

**Aquatic and Riparian Condition Assessment
of the
South Saskatchewan River Basin**

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Bow River: Bow River Basin Council. 2005. Nurture, Renew, Protect: A Report on the State of the Bow River Basin.

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Introduction

The Aquatic and Riparian Condition Assessment of the South Saskatchewan River Basin examines three important factors affecting aquatic condition in the basin: riparian health, water quality and hydrology. The purpose of the assessment is to provide a strategic evaluation of the state of all main-stem river reaches in the South Saskatchewan River Basin (SSRB), using a combination of existing and new information. Figure 1 shows a map of the SSRB.



The Aquatic and Riparian Condition Assessment (ARCA) was developed in response to a need for region-wide evaluation of the state of the watershed and to support the vision of healthy watersheds through shared responsibility, which is an integral part of the mission of Alberta's Water for Life Strategy. ARCA also will help support one of the key actions of Water for Life, which is to complete an initial assessment of the status of aquatic ecosystems, including lakes, wetlands, streams and rivers. ARCA will assist Alberta Environment and its partners in determining where to focus management efforts within the SSRB and for prioritizing further studies.

ARCA builds on previous SSRB assessments such as the Strategic Overview of Riparian and Aquatic Condition (Golder Associates, Ltd., 2003). The report reflected the views of scientists and managers working in the SSRB without any specific data review or analysis. ARCA, on the other hand, gives an overview of ecosystem condition based on assessments of riparian health, water quality and degree of hydrological change. The riparian assessment was done partly using features identifiable on sample sites and partly using existing data provided by Alberta Environment and Alberta Sustainable Resource Development. About 5% of the total river length was sampled. The water quality assessment uses an index that is adapted from Alberta's provincial water quality index. Two widely-used hydrological indices and median monthly-flow charts are used for reporting on hydrological change.



Figure 1. Map of South Saskatchewan River Basin

ARCA Indices



Water Quality

Alberta Environment routinely monitors water quality in the major rivers throughout the province. The water quality variables sampled generally include a wide range of basic descriptors and contaminants. Some are sampled on a discrete basis and others as part of a continuous time-series sampling of temperature, dissolved oxygen, electrical conductivity and pH. A variety of shorter-term surveys, on selected lakes, reservoirs and rivers within each of the sub-basins, have also been carried out and have yielded beneficial data for trend analysis, river health assessments, impact assessments, and modelling purposes.

Some of the water quality data collected by Alberta Environment are summarized in a water quality index that is calculated based on water quality objectives. The index varies with the number of variables that exceed objectives, and the magnitude and frequency of exceedances (Wright et al. 1998, Saffran and Anderson 1999, Saffran et al. 2001).

The ARCA water quality component is based wherever possible on the provincial water quality index (WQI). The water quality index is derived for a specific location and time period (usually monthly samples over one year). Currently the WQI is derived and reported yearly for each of the Long Term River Network (LTRN) sites on each of our major rivers. This information is published annually and is available on-line at the provincial government website.

LTRN sites on the Red Deer River are located at:

- Ⓢ Highway 2 (near Fort Normandeau, upstream of Red Deer),
- Ⓢ near Nevis (downstream of Red Deer),
- Ⓢ and at Morrin Bridge (Highway 27).

In addition, as part of the transboundary apportionment agreement between Alberta and Saskatchewan, Environment Canada and the Prairie Provinces Water Board (PPWB) sample the Red Deer River at Bindloss (near the Alberta Saskatchewan border) on a monthly basis for a similar suite of parameters as the LTRN sites.

LTRN sites on the Bow River are at:

- Ⓢ Cochrane,
- Ⓢ Carseland,
- Ⓢ the Ronalane Bridge.

There also is an LTRN site on Elbow River at the 9th Avenue bridge. Monthly monitoring has been initiated more recently on the Bow River at Exshaw, Cluny and Bow City, but the number of variables being analyzed is more limited than at the official LTRN sites and may not be sufficient for determining an index. In addition there are two monitoring sites in Banff National Park, operated by Environment Canada.

There are three long-term sites on the Oldman River:

- Ⓢ near Brocket,
- Ⓢ at Highway 3 in Lethbridge, and
- Ⓢ further downstream, at Highway 36.

A more extensive list of tributary, mainstem, and effluent sites (up to 40 sites) were sampled as part of AENV's contribution to the Oldman River Basin Water Quality Initiative, first five year plan, from 1998-2002. Data from these sites can enhance our understanding of water quality in various reaches of the Oldman River and tributaries.

Finally, there are two long- term monitoring sites on the South Saskatchewan River:

- ⑧ upstream of Medicine Hat and
- ⑧ at the Alberta-Saskatchewan border, jointly funded by AENV and the Prairie Provinces Water Board (PPWB).

The Provincial Water Quality Index

Many of the ARCA ratings are based on calculations of the Alberta provincial Water Quality Index (AWQI), which is a calculation based on, a) the number of water quality variables that exceed specific guidelines (AENV 1999), b) the frequency and c) magnitude of the guideline exceedances. The resultant scores (index results) are then rated according to the following system:

96 - 100	Guidelines almost always met; "Best" Quality (Excellent)
81 - 95	Guidelines occasionally exceeded, but usually by small amounts; threat to quality is minimal (Good)
66 - 80	Guidelines sometimes exceeded by moderate amounts; quality occasionally departs from desirable levels (Fair)
46 - 65	Guidelines often exceeded, sometimes by large amounts; quality is threatened, often departing from desirable levels (Marginal)
0 - 45	Guidelines almost always exceeded by large amounts; quality is significantly impaired and is well below desirable levels; "Worst" Quality (Poor)

Index values are calculated for each of the four variable groups (metals, nutrients, pesticides, and bacteria). These are then averaged, as in the following example, to produce an overall River Water Quality Index:

Metals	Nutrients	Pesticides	Bacteria	Overall Index
83 Good	63 Marginal	76 Fair	42 Poor	66 Fair

A water quality index was also calculated at (four) LTRN Sites Operated by Environment Canada. This Index was calculated using a smaller set of variables than that used for the provincial Index (AWQI). The differences are: a) the index for the federal sites does not include mercury, nitrites, or cyanide; b) secondly, the federal Index is calculated based on three sub indices (metals, nutrients, and bacteria). It does not include a Pesticide sub-index as per AWQI. Consequently, numbers for the index at the federal sites are not directly comparable to AWQI sites. Although not directly comparable, the two indices do provide additional tools for describing water quality conditions and as such are both good descriptors of general water quality conditions at their respective sites.

Where there are no WQI calculations for a specific reach, other methods were used to describe reach conditions; these include a) extrapolating the WQI between reaches; b) using other sources of information (Golder Assoc. 2003); and c) professional judgment / site specific knowledge on the part of the authors.

Water Quality Characteristics of Alberta Rivers

In all Alberta rivers, during precipitation events and snowmelt runoff, the water quality can be of “marginal to poor” quality due to contaminants such as bacteria, metals, pesticides, sediments and nutrients entering via diffuse runoff.



Riparian Health

Riparian areas can be viewed like a jigsaw puzzle, because they are made up of many pieces that are important to the whole “picture”. How the individual pieces such as vegetation, especially deep-rooted plants, function together affects the health of the riparian ecosystem including the stream, its watershed, and overall landscape health and productivity (Cows and Fish: Alberta Riparian Habitat Management Society 2005).

To be healthy, riparian areas need to perform certain functions including trapping sediment to maintain and build stream and riverbanks, recharging groundwater supplies, storing flood water, reducing energy, filtering water, maintaining biodiversity, and creating primary productivity. Despite comprising a small percentage of the landscape, riparian areas are critical to the long-term sustainability of a healthy landscape. Excessive removal or alteration of vegetation by livestock decreases friction on the banks and increases stream horsepower, reducing the stream's defense against erosion (Cows and Fish: Alberta Riparian Habitat Management Society 2005). Although dams reduce the impact of floods they do not eliminate major flooding downstream. Healthy riparian areas can reduce the impacts of major floods, such as the floods experienced along the Red Deer, Bow and Oldman River rivers in 1995 and 2005.

The ARCA riparian health assessment was based on a visual inspection of sample areas and a subsequent scoring of various factors that are thought to contribute to riparian health (Cows and Fish 2005). Parameters included factors that contribute to stream bank stability and vegetation composition, such as: cottonwood regeneration from seed, regeneration of other tree species, preferred shrub species establishment and regeneration, standing decadent and dead woody material, preferred tree and shrub species utilization, total canopy cover of woody species, exotic undesirable woody species, presence of native graminoids, riverbank root mass protection, human-caused bare ground, and control of flood peak and timing by upstream dams.

Method

1. Site Selection and Reach Delineation

Reach boundaries were provided by AENV, based on past work. Using aerial photographs, each reach was subdivided into homogeneous sub-reaches and one polygon (sample area) was selected for each sub-reach, with the recognition that approximately 40 polygons was the limit of available resources for the project. Physical features that contribute to the broad level stream classification system (Rosgen & Silvey 1998) (Thompson & Hansen 2002) were used to classify sub-reaches.

2. Land Use / Management Descriptions

The riparian areas on both sides of the river were classified into one of the following four categories, using ocular estimations of air photos: 1) agricultural rangelands (grazing), 2) agricultural agronomic lands (cropping), 3) developed: residential and / or industrial, 4) undeveloped: recreational, parks, natural areas. The proportion of each of these four categories was determined for each reach. Target areas that best fit the classifications then were identified within each reach. Finally, landholdings within each of the target areas were identified and randomly selected (each polygon must be located wholly within one landholding). Every attempt was made to select a proportional numbers of polygons based on the length in each land use category.

3. Polygon selection

Sample sites were selected that best represented each overall reach.

4. Field Delineation of Polygon Boundaries

Polygon boundaries were refined in the field. Efforts were made to ensure that the polygon was representative of the overall landholding or management unit in which the polygon was located. The vegetation community was often the factor that determined the length of the polygon, as polygons were extended to include a representative vegetation sample.

5. Riparian Inventory

Once the boundaries of the polygon were determined, an inventory of the entire polygon was conducted using field data and information collected from photographs. Vegetation data collected included plant species identification and ocular canopy cover determinations, as well as age class breakdowns for tree and shrub species. Physical site data included a description of the type of stream channel, substrate composition, stream bank condition, amount and cause of bare ground, and commentary. A health assessment rating then was derived from the detailed inventory information. All field data, with the exception of Reach 6 on the Oldman River, were collected in the field during 2003 and 2004. The Oldman River reach was inventoried in 2005.

6. Lotic Health Assessment for Large River Systems

Assessment of riparian health was based on 16 main parameters highlighting characteristics of vegetation (as described above) and soil/hydrology, with two additional parameters for invasive plants. The level of dewatering of each river used the average (1988-2001) of total uses and diversions as a percentage of natural flow, based on data provided by Alberta Environment. The area of watershed upstream of each polygon that was either dammed or undammed areas was calculated using methodology described in Cows and Fish (2005). The proportion of the floodplain accessible to 100-year flood flows in a polygon was determined in the field and by examination of air photos.

7. Photographic Inventory

Colour digital photographs were taken facing upstream and downstream at the start and end of each polygon.

8. Data Limitations, Riparian Health Assessment

The three rivers examined comprise 1,618 km of river length in Alberta; only 84.13 km of river was assessed in 48 polygons, amounting to 5.2% of the total length examined. Consequently, users of the information contained in this report and associated appendices must recognize that the information is appropriate for planning or developing general recommendations across the watershed, and some comparison of the relative, but not absolute, pressures facing each river system examined. Limited access to the river also affected the representative nature of the sample area.

Data on some of the hydrologic parameters used for riparian health assessment determination were at times less detailed and inclusive than it could have been. For example, determination of dewatering and control of flood peak/timing only includes major dams, diversions and licensed uses, but does not include unlicensed uses, and the effects of small dams or impoundments on tributaries.

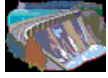
The inventory and assessment of riparian health does not address detailed in-stream or hydrological parameters associated with the project area, such as the timing of flow conditions. Because most of the field work was completed in 2003-2004, additional sampling would be needed to determine what the impacts of the 2005 flood were on riparian health.

