poplar cover is established seedlings and saplings.

2 = Up to 5% of the cottonwood and/or balsam poplar cover is established seedlings and saplings.

0 = None of the cottonwood and/or balsam poplar cover is established seedlings and saplings.

2. Regeneration of Other Native Tree Species

3 = More than 5% of the other (non-cottonwood/balsam poplar) tree cover is seedlings and/or saplings.

2 = 1% to 5% of the other (non-cottonwood/balsam poplar) tree cover is seedlings and/or saplings.

1 = Less than 1% of the other (non-cottonwood/balsam poplar) tree cover is seedlings and/or saplings.

0 = Seedling and saplings of tree species other than cottonwoods/balsam poplars or absent.

3. Regeneration of Preferred Shrub Species

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for preferred trees or shrubs)

6 = More than 5% of the preferred shrub species cover is seedlings and/or saplings.

4 = 1% to 5% of the preferred shrub species cover is seedlings and/or saplings.

2 = Less than 1% of the preferred shrub species cover is seedlings and/or saplings.

0 = None of the preferred shrub species cover is seedlings or saplings.

4. Standing Decadent and Dead Woody Material

3 = Less than 5% of the total canopy cover of woody species is decadent and/or dead.

2 = 5% to 25% of total canopy cover of woody species is decadent and/or dead.

1 = 25% to 50% of total canopy cover of woody species is decadent and/or dead.

0 = More than 50% of total canopy cover of woody species is decadent or dead.

5a. Browse Utilisation of Preferred Trees and Shrubs

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for preferred trees or shrubs)

- 3** = None (0% to 5% of available 2nd year and older leaders of preferred species are browsed).
- 2** = Light (5% to 25% of available 2nd year and older leaders of preferred species are browsed).
- 1** = Moderate (25% to 50% of available 2nd year and older leaders of preferred species are browsed).
- 0** = Heavy (More than 50% of available 2nd year and older leaders of preferred species are browsed).

5b. Live Woody Vegetation Removal by Other than Browsing

(N/A will appear in the Riparian Health Score Table if the polygon lacks potential for trees or shrubs)

- 3** = None (0% to 5% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 2** = Light (5% to 25% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 1** = Moderate (25% to 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).
- 0** = Heavy (More than 50% of live woody vegetation expected on the site is lacking due to cutting and/or removal by beaver).

6. Total Canopy Cover of Woody Species

(N/A will appear in the Riparian Health Score Table on page 1 if the site does not have live woody vegetation or visibly cut stumps)

- 3** = More than 50% of the total area is occupied by woody species.
- 2** = 25% to 50% of the total area is occupied by woody species.
- 1** = 5% to 25% of the total area is occupied by woody species.
- 0** = Less than 5% of the total area is occupied by woody species.

7a. Total Canopy Cover of Invasive Plant Species

- 6** = No invasive plant species (weeds) on the site.
- 4** = Invasive plants present with total canopy cover less than 1% of the polygon area.
- 2** = Invasive plants present with total canopy cover between 1 and 15% of the polygon area.
- 0** = Invasive plants present with total canopy cover more than 15% of the polygon area.

7b. Density/Distribution Pattern of Invasive Plant Species (Table 1)

- 3** = No invasive plant species (weeds) on the site.
- 2** = Invasive plants present with density/distribution in categories 1, 2, or 3.
- 1** = Invasive plants present with density/distribution in categories 4, 5, 6, or 7.
- 0** = Invasive plants present with density/distribution in categories 8, or higher.

8. Disturbance-Increaser Undesirable Herbaceous Species

- 3** = Less than 5% of the reach covered by disturbance-increaser undesirable herbaceous species.
- 2** = 5% to 25% of the reach covered by disturbance-increaser undesirable herbaceous species.
- 1** = 25% to 50% of the reach covered by disturbance-increaser undesirable herbaceous species.
- 0** = More than 50% of the reach covered by disturbance-increaser undesirable herbaceous species.