9. Conclusions

In general, the intent of riparian health inventory and assessment done at a watershed scale is to provide a state of the environment report concerning only a general overview of health. This report will provide information on riparian health or function that was previously unavailable to assist in making more

informed management and planning decisions. Caution should be used when interpreting reach-specific information, considering the limitations concerning the location and size of the sample areas.

Inventories over a period of years at the same locations will provide trend information of whether current management (local and watershed level) is maintaining, improving or negatively impacting riparian health.



Hydrology

Human influences such as reservoir operations, diversions and pumping have changed hydrological conditions in many parts of the SSRB main stems. ARCA reports on the level of dewatering of each river, and gives estimates of total use and diversions by reach. The estimates are based, in most cases, on averages for the period 1988-2001. In addition to giving dewatering statistics, ARCA reports on the percentage of the watershed dammed, based on calculations done by Cows and Fish using data provided by Alberta Sustainable Resource Development. Dammed areas were calculated as any portions of the watershed that flowed into a dam.

Communicating the impact of human alteration on hydrological systems can be difficult. ARCA uses the following methods as a basis for analyzing and reporting on the hydrological changes that have taken place in a river:

- Range of Variability Approach (RVA),
- Dundee Hydrological Regime Alteration Method (DHRAM),
- Charts of median monthly flows.

Range of Variability Approach

Range of Variability Approach (RVA) is a method that uses 32 flow parameters (Table 1) from the widely adopted Index of Hydrological Alteration (Richter et al. 1996, 1997). Index of Hydrological Alteration (IHA) arranges hydrological parameters into five groups (Poff et al. 1997) (Table 1).

Table 1. IHA Parameters

Group	Parameter
1	Monthly magnitude (each month)
2	Magnitude & duration of annual extremes: – 1, 3, 7, 30 and 90-day minima – 1, 3, 7, 30 and 90-day maxima
3	Timing of annual extremes: – Julian dates of annual minimum and annual maximum
4	Frequency & duration of high & low pulses: – Low pulse count, high pulse count, low pulse duration, high pulse duration
5	Rate & frequency of change in conditions: – Fall rate, rise rate, fall count, rise count

Examples for each group that show promise for having ecological relevance include the following (after Richter et al. 1996, 1998):

- Magnitude of monthly water conditions: habitat availability for aquatic organisms,
- Magnitude and duration of annual extremes: structuring of river channel, morphology and physical habitat conditions,
- Timing of annual extremes: compatibility with life cycles of organisms,
- Frequency and duration of high and low pulses: frequency and duration of anaerobic stress for plants,
- Rate and frequency of change in conditions: entrapment on islands and floodplains.

IHA was developed under the following assumptions:

- The suite of parameters adequately characterizes temporal variation in flow regimes,
- The central tendency & dispersion of intra-annual statistics describe inter-annual variation,
- The full range of natural variability in the flow regime is necessary to conserve aquatic ecosystems.

Data requirements for calculating IHA parameters are daily mean water conditions by reach. The RVA uses as its starting point either measured or synthesized daily stream flow values from a period during which human perturbations to the hydrological regime are negligible. The stream flow record is then characterized using 32 different hydrological parameters, using the IHA approach as described by Richter et al. (1996). Using the RVA, a range of variation in each of the 32 parameters (e.g., the values at a +/- 1 standard deviation from the mean or the 25th to 75th percentile range), is selected as an initial flow management target. Next, daily-recorded flow data for a post-impact period (e.g., after dam construction) are used to generate a new set of 32 IHA parameters for each year to the post-impact period. These values then are compared with the RVA target values (Figure 2).

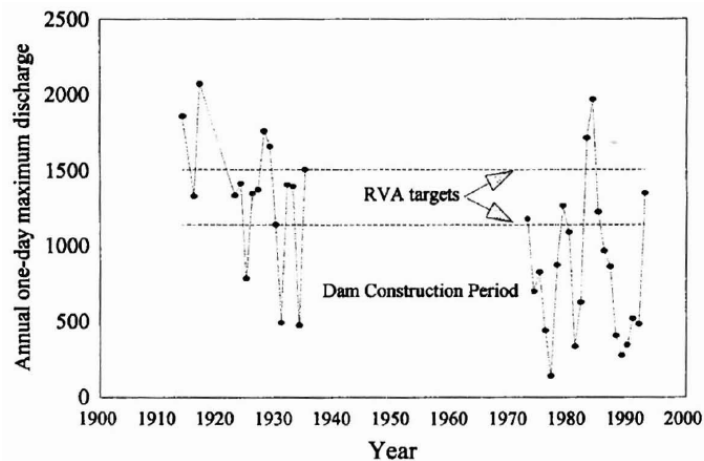


Figure 2. IHA parameter analysis showing RVA targets in the 25-75th percentile for pre and post impact regimes.

RVA Method (ARCA)

Instead of using pre and post impact flows, the ARCA method compares recorded flow with naturalized flow by reach for a specific time period. Comparing the same time period removes uncertainty in the results caused by differences in the length of flow records between the pre- and post impact periods, climate change, and other factors. Recorded daily mean flow data from SSRB gauging stations between 1988-2001 were used for the post-impact period. (Daily flow data are not available prior to 1988). Natural flow for the same time period (1988-2001) was computed using a step-by-sep process by adding known water withdrawals and evaporation estimates to recorded flow data. (Natural flow computations currently are available only up to 2001). Natural flow for this period represents the un-impacted condition.

RVA scores were calculated for each reach in the following way. First, the percentage change in the number of times each of the IHA parameters fell within the middle percentile range (i.e., the 25th to 75th percentile) was calculated. To accord equal weight to each of the IHA groups, mean percentage change was calculated by IHA group, and then an overall average was determined. Finally, the overall average of each reach was scored using the following ranges: (0= <0.33, 1= 0.33-0.76, 2= >0.67) (Table 2).

The original RVA method was modified to adjust for errors caused by a difference between the IHA-program water year and SSRB data, and for errors and inconsistencies associated with low and high pulses. To remove these problems, the data groups, “timing of annual extremes” and “frequency and duration of high and low pulses”, were removed from the analysis. The parameters “number of zero days” and “base flow” were excluded from the analysis for similar reasons.

Table 2. Description of RVA Classes

Class	Points Range	Description, change in flow
Low	<1	Near natural flow
Medium	1--2	Moderate change in flow
High	>2	At most risk of impact

DHRAM (Dundee Hydrological Regime Alteration Method, Black et al., 2005)

DHRAM is an approach developed in the UK to assess changes in the hydrological regime of rivers and is based on IHA. The IHA basis of DHRAM is that comparison of hydrological daily time-series from before the occurrence to an anthropogenic change with those collected after it will allow the hydrological characterization of the change (Black et al. 2005). It uses daily mean flow time-series data, representing un-impacted and impacted situations for the site of interest. Where one or both of the required data sets are unavailable, synthetic data are generated.

In the original method, DHRAM scores are calculated for each reach in the following way. For each of the 32 IHA descriptors, an absolute percentage change in mean and an absolute percentage change in coefficient of variation (CV) are generated. To accord equal weight to each of the IHA groups, averages are found in turn for all of the absolute changes in mean and all of the absolute changes in CV for each group. This results in five summary indicators for changes within group means and five for changes within group CVs. Then, a system of allocating points to indicate relative severity of change in each group is applied.

DHRAM was modified for ARCA in the following way. Recorded daily mean flow data from SSRB gauging stations between 1988-2001 were used for the post-impact period. Insufficient data were available prior to 1988. Natural flow for this same time period was simulated using a step-by-sep process by adding known water uses and evaporation estimates to recorded flow data. Simulations currently are available only up to 2001. Using these two datasets, the IHA program calculated a value for each of the 32 IHA parameters. Then, the DHRAM method as described above was applied to the IHA output. The next paragraph describes the method of allocating points to indicate relative severity of change. The original DHRAM method was further modified to adjust for errors caused by a difference between the IHA-program water year and the SSRB data, and for errors and inconsistencies associated with low and high pulses. To remove these problems, the data groups, “timing of annual extremes” and “frequency and duration of high and low pulses”, were removed from the ARCA DHRAM analysis. The parameters “number of zero days” and “base flow” were excluded from the analysis for similar reasons.

For each reach within a river or sub-basin, the absolute average percentage change by IHA group was scored by comparing its value to the total range of values across all reaches. Percentiles were used for this comparison. The lowest percentile was set at 15%, then the remaining difference in values was divided into three equal percentiles (43.3%, 71.7% and 100%), representing classes of increasing hydrological change. Once the value for a particular group was ranked within a percentile, it was scored. A total of one impact point was awarded for any group mean exceeding the 15% percentile, another point exceeding the 43.3% percentile, and a maximum of three impact points for exceeding the 71.7% percentile, giving a theoretical maximum of 18 points for any river (three group means + three CV means). Finally, the DHRAM classes were defined using the breaks in the distribution of results as defined by Black et al.

(2005) (Table 3). The term “risk of impact” was dropped from the class descriptions as used by Black et al. (2005) with the exception of the highest class because of the lack of information that correlates hydrological change with ecological impacts.

Table 3. Definition of DHRAM Classes

Class	Points Range	Description, Change in Flow
1	0	Negligible
2	1--3	Slight
3	4--6	Slight-moderate
4	7--12	Moderate
5	13--18	At most risk of impact

Charts

Monthly flows were charted by reach to illustrate the following:

- Median natural flow vs. median recorded flow,
- Yearly data points by month,
- # of times natural and recorded flow occurred in each quartile.

Interpreting RVA, DHRAM and Median Monthly Flow Charts

The ARCA RVA index provides information about the degree of hydrological change within the middle percentile range of flows in a reach compared to natural flow, whereas the DHRAM index provides information about the relative degree of hydrological change among reaches within a basin or sub-basin. Both the DHRAM index and the RVA index reflect changes in the variation and mean for each of the IHA parameters. The charts provide detailed information about the degree of hydrological variability by reach for both the open water season and the winter season. The charts section in this report contains more information about interpreting the charts.

Black et al. (2005) note that both Richter et al. (1996) and Poff et al. (1997) provide widespread evidence that the IHA shows promise as a method to characterize ecologically relevant hydrological regime alteration. However, where ecological data are unavailable or lacking in areas such as in the SSRB, these results only provide information about hydrological variability. It is hoped that the results can be used to help determine where research efforts should be focused, or complement studies where biological data become available.

Sub-Basin Assessments

The Red Deer River is divided into eight reaches for ARCA (see map). The following sections first give an overview, then a reach-by-reach assessment of water quality, riparian health and hydrology for the Red Deer River main stem.

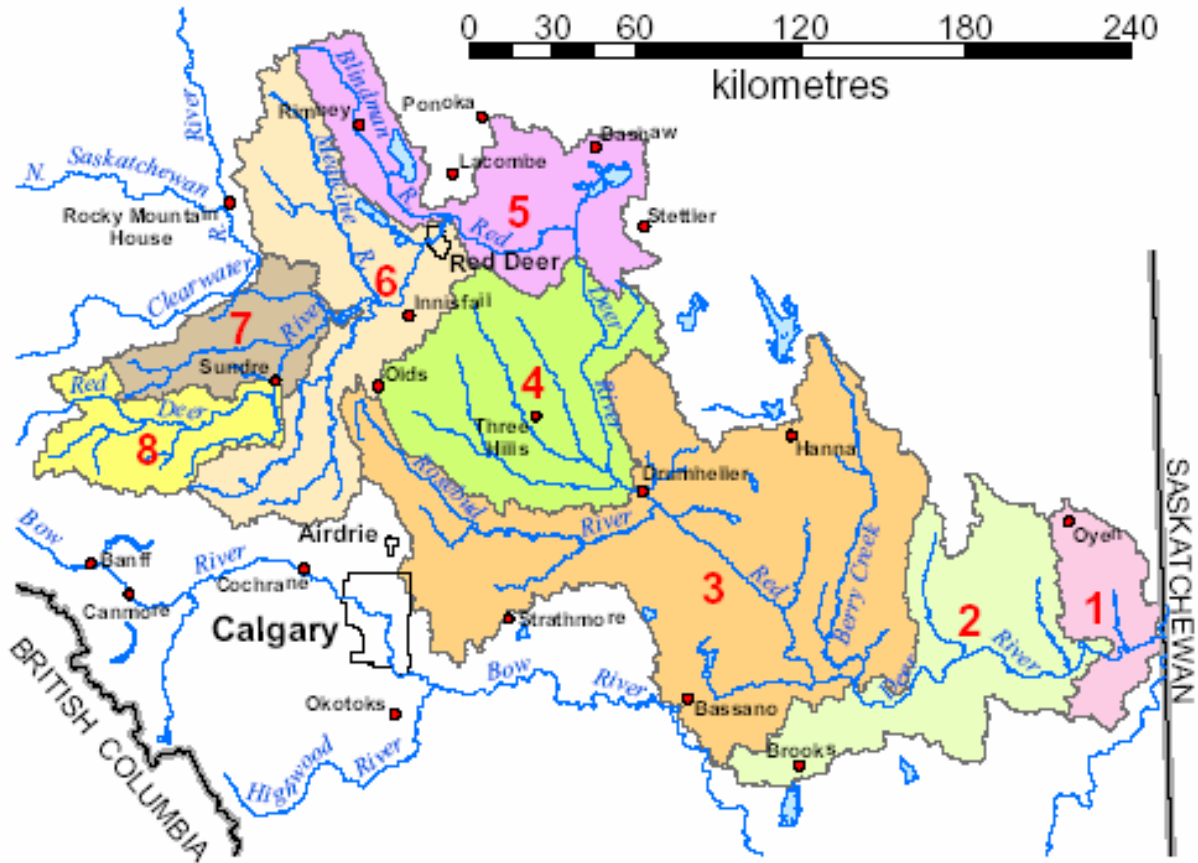


Figure 3. Map of Red Deer River Sub-basin

Red Deer River Sub-Basin Overview

Water quality ratings

Throughout most of the Red Deer River reaches, water quality is rated good (with a few fair ratings). Primary stressors in the Red Deer River that drive the index down include nutrient loading from point and non-point sources, as well as pesticides. High levels of some metals have also been observed on some occasions, though this has been attributed to local geology.

Overall expected water quality trend

Due to increased water allocations, and hence reduced instream flows, water quality is expected to decline. This downward trend can be slowed through improvements in treatment of water before returning it to the river, and by having licence holders actively practise water conservation techniques.

Red Deer River ARCA Summary

Tables RD1 and RD2 contain a summary of ARCA indicators for the Red Deer River. Compared to other reaches along the Red Deer River, Reach # 6 is impacted the most by operation of the Dickson Dam (Table RD1). The individual reach reports and the charts at the end of this report provide more detailed information about water quality, riparian health and hydrological change along the Red Deer River.

Table RD1. Red Deer River ARCA Summary

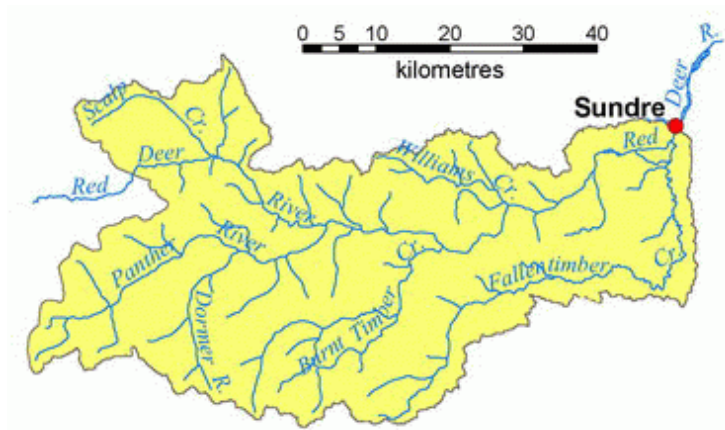
Reach #	Water Quality	Riparian Health	Degree of Hydrological Change (DHRAM)	
			Calendar Year	Open Water Season
8	Fair	Healthy	--	--
7	Fair	Healthy		
6	Good	Healthy	At most risk of impact	At most risk of impact
5	Good	Healthy with problems	--	--
4	Fair	Healthy with problems	--	--
3	Fair	Healthy with problems	Slight-Moderate	Moderate
2	Fair	Healthy with problems	--	--
1	Fair	Healthy with problems	Moderate	Slight-Moderate

Table RD2. Red Deer River RVA Analysis

Reach #	Degree of Hydrological Alteration	
	Calendar Year	Open Water Season
6	At most risk of impact	Moderate
3	Moderate	Near natural
1	Moderate	Near natural

Red Deer River Reach #8

Banff National Park Boundary to Upstream of Sunde Gauging Station



Reach Description: This reach is the Red Deer River headwaters and occupies an area of about 3200 km² or 7% of the Red Deer River basin. The reach falls within a transition zone encompassing the Dry Mixedwood, Lower Foothills and Upper Foothills Natural Subregions. Forestry is the major land use in this watershed; however harvested areas do not encroach on the riparian areas assessed. The highest headwaters are located within Banff National Park.

Human Use: This stretch of river of the Red Deer River is relatively unaltered by impoundments or land use.



Overall, the water quality in this reach is rated fair to good. The water quality in this region is good because it has not been influenced by any major sources of pollutants. Little water is removed from the Red Deer River in this reach.

Concerns include:

- Ⓢ Occasional high TSS from high runoff events
- Ⓢ Pipeline (hydrocarbons) crossings have been exposed by high flood events
- Ⓢ Light agriculture and forestry clearing affects the floodplain and river bank stabilization



Overall, the riparian health in this reach is rated as healthy. This rating is based on four sample sites.

Currently, preferred tree and shrub communities are abundant and are providing significant vegetative cover. Woody plant communities are also diverse, offering multiple species and layers, with good establishment and regeneration of cottonwoods, other trees species and shrubs.

- Ⓢ A positive attribute of the Red Deer River reach RD-08 riparian areas is the moderately low presence of invasive plant communities. Graminoids and forbs are diverse, and primarily native species.
- Ⓢ Disturbance-caused species are present at low to moderate levels.





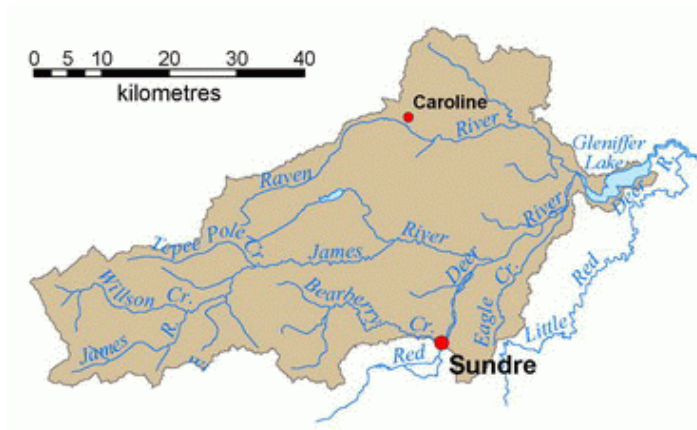
There are no dams and diversion impacts in this reach, and consequently the hydrology is in a near natural state.

- ⑧ There currently are no concerns with altered flow or timing and the river readily accesses the floodplain (Cows and Fish).



Red Deer River Reach #7

Sundre Gauging Station to Dickson Dam



Reach Description: This reach drains a watershed of about 2300 km² or 5% of the Red Deer River basin and includes the reservoir, Gleniffer Lake. The watershed is partly forested. The reach falls within a transition zone consisting of Dry Mixedwood and Central Parkland Subregions. Fish species include mountain whitefish, bull trout, and brown and brook trout (introduced).

Human Uses: Land use adjacent to the Red Deer River in this reach consists of agriculture (mainly livestock grazing), forestry, recreation and acreage developments.



Overall, the water quality in this reach is rated fair to good.

Impacts include:

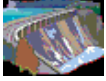
- Ⓢ Extensive livestock operations (cow-calf ranching), agricultural runoff, and poorer quality tributary water.



Overall, the riparian health of this reach is rated as healthy. This rating is based on two sample sites.

- Ⓢ Tree and shrub communities are abundant, covering nearly three quarters of the assessed area, which, in combination with other vegetation life forms, are ensuring excellent vegetative cover. Silverberry (*Elaeagnus commutata*), river alder (*Alnus tenuifolia*) and several willow species (*Salix* spp.) provide considerable cover. Preferred trees and shrubs are successfully regenerating in this reach, with normal amounts of dead and decadent material.
- Ⓢ Invasive species do not provide extensive cover, but are widely distributed. Disturbance-caused species cover over half of the area examined. These species reduce stream bank stability.





There are no dams or major diversions affecting this reach, and consequently the hydrology is in a near natural state.

- ⑧ Less than 5% of the average river discharge is being removed from this reach.
- ⑧ No significant impacts on the overall riparian health are apparent (Cows and Fish).
- ⑧ Dams and berms are not impacting control of flow or floodplain accessibility in this reach (Cows and Fish).



Red Deer River Reach #6

Dickson Dam to Upstream of the Blindman River Confluence



Reach Description: This reach drains a watershed of about 6600 km² or 14% of the Red Deer River basin, and includes Sylvan Lake. It is a diverse watershed located within the Central Parkland and Dry Mixedwood Subregions. Key fish species include mountain whitefish, brown trout and walleye (seasonally).

Human Uses: Land use adjacent to the Red Deer River in this reach is mixed, with considerable livestock grazing, cropping, development, and a small amount of undeveloped areas. This reach includes areas that have been settled and farmed for most of a century and thus some additional impacts have occurred compared to the reaches upstream, which are less densely populated and have not been settled as extensively for as long a period.



Overall, the water quality in this reach is rated good. The water quality index results for this reach (as recorded from sampling above the city of Red Deer, near Fort Normandeau) ranged between 76 and 94 (1996-2004). Conditions (as indicated by the WQI values) have steadily improved since 1996, primarily the result of reduced pesticide levels. Dickson Dam is the largest impact on the river and has led to problems such as increased/decreased scouring, increased phytoplankton, and other adverse effects on the aquatic environment

Impacts include:

- Ⓢ Sewage and stormwater runoff, hydrocarbon exploration.
- Ⓢ Extensive livestock operations (cow-calf ranching), grazing, reduction of wetlands/drainage and runoff from Medicine River all degrade water quality.
- Ⓢ Soil erosion and reduced bank cover.



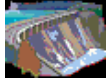
Overall, the riparian health is rated as healthy. This rating is based on two sample sites.

- Ⓢ Five different plant communities were



identified, with tree and shrub cover abundant, covering over half of the area assessed. 70% of the sites inventories are occupied by tree and shrub communities. As in upstream reaches, regeneration and establishment of trees and shrubs is good to excellent, with light to no utilisation on preferred trees and shrubs. Some ornamental or domestic woody plants were found in this reach.

- ⑧ Invasive species do not provide extensive cover, but are widely distributed, including within the urban area assessed. Disturbance-caused species cover more than half of the area examined and reduce bank stability to a moderate degree.
- ⑧ Although generally quite good, bank stability is being impacted by disturbance-caused species.



RVA analysis rates the degree of hydrological change in this reach as “At most risk of impact” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other reaches below the Dickson dam during the calendar year, and as “At most risk of impact” during the open water season. The proximity of Reach 6 to the Dickson Dam explains the degree of hydrological change within this reach.

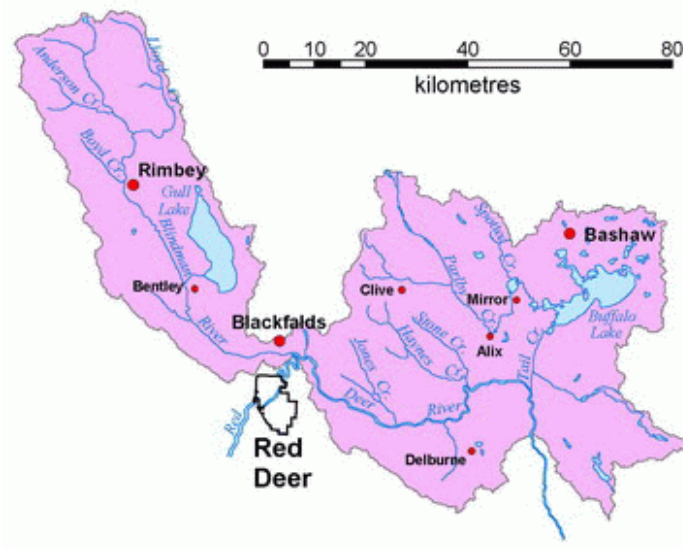
Within this reach, less than 5% of the average river discharge is being removed. Water extractions are minimal from this portion of the Red Deer River and are having no significant impacts on the overall riparian health rating of this reach. The level of water withdrawal within reach appears to be sustainable for a healthy riparian system (Cows and Fish).