9. Riverbank Root Mass Protection

- 6** = More than 85% of the riverbank has a deep, binding root mass.
- 4** = 65% to 85% of the riverbank has a deep, binding root mass.
- 2** = 35% to 65% of the riverbank has a deep, binding root mass.

0 = Less than 35% of the riverbank has a deep, binding root mass.

10. Human-Caused Bare Ground

6 = Less than 1% of the polygon is human-caused bare ground.

4 = 1% to 5% of the polygon is human-caused bare ground.

2 = 5% to 15% of the polygon is human-caused bare ground.

0 = More than 15% of the polygon is human-caused bare ground.

11. Removal or Addition of Water from/to the River System

9 = Less than 10% of average river flow volume during the critical growing season is changed.

6 = 10% to 25% of average river flow volume during the critical growing season is changed.

3 = 25% to 50% of average river flow volume during the critical growing season is changed.

0 = More than 50% of average river flow volume during the critical growing season is changed.

Table 1. Density/distribution of invasive plant species.

CLASS	DESCRIPTION OF ABUNDANCE	DISTRIBUTION PATTERN
0	No invasive plants on the polygon	
1	Rare occurrence	.
2	A few sporadically occurring individual plants
3	A single patch	••••
4	A single patch plus a few sporadically occurring plants	•••
5	Several sporadically occurring plants
6	A single patch plus several sporadically occurring plants ••••
7	A few patches	••• ••• •••
8	A few patches plus several sporadically occurring plants	••• . ••• . •••
9	Several well spaced patches	••• ••• •••
10	Continuous uniform occurrence of well spaced plants
11	Continuous occurrence of plants with a few gaps in the distribution	••••••••••
12	Continuous dense occurrence of plants	••••••••••
13	Continuous occurrence of plants associated with a wetter or drier zone within the polygon	••••••••••

12. Control of Flood Peak and Timing by Upstream Dam(s)

9 = Less than 10% of the watershed upstream of the reach is controlled by dams.

6 = 10% to 25% of the watershed upstream of the reach is controlled by dams.

3 = 25% to 50% of the watershed upstream of the reach is controlled by dams.

0 = More than 50% of the watershed upstream of the reach is controlled by dams.

13. Riverbanks Structurally Altered by Human Activity

- 6** = Less than 5% of the bank length has been structurally altered by human activity.
- 4** = 5% to 15% of the bank length has been structurally altered by human activity.
- 2** = 15% to 35% of the bank length has been structurally altered by human activity.
- 0** = More than 35% of the bank length has been structurally altered by human activity.

14. Human Physical Alteration to the Rest of the Polygon

- 6** = Less than 5% of the polygon is altered by human causes.
- 4** = 5% to 15% of the polygon is altered by human causes.
- 2** = 15% to 25% of the polygon is altered by human causes.
- 0** = More than 25% of the polygon is altered by human causes.

15. Floodplain Accessibility within the Polygon

- 6** = More than 85% of the floodplain is accessible to flood flows.
- 4** = 65% to 85% of the floodplain is accessible to flood flows.
- 2** = 35% to 65% of the floodplain is accessible to flood flows.
- 0** = Less than 35% of the floodplain is accessible to flood flows.

APPENDIX D. Complete summary of riparian health indicators and their significance to riparian function.