- ⑧ Although a berm is present in the City of Red Deer, there is no appreciable impact on floodplain accessibility.
- ⑧ Owing to the location of the Dickson Dam, more than 50% of the watershed upstream of this reach is influenced by the dam, but no signs of impacts on the riparian plant community were seen on the sites assessed (Cows and Fish).
- ⑧ Dickson Dam has the largest impact on the river (SORAC) including:
 - ⑥ increased scouring and bank erosion immediately below the dam;
 - ⑥ enhanced flows in winter, delayed winter cooling and spring warming and lower summer temperatures in some of the reach;
 - ⑥ mountain whitefish continue to be the dominant species with populations increasing;
 - ⑥ phytoplankton and attached (epilithic) algae have increased downstream of dam;
 - ⑥ reduced diurnal variation in temperature; and,
 - ⑥ benthic invertebrates: worms and midges have increased while mayflies and stoneflies have declined since the dam was built.



Red Deer River Reach #5

Blindman River Confluence to the Proposed Special Areas Water Supply Project Diversion Site



Reach Description: This reach drains a watershed of about 5050 km², or 11% of the Red Deer River basin, and includes Buffalo Lake and Gull Lake. Key fish species include goldeye and walleye. It is located within the Central Parkland and Dry Mixedwood Subregions.

Human Uses: Livestock grazing is the dominant land use adjacent to the Red Deer River in this reach, with more than 75% of the reach under this land use. Cropping is also a significant land use, at just over 20%. Agricultural use of these areas began more than a century ago in this region. Water diversions include the Prentiss and Joffre petrochemical plants, and the Buffalo Lake diversion. The City

of Red Deer discharges treated effluent from its wastewater treatment plant into the Red Deer River.



Overall, the water quality in this reach is rated good. The water quality index results for this reach (as recorded from sampling near Nevis) ranged between 84 and 92 (1999-2004). As with reach #4, improved conditions are primarily the result of reduced pesticide levels.

Impacts include:

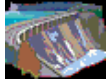
- Ⓢ Increased local water diversions, high temperature and low dissolved oxygen, extensive livestock operations, grazing, reduction of wetlands/drainage
- Ⓢ Reduced peak flows.
- Ⓢ Treated sewage effluent from the City of Red Deer.
- Ⓢ Discharge of process water from large petrochemical plants.



Overall, the riparian health is rated as healthy to healthy but with problems. This rating is based on two sample sites.

- Ⓢ Riparian inventories in 2004 identified four different plant community types. Trees cover 21% of the area inventoried, with 5 species present. 78% of the area inventoried is occupied by tree and shrub communities. Regeneration and establishment of cottonwoods and shrubs is good to excellent, but seedlings and saplings of other tree species are absent on one site. Tree and shrub communities show normal amounts of dead and decadent branches in the canopy, suggesting that there is sufficient moisture within the system, and that disease is not a problem in maintaining these communities.

- ⑧ As is common with most reaches on this system, invasive species do not provide extensive cover, but are sporadic throughout. Disturbance-caused species cover a large portion of each polygon and reduce bank stability to a moderate degree in one polygon. Native graminoids cover more than 50% of one polygon, but 25-50% of the area on the other polygon.
- ⑧ Human-caused vegetation clearing is minimal. One natural gas pipeline was documented.
- ⑧ Deep binding roots stabilize at least 65% of the polygon length, but could be improved with the presence of fewer disturbance-caused species.



No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ Less than 10% of the average river discharge is being removed from this reach.
- ⑧ Water diversion is not significant in this area, and although the distance from the Dickson Dam is greater than upstream reaches, control of flood peak and timing is assessed as impacting riparian health (Cows and Fish).
- ⑧ Water extractions are minimal from this portion of the Red Deer River and are having no significant impacts on the overall riparian health rating of this reach, although they may be impacting spruce regeneration (Cows and Fish).
- ⑧ This reach is rated as poor regarding proportion of the watershed dammed, with the Dickson Dam controlling 25-50% of the watershed upstream of these polygons. Spruce regeneration may be affected, but cottonwood and shrub regeneration is successful at the present (Cows and Fish).
- ⑧ Reduced peak flow may be causing increased sediment build-up in the lower reaches (little scour). May also be leading to establishment of floodplain willows (SORAC).



Red Deer River Reach #4

Proposed Special Areas Water Supply Project Diversion to western boundary of Drumheller



Reach Description: This reach drains a watershed of about 6400 km² to the northwest of Drumheller, or about 14% of the Red Deer River basin. Key fish species include mountain whitefish and goldeye. This reach falls within the Northern Fescue and Central Parkland Subregions.

Human Uses: Land use adjacent to the Red Deer River in this reach is dominated by grazing with some crops, and development such as oil and gas operations.



Overall, the water quality in this reach is rated fair to good. The water quality index results for this reach (as recorded from sampling at the Morrin Bridge) ranged between 75 and 93 (1996-2004). Historically low nutrient and bacteria index values have improved in recent years due to improved treatment of sewage upstream of this site. Pesticide levels have been more variable over the years.

Impacts include:

- Ⓢ Loss of peak flows.
- Ⓢ Municipal and agricultural influences including nutrients from sewage, stormwater runoff, and biological contaminants (*Giardia lamblia* / *Cryptosporidium sp.*).
- Ⓢ Extensive livestock operations (cow-calf operations), grazing and reduction of wetlands/drainage.



Overall, riparian health is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ Riparian inventories in 2004 identified three different plant community types. Shrubs occupy 81% of the area and trees account for 28% of the inventoried area. In general, tree species, including cottonwoods, do not have as strong a presence in this reach. Two tree species and 16

shrub species were recorded. Included in the total number of shrub species is common caragana (*Caragana arborescens*), an introduced shrub species.

- ⑧ Regeneration of trees is fair to minimal and therefore there could be a decline in these species in the future. In contrast, preferred shrub species are present and are successfully regenerating. Light to moderate browse, in combination with limited regeneration of trees could be of concern in terms of maintaining a sustaining woody plant community.
- ⑧ Native grasses covered 25-50% of the area in the inventoried polygons in this reach, which is balanced against modest to considerable cover of disturbance-caused species (from 5-25% at one site, and 25-50% at the second). Invasive species cover a minimal area, but are widely spread throughout, and include purple loosestrife, Canada thistle and smooth brome grass.
- ⑧ Livestock and recreational activities are the main causes of bank alterations and bare ground in this reach, although alterations affect a small portion of the sites. Deep binding roots stabilize less than 65% of the polygon length, linked to abundant disturbance plants.



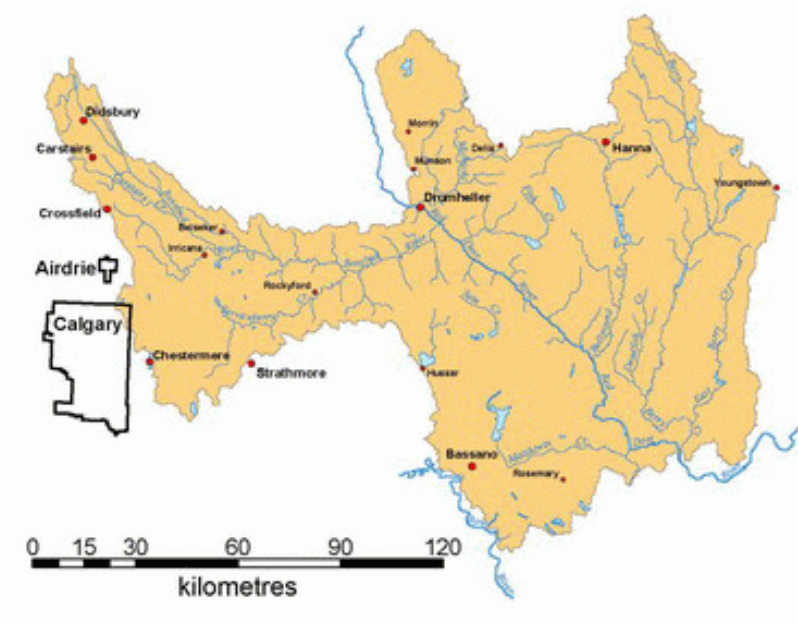
No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ Diversion of water from this reach is slightly higher than upstream, but the proportion of the watershed dammed upstream is less, with increasing distance from the Dickson Dam (Cows and Fish).
- ⑧ Less than 10% of the average river discharge is being removed, and it is rated well for this parameter, however regeneration of trees suggest that this factor, perhaps in conjunction with proportion of watershed dammed (between 25 and 50%), which is rated as poor, may be impacting the establishment of seedlings and saplings. There are no obstructions for floodwaters to overcome when trying to spill onto the floodplain; floodwaters have access to over 85% of the floodplain (Cows and Fish).
- ⑧ Loss of peak flows, due to the dam, could result in long-term build up of sediment and macrophytes in the reach. May also be leading to establishment of floodplain willows (SORAC).



Red Deer River Reach #3

Western Boundary of Drumheller to upstream of Dinosaur Provincial Park



Reach Description: This reach includes the Berry Creek watershed and comprises an area of 15,600 km² or 25% of the Red Deer River basin. The watershed includes three small lakes: Hand Hills, Little Fish, and Coleman Lakes. The reach also includes the Crawling Valley Reservoir that receives trans-basin irrigation water from the Bow River. Key fish species include goldeye, walleye and sauger. The reach occurs in a transition zone including Central Parkland, Northern Fescue, Mixedgrass and Dry Mixedgrass Subregions.

Human Uses: Land use in this reach is predominantly grazing, but also consists of some crops and developed land. Light recreational use occurs along this reach.



Overall, the water quality in this reach is rated fair to good.

Impacts include:

- Ⓢ Return flows from the Eastern Irrigation District (EID) and Western Irrigation District (WID) increase the volume and decrease the water quality of the Red Deer River.
- Ⓢ Increased municipal water diversions to Drumheller and sewage effluent.



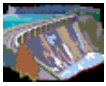
Overall, riparian health is rated as healthy but with problems. This rating is based on three sample sites.

- Ⓢ Riparian inventories in 2004 identified seven different plant community types. Shrubs occupy 57% of the area inventoried in RD-03 and trees account for 34% of the inventoried area. 5 tree species and 22 shrub species were recorded. Included in the total number of shrub species is common caragana (*Caragana arborescens*), an introduced



shrub species.

- ⑧ Cottonwood regeneration is poor, but other trees are regenerating poorly (1 site) to well (2 sites). Preferred shrub species are successfully regenerating. Browse ranges from nil to moderate browse. Browse pressure is not consistently correlated to successful tree regeneration, which suggests other reasons may be limiting seedlings and saplings.
- ⑧ As at most sites, invasive species cover a minimal area, but are widely spread throughout, and include purple loosestrife, Canada thistle and smooth brome grass.
- ⑧ Native grasses cover is variable (5-50%). Overall, 11% of the inventoried area is covered by disturbance species—this is better than most reaches, but the range is from less than 5% to over 50% of an individual polygon.
- ⑧ Overall human-caused structural alterations are minor. Livestock have caused some bank alterations and bare ground in this reach. Recreation is also resulting in bare ground. Deep binding roots are prominent, stabilizing over 85% of 2 sites, and over 65% of the third site.



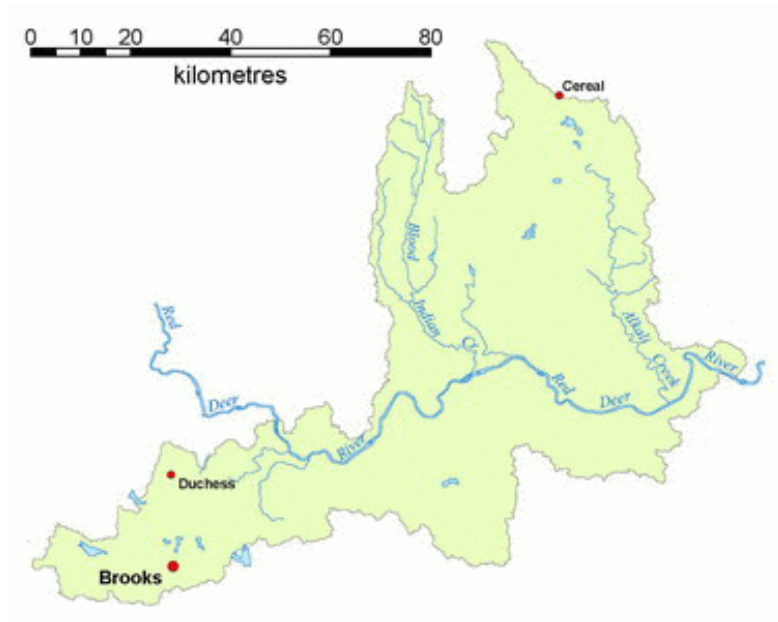
RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Near natural” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Slight-Moderate” when compared to other reaches below the Dickson dam during the calendar year, and as “Moderate” during the open water season. Return flow from the irrigation district during the open water season explains the difference in DHRAM rating between this reach and Reach 6 (immediately below Dickson Dam).

- ⑧ Diversion of water from this reach is slightly higher than upstream reaches, with just under 11% withdrawn.
- ⑧ The proportion of watershed dammed upstream is just over 10%. Water diversion and damming may explain the poor to moderate regeneration of trees in this reach (Cows and Fish).
- ⑧ Man-made barriers are restricting flooding of riparian areas in some parts of the reach.



Red Deer River Reach #2

Western Boundary of Dinosaur Provincial Park to Upstream of Bindloss Gauging Station



Reach Description: This reach drains an area of about 5800 km² or about 12% of the Red Deer River basin. Fish species include goldeye, walleye and sauger. There has been some clearing of riparian forest cover adjacent to the Red Deer River. The main tree species are cottonwood and willow. Exotics include Canada thistle and smooth brome grass. This reach falls entirely within the Dry Mixedgrass Subregion.

Human Use: Land use in this reach is heavily dominated grazing, with a small area of cropping. There are extensive cow-calf operations within this reach, including water extraction,

grazing and wintering of cattle in riparian zones. There are oil and gas operations in the area, and pipeline crossings of streams are common.



Overall, the water quality in this reach is rated fair to good.

Impacts include:

- ⑧ Reductions in high, moderate and low flood peaks due to Dickson dam
- ⑧ Extensive livestock operations (cow-calf operations), water extraction, grazing and wintering of cattle in riparian zones.
- ⑧ Oil and gas operations and pipeline crossings.

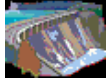


Overall, riparian health is rated as healthy but with problems. This rating is based on two sample sites.

- ⑧ This reach contained 4 different plant community types. Although 14 species of shrubs occupy a similar amount to the adjacent RD-03 (80%), a smaller area is covered by trees (10%). Plains cottonwood (*Populus deltoides*) was the only tree species present, although there was potential for non-cottonwood species in this reach.
- ⑧ Cottonwood regeneration varies from fair to poor, with very good regeneration of shrubs. Browse is rated at moderate at both sites. Regeneration may be influenced by a combination of browse

pressure as well as hydrologic limitations. As in all reaches, the proportion of dead and decadent standing trees/shrubs is normal, suggesting utilisation, disease, and hydrology are not leading to increased death of existing plants.

- ⑧ Invasive plant distribution and disturbance-caused species cover are somewhat less in this reach than elsewhere, but they are still generally widespread and should be of concern. Native grass cover rates moderate to excellent.
- ⑧ Very minor structural bank alterations exist in this reach, but lack of bank stability, based on deep-binding roots, is poor.
- ⑧ No obstructions were found that would restrict floodwaters from accessing the floodplain.



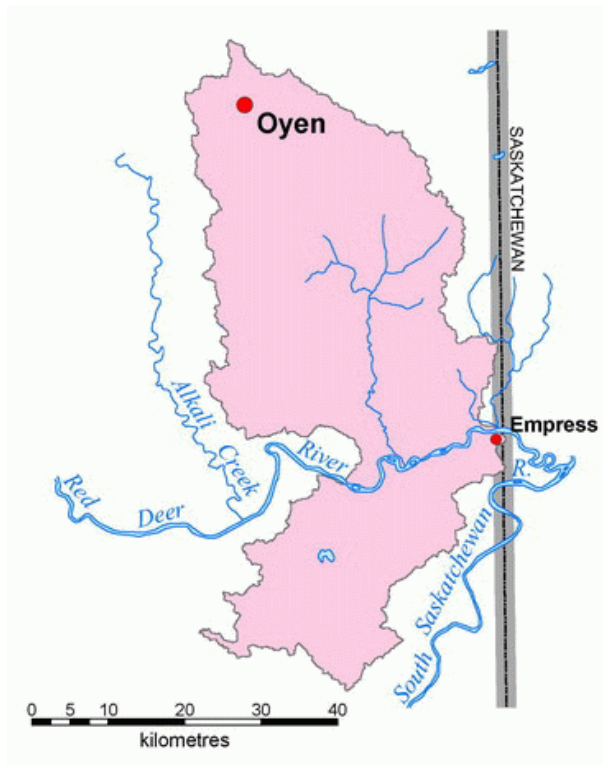
No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ About **Error! Not a valid link.**% of the average river discharge is being removed from this reach.
- ⑧ As in neighbouring reaches, the proportion of watershed dammed upstream is impacting riparian health to a small extent (Cows and Fish).
- ⑧ Dickson Dam has had significant impacts on the two lowest reaches by reducing the highest flood peaks. Before the dam, the river had a shifting sand substrate. Since the dam, the river bed has stabilized and sand bars have become colonized by willows. There are also reductions in moderate to low flood peaks, which have resulted in a decrease in cottonwood recruitment (SORAC).



Red Deer River Reach #1

Bindloss Gauging Station to Alberta/Saskatchewan Border



Reach Description: This reach drains an area of about 2000 km² or about 4% of the Red Deer River basin. Fish species include goldeye, walleye and sauger. There has been some clearing of riparian forest cover along the Red Deer River. The main tree species are cottonwood and willow. This reach falls entirely within the Dry Mixedgrass Subregion.

Human Use: There are extensive cow-calf operations within this reach, including water extraction, grazing and wintering of cattle in riparian zones. There are oil and gas operations in the area, and pipeline crossings of streams are common.



Overall, the water quality in this reach is rated fair to good.

- Ⓢ Reductions in high, moderate and low flood peaks due to Dickson dam
- Ⓢ Extensive livestock operations (cow-calf operations), water extraction, grazing and wintering of cattle in riparian zones.
- Ⓢ Oil and gas operations and pipeline crossings.



Overall, riparian health is rated as healthy but with problems. This rating is based on two sample sites.



- Ⓢ Land use in this reach is more heavily dominated by grazing (98% by length) than any other reach along the Red Deer.
- Ⓢ Cottonwood regeneration varies from very good to poor, with very good regeneration of shrubs.

- ⑧ Browse is rated as light to moderate, and the heavier browse may be related to poorer tree regeneration in this reach.
- ⑧ As in most reaches, invasive plants are widely distributed. Disturbance-caused species cover from 25-50% of the areas inventoried. Both sites had excellent native grass cover, with over 50% cover.
- ⑧ Structural alterations and bare ground are not impacting health, so focus on improving plant vigour, including increasing the proportion of native species, which will increase deep-binding roots and improve bank stability. Rest, appropriate timing, distribution and stocking rate will be required to reduce expansion of disturbance species (primarily tame forage species).



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Near natural” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Dickson dam during the calendar year, and as “Slight-Moderate” during the open water season. Return flow from the irrigation district during the open water season explains the lower DHRAM rating for this reach compared to upstream reaches that are closer to Dickson Dam.

- ⑧ Dickson Dam is impacting the riparian health to a small extent (Cows and Fish).
- ⑧ Withdrawals from this reach are slightly higher than upstream reaches, with just under 15% withdrawn.
- ⑧ Dickson Dam has had significant impacts on the two lowest reaches by reducing the highest flood peaks. Before the dam, the river had a shifting sand substrate. Since the dam, the river bed has stabilized and sand bars have become colonized by willows. There are also reductions in moderate to low flood peaks, which have resulted in a decrease in cottonwood recruitment (SORAC).



Bow River Sub-Basin Overview

The Bow River is divided into ten reaches for ARCA (see map). The following sections first give an overview, then a reach-by-reach assessment of water quality, riparian health and hydrology for the Bow River main stem.

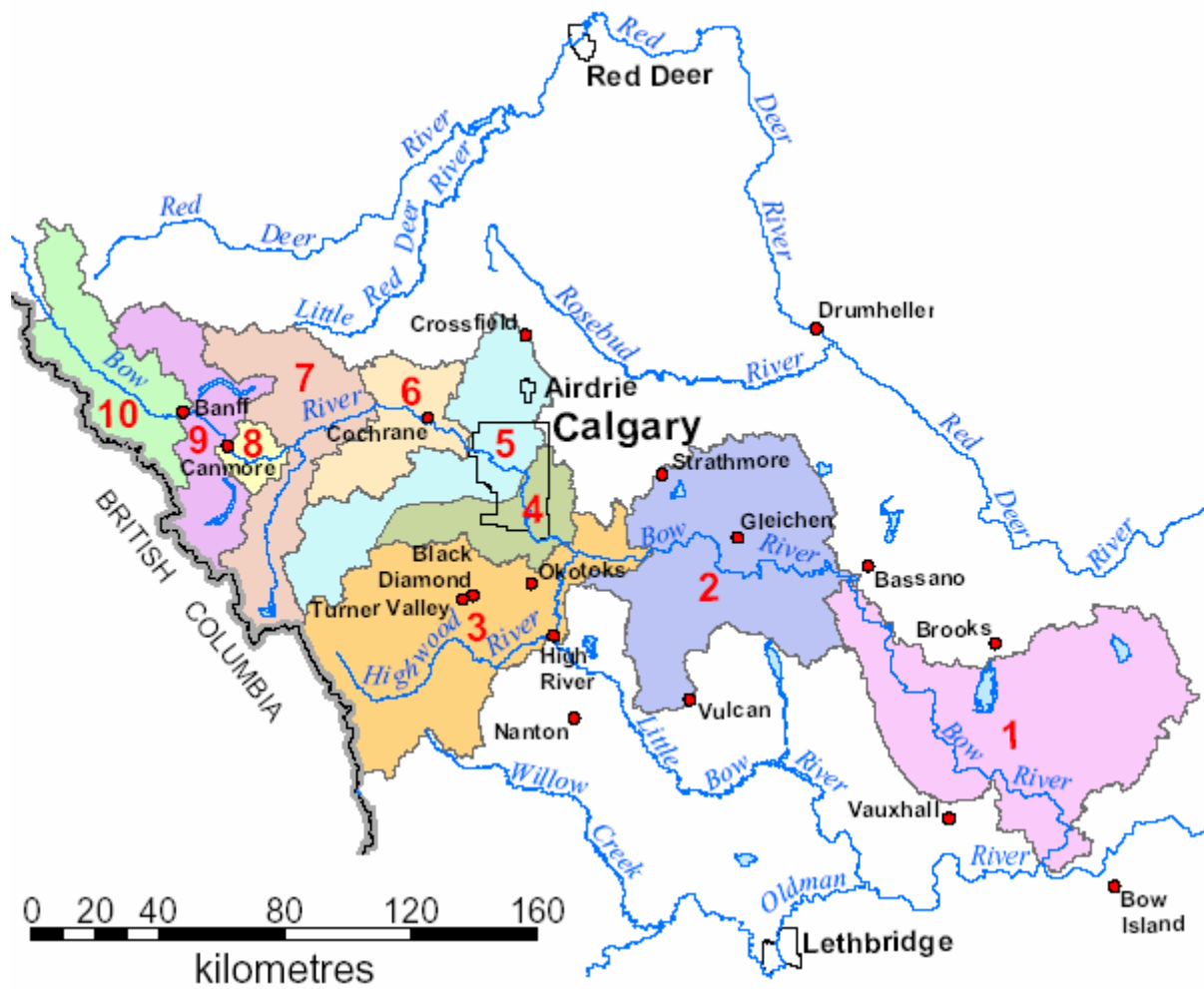


Figure 4. Map of Bow River Sub-basin

Water quality ratings

At most of the Bow River sampling sites, water quality has been rated good to excellent overall during recent years using the Water Quality Index (WQI) for 1996-2003 (GOA 2004)(D. McDonald, personal communication), with fair ratings some years for nutrients in several reaches and marginal ratings for pesticides some years in the Bow River at Ronalane.