Riparian Health Indicators	Application	Significance
Cottonwood and Balsam Poplar Regeneration	Large Rivers Only	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Regeneration of Other Native Tree Species	Large Rivers Only	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Vegetative Cover of Floodplain and Streambanks	Lakes and Wetlands and Streams and Small Rivers	Native plants provide deep binding root mass to maintain streambanks, slow the flow of overland runoff to facilitate water quality improvements, provide summer and winter forage for wildlife and livestock.
Regeneration of Preferred Shrub Species	Large Rivers Only	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Preferred Tree and Shrub Establishment and Regeneration	Lakes and Wetlands, Streams and Small Rivers	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Standing Decadent and Dead Woody Material	Large Rivers, Streams and Small Rivers	The amount of decadent and dead woody material may indicate a change in water flow due to human or natural causes, dewatering of a reach can change vegetation from riparian to upland species, flooding of a reach or persistent high water table can kill or eliminate some species, chronic overuse of browse, physical damage such as rubbing and trampling and climatic impacts.
Browse Utilisation of Preferred Trees and Shrubs	Lakes and Wetlands, Large Rivers and Streams, Small Rivers	Heavy browse can deplete root reserves, inhibit establishment and regeneration, cause the loss of preferred woody species, lead to replacement by less desirable wood species and lead to invasion by disturbance or weed species.
Live Woody Vegetation Removal by Other than Browsing	Lakes and Wetlands, Large Rivers, Streams and Small Rivers	The root systems of woody species provides streambank stability. Removal of this material reduces stability, causes loss of preferred woody species and leads to invasion of disturbance and weed species.
Total Canopy Cover of Woody Species	Large Rivers Only	The root systems of woody species stabilize streambanks, while their spreading canopies provide protection to soil, water, wildlife and livestock.
Total Canopy Cover of Invasive Plant Species	Lakes and Wetlands, Large Rivers	Invasive plants do not provide deep-binding root mass for bank protection and they provide minimal structural and habitat diversity when present in high densities. Weeds impact wildlife and livestock by replacing the vegetation they utilize for shelter and food.
Occurrence of Invasive Plant Species	Streams and Small Rivers Only	Invasive plants do not provide deep-binding root mass for bank protection and they provide minimal structural and habitat diversity when present in high densities. Weeds impact wildlife and livestock by replacing the vegetation they utilize for shelter and food.
Density/Distribution Pattern of Invasive Plant Species	Lakes and Wetlands, Large Rivers and Streams, Small	Invasive plants do not provide deep-binding root mass for bank protection and they provide minimal structural and habitat diversity when present in high densities. Weeds impact wildlife and livestock by replacing the

Riparian Health Indicators	Application	Significance
	Rivers	vegetation they utilize for shelter and food.
Disturbance-Increaser Undesirable Herbaceous Species	Lakes and Wetlands, Large Rivers and Streams, Small Rivers	Disturbance plants generally do not have deep binding root mass to protect streambanks. These plants are not as palatable to wildlife and livestock.
Riverbank (Streambank) Root Mass Protection	Large Rivers and Streams and Small Rivers	Root mass provide by native vegetation acts similar to rebar and hold streambanks together, preventing erosion and limiting lateral cutting.
Human-Caused Bare Ground	Lakes and Wetlands, Large Rivers, Streams and Small Rivers	Bare ground is void of plants, plant litter, woody material or large rocks and is more susceptible to erosion processes. Human-caused bare ground may be caused by livestock, recreationists and vehicle traffic. It provides an opportunity for disturbance or weed species.
Removal or Addition of Water from/to the River System	Lakes and Wetlands, Large Rivers	The removal or addition of water may impact riparian vegetation by flooding (suffocating vegetation) or dewatering (desiccating vegetation).
Control of Flood Peak and Timing by Upstream Dam(s)	Large Rivers Only	Flood peak and timing is important to riparian vegetation establishment and regeneration.
Riverbanks (Streambanks) Structurally Altered by Human Activity	Large Rivers and Streams and Small Rivers	Structural alterations of the streambanks (e.g., mechanically broken down by livestock activity or vehicle traffic) increase the potential for erosion while inhibiting the establishment of riparian vegetation.
Human Physical Alteration to the Rest of the Polygon	Lakes and Wetlands, Large Rivers, Streams and Small Rivers	Stable streambanks maintain channel configuration and bank shape. Altered streambanks may increase erosion and mobilize channel and bank materials, water quality can deteriorate and instability can increase downstream.
Floodplain Accessibility within the Polygon	Large Rivers Only	Floodplains provide storage for high water and provide an opportunity to slow water to reduce energy.
Stream Channel Incisement (Vertical Stability)	Streams and Small Rivers Only	Incisement can increase stream energy by reducing sinuosity, water retention and storage and increase erosion.