These ratings are based on (a) the number of water quality variables (various nutrients, bacteria, metals) that exceed specific guidelines (AENV 1999), and (b) the frequency and (c) magnitude of the guideline exceedances. The resulting scores (index results) are given the following values: 100-96 excellent; 95-81 good; 80 – 66 fair; 65-46 marginal; 45 – 0 poor. In the case of pesticides alone, any detection of pesticides has been treated as a guideline exceedance. This conservative approach likely accounts for the marginal ratings for pesticides in the Bow River at Ronalane some years, and does not indicate that pesticides exceeded accepted guidelines in this reach.

Overall expected trend in the River

Closure of the basin to licensing of further water withdrawal has been approved under the South Saskatchewan River Basin Plan. The current rate of dilution of effluents would be maintained if no further diversion occurs. However, transfer of allocations from holders of existing licenses to new users could mean decreased dilution. The effects on water quality if all allocations are used should be assessed. If the current rate of dilution is maintained, then future water quality in the Bow River will likely depend on the success of the total loadings management plan that has been developed to manage water quality impacts associated with the high rate of population growth in Calgary. If this plan is successfully implemented, then current mainstem water quality should be maintained. Efforts of watershed stewardship groups and management plans should improve conditions on some tributaries.

Bow River ARCA Summary

Tables BW1 and BW2 contain a summary of ARCA indicators for the Bow River. The degree of hydrological change during the open water season is about the same for all reaches because of alteration by hydro-electric dams, irrigation development or both (Table BW1). In contrast, the relative degree of hydrological change increases during the calendar year as one travels downstream because of the cumulative effect of water releases from hydroelectric dams (Table BW1). The individual reach reports and the charts at the end of this report provide more detailed information about water quality, riparian health, and hydrological change along the Bow River.

Table BW1. Bow River ARCA Summary

Reach #	Water Quality	Riparian Health	Degree of Hydrological Change (DHRAM)	
			Calendar Year	Open Water Season
10	Excellent	Healthy	--	
9	Excellent	Healthy with problems	Slight-Moderate	Slight-Moderate
8	Excellent	Healthy	Moderate	Slight-Moderate
7	Excellent	Healthy with problems	Moderate	Slight-Moderate
6	Excellent	Healthy with problems	Moderate	At most risk of impact
5	--	Healthy with problems	At most risk of impact	Moderate
4	--	Healthy with problems	Moderate	At most risk of impact
3	Good	Healthy with problems	Moderate	Moderate
2	Good	Healthy with problems	Moderate	Moderate
1	Good	Unhealthy	Moderate	At most risk of impact

Table BW2. Bow River RVA Analysis

Reach #	Degree of Hydrological Alteration	
	Calendar Year	Open Water Season
9	Moderate	Moderate
8	Moderate	Moderate
7	Moderate	Moderate
6	Moderate	Moderate
5	At most risk of impact	Moderate
4	At most risk of impact	Moderate
3	Moderate	Moderate
2	Moderate	Moderate
1	Moderate	Moderate

Bow River Reach #10

Lake Louise Village to Upstream of Town of Banff



Reach Description: This reach is near the headwaters of the Bow River and drains a watershed of about 1600 km², or 6% of the Bow River basin. The watershed is mountainous and mainly forested, and is located within the Montane, Subalpine and Alpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: Land use adjacent to the Bow River within this reach is very limited, and includes a minor amount of recreation. The Trans-Canada Highway and CPR railway are located in the valley bottom a short distance from the river.



Overall, the water quality in this reach is rated excellent.

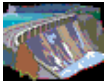
- Ⓢ Water quality in this reach has not been adversely influenced to a significant extent by any major sources of contaminants, and is considered relatively high quality compared to downstream reaches.
- Ⓢ Lake Louise releases treated effluent to the Bow River. While upgrades to treatment (including ultraviolet disinfection) have improved effluent quality, this and the discharge from Banff contribute organic material, bacteria, and nutrients to the Bow River.
- Ⓢ Persistent organic pollutants such as organochlorine pesticides and other compounds, below concentrations considered a human health risk (Bow River Basin Council 2005) have been detected in fish from Bow Lake, upstream from this reach. These pollutants are thought to be from long-range atmospheric transport.





Overall, the riparian health of the Bow River in this reach is rated as healthy. This rating is based on two sample sites.

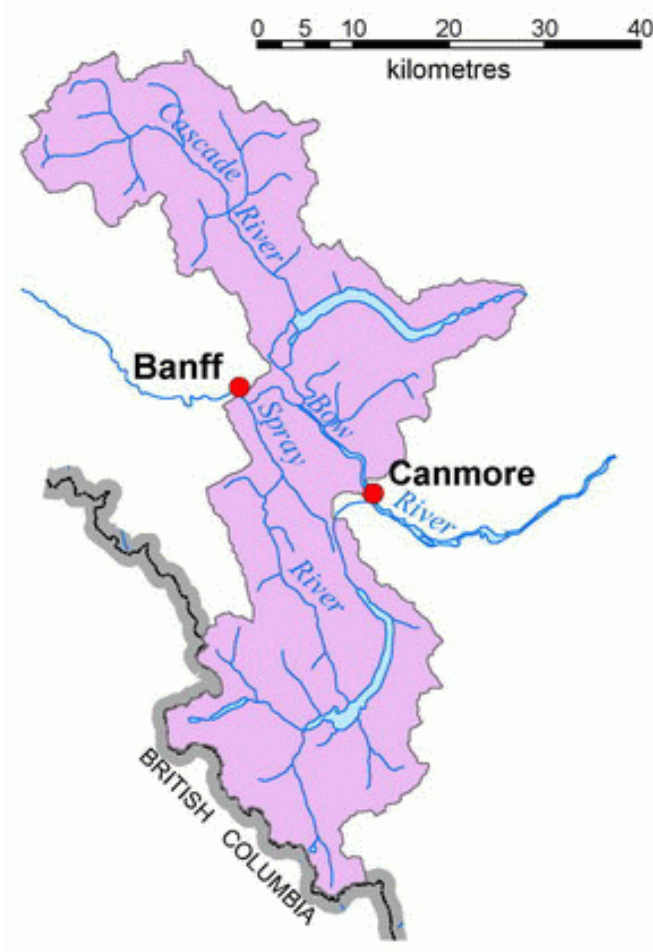
- ⑧ Currently, preferred tree and shrub communities are abundant and are providing significant vegetative cover. Woody plant communities are also diverse, offering multiple species and layers, with excellent establishment and regeneration of cottonwoods, other trees species and shrubs. Light browse levels from wildlife are assisting establishment of new trees and shrubs, as well as maintaining plant vigour.
- ⑧ A positive attribute of this reach is that disturbance-caused plant communities cover riparian areas here less than most other reaches. Railroad and recreational activities are contributing to the limited structural alterations in this reach. There is excellent riverbank root mass protection in this reach.



There are no dams and diversions in this reach, and consequently hydrological conditions are in a natural condition.

- ⑧ The river readily accesses the floodplain.
- ⑧ Lake Louise draws its municipal water supply from local groundwater wells and not directly from the Bow River.

Bow River Reach #9
Town of Banff to upstream of Canmore



Reach Description: This reach drains a watershed of about 1600 km², or 6% of the Bow River basin. The watershed is mountainous and mainly forested, and is located within the Montane, Subalpine and Alpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: This reach is largely undeveloped. The town of Banff is located adjacent to the river at the upper end of the reach.



Overall, the water quality in this reach is rated excellent. Water quality in this reach has not been adversely influenced to a significant extent by any major sources of contaminants.

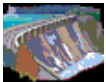
- Ⓢ The growing community of Banff releases treated effluent. There has been public concern that reduced nutrient discharge following improved wastewater treatment at Banff has resulted in reduced fish growth rates.





Overall, the riparian health of the Bow River in this reach is rated as healthy, to healthy but with problems. This rating is based on two sample sites.

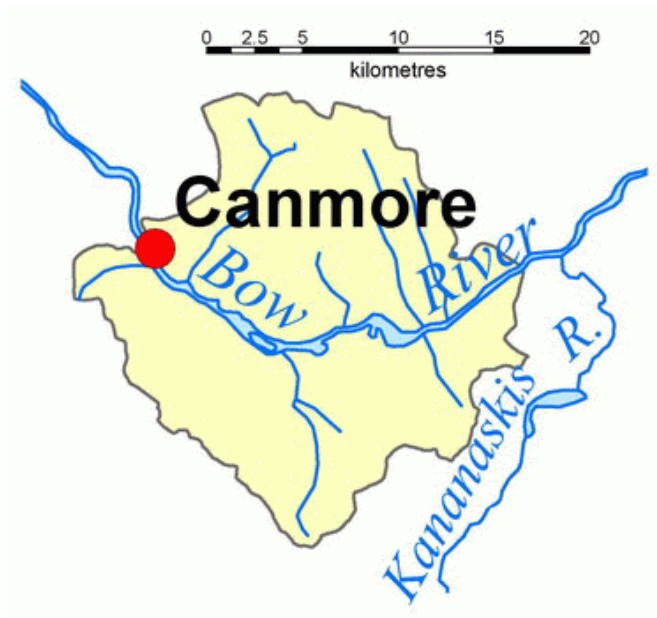
- ⑧ Trees and shrubs communities are abundant in the area, with variable success at regeneration and establishment. In particular, one polygon has poor cottonwood regeneration, as well as moderate regeneration of other tree species. Utilisation at this site is heavy, and may be contributing to reduced seedlings and saplings. Light utilization exists in the other polygon.
- ⑧ Health of herbaceous communities is variable, with no invasive species and very low disturbance species in one polygon, but heavy invasive species infestations and extensive disturbance-caused species cover on the other site. Native grass cover is fair to good.
- ⑧ Riverbank root mass protection is variable, from excellent to poor.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Slight-Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “Slight-Moderate” during the open water season.

- ⑧ Water withdrawals in this reach are minimal and are not impacting riparian health. Banff draws its municipal water supply from local groundwater wells and not directly from the Bow River.
- ⑧ The Cascade and Spray River hydroelectric plants are situated on tributaries of the Bow River that enter this reach. The majority of flows from the Spray River is diverted through the Three Sisters Dam and now enters further downstream via a canal at the Town of Canmore. The remaining flow in the Spray River is highly regulated and much lower than historic flows. The Cascade hydroelectric generation system was created through the damming of the Cascade River. In addition, a portion of the North Ghost River is diverted to the Cascade River via Lake Minnewanka. As a result, some flows from the North Ghost River now enter the Bow River in this reach instead of Reach 7. Overall, about 18.4% of natural flow is diverted from this reach.
- ⑧ Access to the full floodplain is somewhat limited in one polygon, but no barriers to floodwaters exist at the other site.

Bow River Reach #8
Canmore to Upstream of Kananaskis River Confluence



Reach Description: This reach drains a watershed of about 400 km², or 1.5% of the Bow River basin. The watershed is mountainous, and is located within the Montane and Subalpine and Alpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: Land use adjacent to the Bow River within this reach includes urban development (Town of Canmore) and recreation. Several surface mines, including gravel land limestone, are located within the watershed, downstream of Canmore.



reach has been rated excellent.

Overall, the water quality in this

- ⑧ Water quality in this reach has not been adversely influenced to a significant extent by any major sources of contaminants.
- ⑧ The growing community of Canmore releases treated effluent.
- ⑧ There has been public concern that reduced nutrient discharge following improved wastewater treatment at Canmore has resulted in reduced fish growth rates



Overall, the riparian health of the Bow River in this reach is rated as healthy. This rating is based on two sample sites.

- ⑧ Trees and shrubs are dominant in the inventoried area; these species occupy 87% of the area inventoried. There is excellent establishment and regeneration of preferred trees and shrubs in this reach. Utilisation is light on preferred trees and shrubs.
- ⑧ Native grass cover is fair to good, with it being replaced by considerable areas of disturbance-caused species, and to a lesser extent, invasive plants. Invasive species are widespread throughout the area examined.
- ⑧ Less than 10% of the riverbank length has human-caused structural alterations, but where they do exist, they are a result of housing developments and the presence of a pipeline. Human-caused bare ground is minimal and due to the presence of a pipeline and coal deposits within the riparian area. Riverbank root mass protection is variable, from excellent to poor (Cows and Fish).