APPENDIX E. Summary of changes made to field methodologies to render the Milk River riparian health data comparable among years.

1. **Live Woody Vegetation Removal by other than Browsing** was added to the inventory in 2008. Prior to 2008, this indicator is marked with the letters **NC** that denotes “not collected”.
2. **Invasive plant questions** have changed scoring several times throughout the years, but have always summed to a cumulative total value of 9 when the three different questions/parameters related to invasive plants have been combined. A column called “Invasives” was created in the data spreadsheets to represent the combined scores out of a total of 9 points. The new column was used in the **health parameters graph only**. Any of the rows that are denoted by **NC** are years that a specific invasive question was not part of the river health survey.
 - a. Specifically, from the late 1990s until 2001 canopy cover/distribution were all covered under the canopy cover question that could score a possible 6 points. Exotic woody species was addressed in a separate question that could score a possible of 3 points. The two questions combined totalled 9 points.
 - b. In 2002, the methods were changed to separate canopy cover and density distribution; each question could score a possible 3 points. Exotic woody species remained the same and could score a possible 3 points. The three questions combined totalled 9 points.
 - c. In 2007, the methods were changed again, reverting the canopy cover question back to a total of 6 points and density distribution a possible 3 points. The invasive woody species question was incorporated into the invasive plants question rather than considering invasive woody species separately. The two questions, canopy cover and density distribution canopy cover and density distribution total 9 points.
3. **Addition / Dewatering of the River System:** All sites at Reach 1 - North Milk River, Reach 3 – Milk River Gravel-bed and Reach 4 – Milk River Sand-bed received a score of 0 points out of a possible 9 points due to the addition of water to the system from the St. Mary/Milk River Diversion (Information provided by AENV (2009)). At Reach 2 – South Fork Milk River, just upstream of the confluence with the North Fork Milk River, AENV (2006) provided data that some dewatering (e.g., irrigation) of the system was occurring at these sites and therefore they receive a score of 6 points out of a possible 9 points. There are seven sites upstream that had no information; therefore, these sites were denoted with the letters **NC** for “not collected”. The data could not be extrapolated because the exact location of the dewatering was unknown.

APPENDIX F. Summary of riparian health assessment data collected in the Milk River watershed from 1997 to 2011.

Year	Reach 1		Reach 2		Reach 3		Reach 4		Reach 5	Wetlands	Organization
	Mainstem	Tributary	Mainstem	Tributary	Mainstem	Tributary	Mainstem	Tributary			
1997							5	3			Cows & Fish
1998							1	2		1	Cows & Fish
1999					29		14				Cows & Fish
2000	3		6		7		8		7		Cows & Fish
2002	3								28		Cows & Fish
2003					1				23	5	Cows & Fish
2005	1				5						Cows & Fish
2006								13		2	Cows & Fish
2007							1				Cows & Fish
2008						2	15	2		2	Cows & Fish
2009	5	2	7								Cows & Fish
2011							11	4			Cows & Fish
2011								5		9	Alberta Conservation Association
Total Sites Assessed											

Appendix G. Recruitment boxes for cottonwood and willow establishment for the Milk River (Golder Associates 2010).