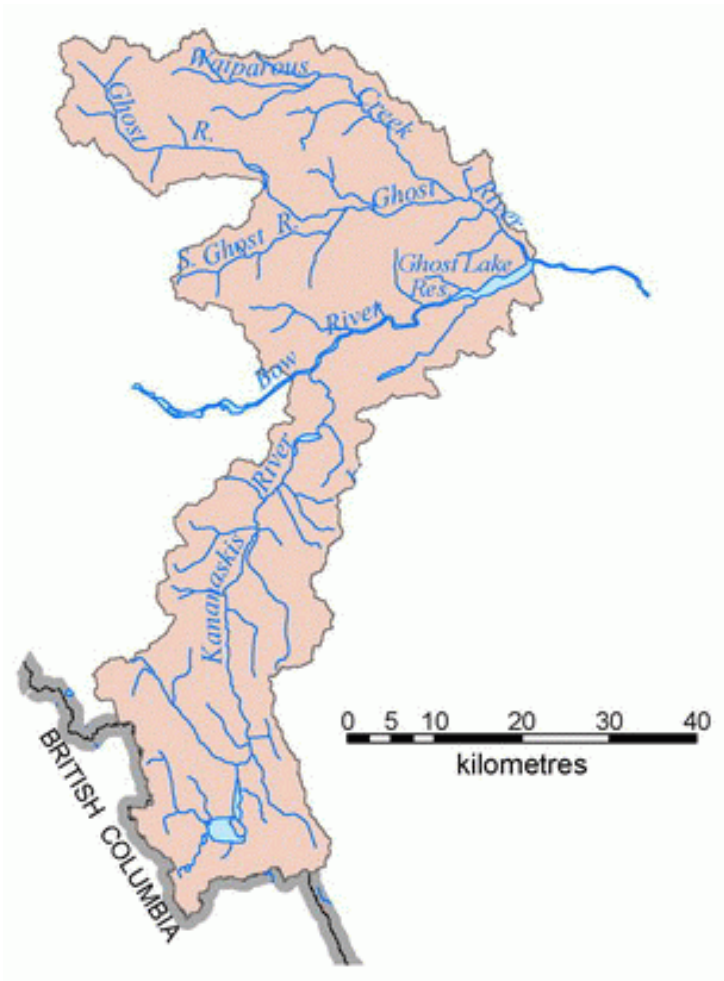


RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “Slight-Moderate” during the open water season.



- ⑧ Water withdrawals in this reach are minimal and are not impacting riparian health (Cows and Fish).
- ⑧ Access to the full floodplain is somewhat limited in one polygon due to a railroad, but no barriers to floodwaters exist at the other sites (Cows and Fish).
- ⑧ Although there are no dams on this reach, the regulated flows from the Cascade and Spray hydroelectric plants on upstream tributaries have affected peak flows and timing.

Bow River Reach #7
Kananaskis River Confluence to Upstream of Ghost Dam



Reach Description: This reach drains a watershed of about 2500 km², or 9% of the Bow River basin. The watershed for this reach is mostly forested, and is located within the Montane, Subalpine and Alpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: Land use adjacent to the Bow River within this reach includes some livestock grazing. Land use within the watershed includes settlements such as Exshaw and the Stoney Indian Reserve, forestry and recreation.



Overall, the water quality in this reach has been rated excellent.

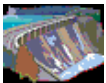
- ⑧ Water quality in this reach has not been adversely influenced to a significant extent by any major sources of contaminants.
- ⑧ There are concerns about impacts of uncontrolled OHV use and random camping in the Ghost-Waiparous basin. These concerns have been evaluated by monitoring programs, and will be addressed by an access management plan coordinated by SRD.





Overall, the riparian health of the Bow River in this reach is rated as healthy, to healthy but with problems. This rating is based on two sample sites.

- ⑧ Trees and shrubs communities are abundant in the area, with variable success at regeneration and establishment. In particular, one polygon has poor cottonwood regeneration, as well as moderate regeneration of other tree species. Utilisation at this site is heavy, and may be contributing to reduced seedlings and saplings. Light utilization exists in the other polygon.
- ⑧ Health of herbaceous communities is variable, with no invasive species and very low disturbance species in one polygon, but heavy invasive species infestations and extensive disturbance-caused species cover on the other site. Native grass cover is fair to good.
- ⑧ Riverbank root mass protection is variable, from excellent to poor.
- ⑧ Upstream dams (Kananaskis, Barrier and Horseshoe) are having the most impact on the riparian health rating of this reach. There could be future concerns with cottonwood (and other tree or shrub) regeneration.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “Slight-Moderate” during the open water season.

- ⑧ Dams on the Kananaskis River and Bow main stem have considerably modified the hydrology within this reach. Upstream dams affect timing and peak flows, and the Horseshoe and Ghost Dams have created on-stream reservoirs.
- ⑧ Dams on the Kananaskis River and the Bow main stem are controlling more than 50% of the upstream watershed.
- ⑧ Water withdrawals in this reach are minimal and are not impacting riparian health. Access to the full floodplain is not restricted (Cows and Fish).

**Bow River Reach #6
Ghost Dam to Bearspaw Dam**



Reach Description: This reach drains a watershed of about 1600 km², or 6% of the Bow River basin. The watershed for this reach is partly grassland and partly forested. It is located within a transition zone consisting of Foothills Fescue, Foothills Parkland, Montane and Subalpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: Land use adjacent to the Bow River within this reach includes grazing, urban development (Town of Cochrane), and acreage development. The City of Calgary obtains part of its drinking water supply from the Bearspaw Dam reservoir.



Overall, the water quality in this reach has been rated excellent.

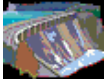
- Ⓢ Water quality in this reach has not been adversely influenced to a significant extent by any major sources of contaminants.
- Ⓢ There are concerns about agricultural activities on tributaries in this reach. A watershed stewardship group is working to improve conditions in Grand Valley Creek
- Ⓢ The Town of Cochrane now sends its wastewater to the City of Calgary treatment system through a pipeline



Overall, the riparian health of the Bow River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ Four different plant communities were identified, with trees and shrub cover abundant. Regeneration and establishment of all groups of trees and shrubs is excellent, with light utilisation on preferred trees and shrubs.
- Ⓢ Health of herbaceous communities is variable, with few invasive species and low canopy cover of disturbance species in one polygon, but extensive invasive species infestations and widespread disturbance-caused species cover on the other site. Native grass cover is fair to good. Yellow toadflax, Canada thistle and perennial sow thistle are the invasive weeds that were found in this reach.

- ⑧ Riverbank root mass protection is fairly good to excellent, and results from the extensive woody plants along the banks.

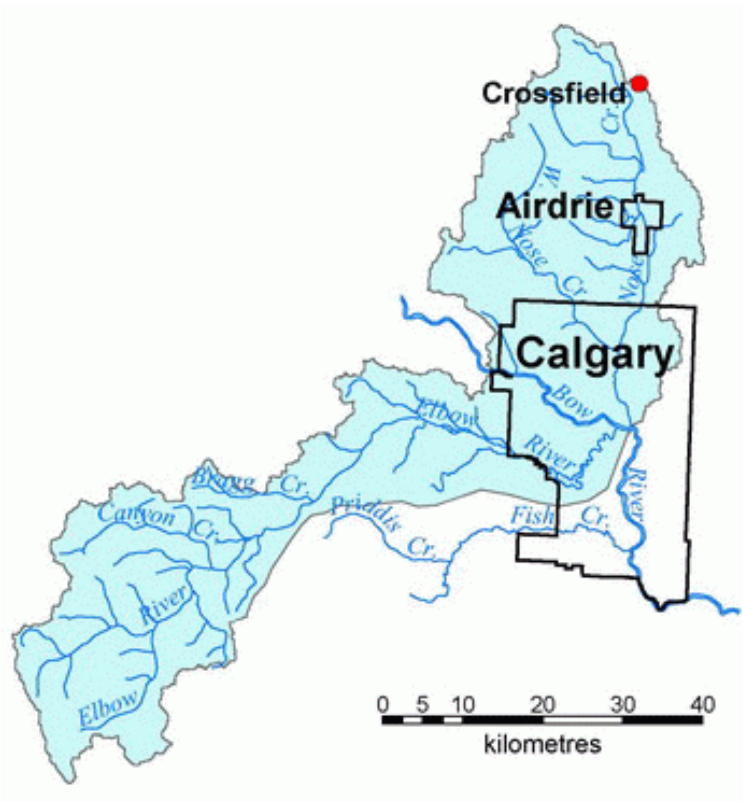


RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “At most risk of impact” during the open water season; however, Alberta Environment advises the impact during the open water season be upgraded to “At most risk of impact”. The impact of the Ghost Dam creates a higher DHRAM rating on this reach compared to the reach immediately upstream.

- ⑧ Water withdrawals in this reach are minimal and are not impacting riparian health (Cows and Fish).
- ⑧ Access to the full floodplain is not restricted.
- ⑧ This reach is immediately below the Ghost Dam. This dam and several dams further upstream affect timing and peak flows. Bearspaw Dam has created an on-stream reservoir within this reach.
- ⑧ Upstream dams are impacting the riparian health rating because more than 50% of the upstream watershed is dammed (Cows and Fish).



Bow River Reach #5 Bears paw Dam to Upstream of WID Weir



Reach Description: This reach drains a watershed of about 2400 km², or 9% of the Bow River basin. The watershed for this reach includes Nose Creek and Elbow River watersheds, and partly falls within the City of Calgary limits. The watershed for this reach is located within the Foothills Fescue, Foothills Parkland, Montane and Subalpine Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: Land use adjacent to the Bow River within this reach includes urban development, farmland, gravel pits, golf courses and acreages. The City of Calgary obtains part of its drinking water supply from the Elbow River (Glenmore Reservoir).



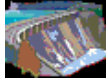
Until 2005, there has been no recent water quality monitoring suitable for index calculation in this reach. In 2005, the City of Calgary, with support from AENV, began sampling a site immediately downstream from this reach. These results will be available for future evaluations.

- Ⓢ There are neither major industrial or municipal treatment plant outfalls within this reach. It does, however, receive storm sewer discharge, and contains the former Canada Creosote site that once resulted in creosote seepage into the Bow River, which has since been contained.
- Ⓢ Impervious area in the City of Calgary increases peaks of storm events which may degrade water quality following storm events. Aside from storm events, water quality in this reach is relatively good during base flows.
- Ⓢ Little water is removed in this reach except for City of Calgary withdrawals from Bears paw and Glenmore reservoirs. The re-regulation of hydropeaking flows is thought to be a benefit to water quality, as are higher winter flows.



Overall, the riparian health of the Bow River in this reach is rated as healthy but with problems, and unhealthy. This rating is based on two sample sites.

- ⑧ Four different plant community types were identified, with trees and shrub cover similar to the upstream reach, with approximately 25-30% cover by each. Regeneration is present within this reach, however in one of the sites regeneration of cottonwoods and other tree species is minimal, with moderate regeneration of preferred shrub species. The other site has excellent cottonwood and preferred shrub regeneration, but very poor aspen regeneration. Light to no use is occurring on preferred trees and shrubs.
- ⑧ Extensive distribution of invasive species and over 50% cover of disturbance species are impacting the herbaceous community, with very small amounts of cover provided by native graminoids.



RVA analysis rates the degree of hydrological change in this reach as “At most risk of impact” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other reaches below the Town of Banff during the calendar year, and as “Moderate” during the open water season. The presence of the Bearspaw Dam does not change the DHRAM rating on this reach compared to Reach 6 because there is steady flow past the dam.

- ⑧ Water withdrawals are not impacting riparian health in this reach (Cows and Fish).
- ⑧ Dewatering from water withdrawals is moderately impacting riparian health, but floodplain accessibility is good. Four upstream dams are impacting the riparian health rating due to changes in peak flow and timing, with over 50% of the upstream watershed dammed (Kananaskis Falls Dam, Horseshoe Dam, Ghost Dam and Bearspaw Dam).
- ⑧ This reach is immediately downstream from the Bearspaw Dam, and the small watershed for the most of the reach has minimal effect on mitigating the effects on timing and peak flows.
- ⑧ Access to the floodplain is variable, from severely restricted to unrestricted.
- ⑧ Owing to the extensive damming upstream, there could be future concerns with cottonwood (and other tree and shrub) regeneration.