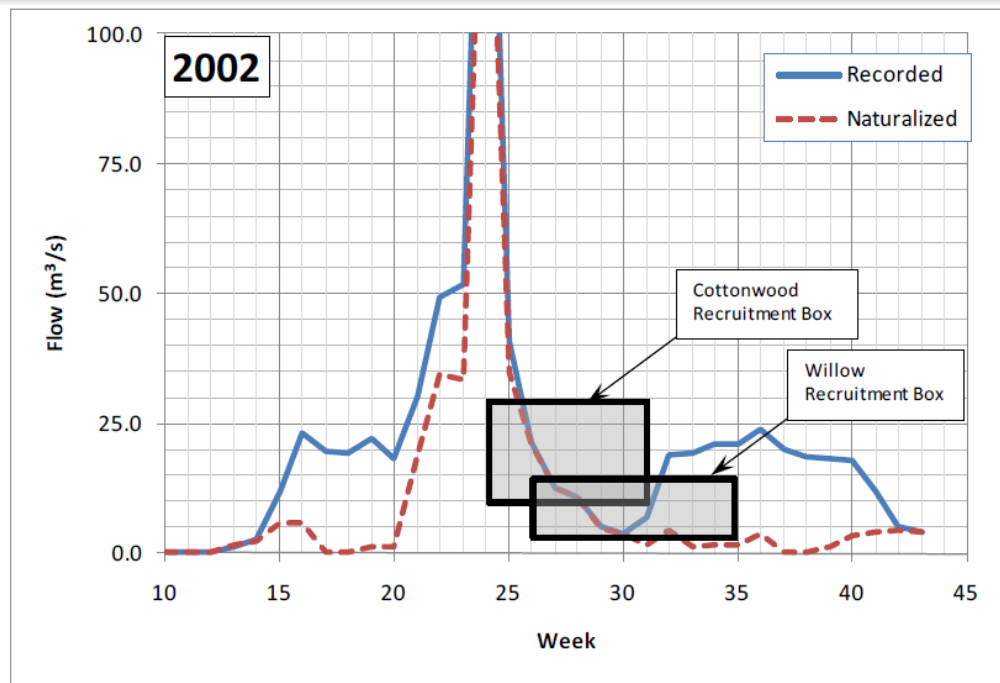


Figure 40: Naturalized and recorded flows for the Milk River at the Eastern Crossing in 2002 with riparian recruitment boxes

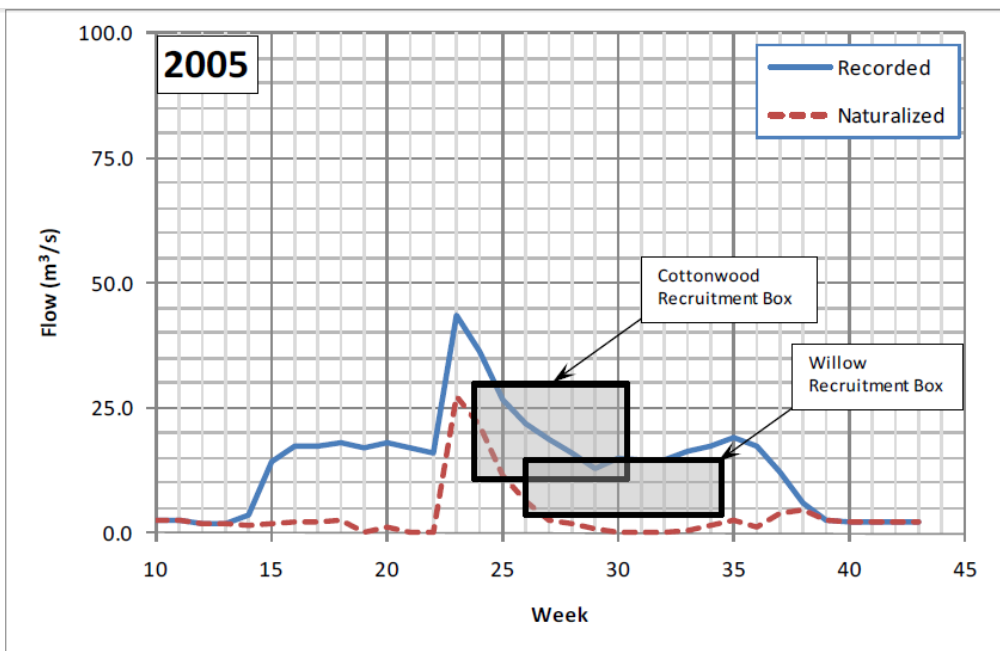


Figure 41: Naturalized and recorded flows for the Milk River at the Eastern Crossing in 2005 with riparian recruitment boxes

APPENDIX H. Surficial geology of the Milk River watershed (MRWCC 2008).