Bow River Reach #4
WID Weir to Upstream of Highwood River Confluence



Reach Description: This reach drains a watershed of about 1140 km², or 5% of the Bow River basin. The watershed for this reach includes Fish Creek and is falls partly within the City of Calgary limits. The watershed for this reach is located within the Foothills Fescue and Foothills Parkland Subregions. Fish species include mountain whitefish, brown and rainbow trout.

Human Uses: This reach includes the southern half of the City of Calgary and includes the Bonnybrook and Fish Creek sewage outfalls as well as the major industrial parks. Outside the city

limits, land uses include farmland and acreages.



Until 2005, there has been no recent water quality monitoring suitable for index calculation in this reach. In 2005, the City of Calgary, with support from AENV, began sampling a site on the Bow River immediately upstream from the Highwood River.

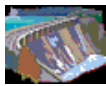
- ⑧ The influence of the stabilized flow from the Bearspaw Dam is still significant in this reach. This reach includes the southern half of the City of Calgary and includes the Bonnybrook and Fish Creek sewage outfalls as well as major industrial parks.
- ⑧ Water quality in this reach has improved due to upgrading of the sewage treatment in Calgary, but dissolved oxygen has sometimes fallen below guidelines in recent years, most likely from nutrient loading from continued population growth, and low flows during the recent drought.
- ⑧ Loadings of nutrients and other key variables will be managed under a total loadings management plan proposed by the City of Calgary, in consultation with AENV and stakeholders in 2005. The sewage outfalls provide an enriched environment in this and downstream reach.





Overall, the riparian health of the Bow River in this reach is rated as healthy but with problems, and unhealthy. This rating is based on two sample sites.

- ⑧ Four different plant community types were identified, with trees and shrub cover similar to the upstream reach, with approximately 25-30% cover by each. Regeneration is present within this reach, however in one of the sites regeneration of cottonwoods and other tree species is minimal, with moderate regeneration of preferred shrub species. The other site has excellent cottonwood and preferred shrub regeneration, but very poor aspen regeneration. Light to no use is occurring on preferred trees and shrubs.
- ⑧ Extensive distribution of invasive species and over 50% cover of disturbance species is impacting the herbaceous community, with very small amounts of cover provided by native graminoids.

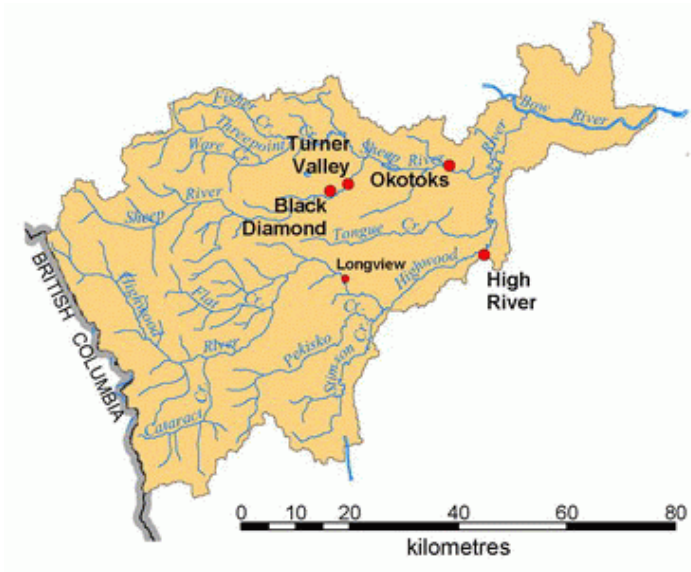


RVA analysis rates the degree of hydrological change in this reach as “At most risk of impact” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “At most risk of impact” during the open water season. The DHRAM rating for the open water season is higher for this reach compared to Reach 5 because of water diversion from the Western Irrigation District weir.

- ⑧ Dewatering from water withdrawals is moderately impacting riparian health, but floodplain accessibility is good (Cows and Fish).
- ⑧ Four upstream dams (Kananaskis Falls Dam, Horseshoe Dam, Ghost Dam and Bearspaw Dam) are impacting the riparian health rating due to changes in peak flow and timing, with over 50% of the upstream watershed dammed (Cows and Fish).
- ⑧ Water withdrawals and damming upstream appear to be impacting cottonwood and other tree seedling establishment (Cows and Fish).



Bow River Reach #3
Highwood River Confluence to Carseland Weir



Reach Description: This reach drains a watershed of about 4400 km², or 17% of the Bow River basin. The watershed for this reach consists mainly of the Sheep and Highwood River watersheds. The watershed for this reach is located within a transition zone including Foothills Fescue, Foothills Parkland, Montane and Subalpine Subregions. Key fish species include mountain whitefish, brown and rainbow trout. In Reach 3, the river leaves Calgary, cutting deeply and flowing more slowly through 53 kilometers of prairie to the Bow River Irrigation District Headworks weir at Carseland. The Highwood River joins the Bow within this reach. The river continues as a cold-water ecosystem, and

Reach 6 is an excellent large trout fishery.

Human Uses: Land use adjacent to the Bow River in this reach is heavily dominated by grazing, with a very small amount in each of cropping, development and undeveloped lands. Agriculture has been in this area for more than a century. The greatest consumptive use of water occurs at the very bottom of the reach where the headworks of the Bow River Irrigation District are located.



Overall, water quality in this reach has been rated good in recent years, with a fair rating for nutrients due to enrichment from Calgary.

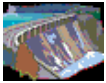
- Ⓢ Water quality in this reach has improved due to upgrading of the sewage treatment in Calgary, and removal of High River's sewage from the Highwood River in 1989.
- Ⓢ Sewage discharge continues to provide an enriched environment in this and downstream reaches. Coupled with the enhanced winter flows from Bearspaw Dam, this is thought to result in a highly productive sport fishery for non-native trout (rainbow and brown trout).
- Ⓢ There are irrigation return flows in this reach that contribute fertilizers and pesticides to the Bow River, but their impacts are less than treated wastewater from Calgary.





Overall, the riparian health of the Bow River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- ⑧ Although shrubs cover 80% of the inventoried area, a considerable portion of these are grazing-resistant species (buckbrush and rose). Only 17% of the area is covered by trees. Regeneration of cottonwoods and preferred trees and shrubs is excellent; other tree species are reproducing well on one site, but are absent from the other site, which was identified as having potential to support them. Utilisation on preferred trees and shrubs is light to nil.
- ⑧ Water withdrawals and damming upstream do not appear to be impacting seedling establishment, but there could be future concerns with cottonwood (and other tree or shrub) regeneration, which warrants monitoring to ensure establishment of seedlings/saplings results in maintenance and survival to mature plants.
- ⑧ Invasive and disturbance species are of concern, with extensive distribution of invasive species and 64% cover by disturbance species. Native graminoid cover is poor to moderate.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “Moderate” during the open water season. The high DHRAM ratings during the calendar year are caused by a combination of irrigation withdrawals during the open water season and increased winter flows as a result of release from hydro-electric dams. DHRAM ratings during the open water season are lower compared to Reach 5 because of augmented flow from the Highwood River, which enters this reach.

- ⑧ Water withdrawals are removing 10-25% of the average river discharge.
- ⑧ Water withdrawals and upstream dams are impacting the riparian health rating due to changes in peak flow and timing, with over 50% of the upstream watershed dammed (Kananaskis Falls Dam, Horseshoe Dam, Ghost Dam, Bearspaw Dam and Carseland Weir) (Cows and Fish).
- ⑧ Water withdrawals and damming upstream do not appear to be impacting seedling establishment, but there could be future concerns with cottonwood (and other tree and shrub) regeneration (Cows and Fish).
- ⑧ This reach exhibits some recovery towards a natural flow regime due to discharges from the Highwood River. The flows are somewhat enhanced due to downstream water conveyance for irrigation license priorities (oldest licenses) of the Bow River Irrigation District (BRID) and EID.



**Bow River Reach #2
Carseland Weir to Upstream of Bassano Dam**



Reach Description: This reach drains a watershed of about 4300 km², or 17% of the Bow River basin. Although the valley is quite deep and wide, valley slopes are gentler than upstream. The valley bottom is generally open pastureland with dense groves of poplar and individual trees along the riverbank. This 136-kilometre reach of the river passes through the Siksika Nation Reserve for most of its length. Mountain whitefish and to a lesser extent, brown and rainbow trout are found in the upper portions of the reach. Northern pike and walleye are present in the lower part of the reach. The watershed of this reach is located within the Mixedgrass Subregion.

Human Uses: Land use adjacent to the Bow River in this reach is mainly grazing, with a very small amount of cropping, development

and undeveloped lands. There is one golf course in the reach. The largest amount of water withdrawn in this reach occurs at the Carseland weir at the start of the reach.



Overall, the water quality in this reach was rated fair to good from 1996 to 2001/2002, the last year when the site at Cluny was sampled for the variables required to calculate a water quality index. Sampling of this site for these variables resumed in 2005, and results from this site will be available for future evaluations.

- Ⓢ Reduced peak flows and impoundments result in reduced sediment transport capability
- Ⓢ Water quality in this region has generally improved due to better wastewater treatment upstream
- Ⓢ Concerns have been expressed by the Siksika Nation about a proposed discharge of treated wastewater from Strathmore upstream from their boundary
- Ⓢ There are irrigation return flows transporting some fertilizers, pesticides, and nutrients from feedlots (e.g., Crowfoot Creek).



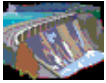
Overall, the riparian health of this reach is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ This reach contains the largest and densest stands of balsam poplar along the river valley.
- Ⓢ Although shrubs cover 80% of the inventoried area, a considerable portion of these are grazing-resistant species (buckbrush and rose).



Only 17% of the area is covered by trees. Regeneration of cottonwoods and preferred trees and shrubs is excellent; other tree species are reproducing well on one site, but are absent from the other site, which was identified as having potential to support them. Utilisation on preferred trees and shrubs is light to nil.

- ⑧ Invasive and disturbance species are of concern, with extensive distribution of invasive species and 64% cover by disturbance species. Native graminoid cover is poor to moderate.



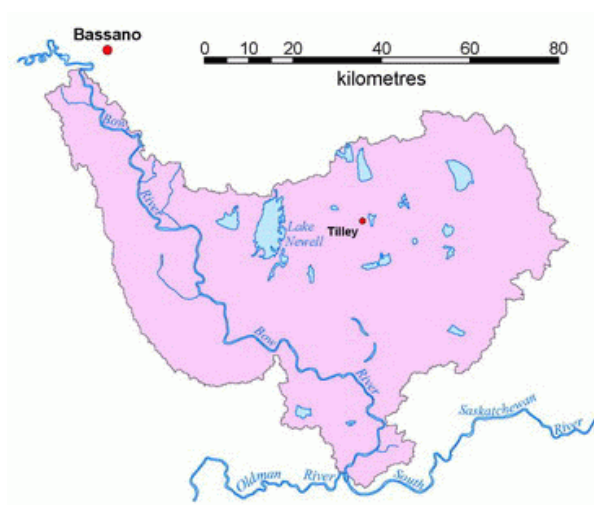
RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “Moderate” during the open water season.

- ⑧ Water withdrawals are removing 10-25% of the average river discharge, impacting riparian health.
- ⑧ Upstream dams (Kananaskis Falls Dam, Horseshoe Dam, Ghost Dam, Bearspaw Dam and Carseland Weir) are impacting the riparian health rating due to changes in peak flow and timing, with over 50% of the upstream watershed dammed (Cows and Fish).
- ⑧ Moderate water withdrawals and damming upstream do not appear to be impacting seedling establishment, but there could be future concerns with cottonwood (and other tree and shrub) regeneration (Cows and Fish).
- ⑧ A small irrigation flow is transferred to Eagle Lake in the northwest of the watershed. Trans-basin irrigation flows are transferred via McGregor Lake, south of the watershed, into the Oldman sub-basin, and to the north, to Crawling Valley Reservoir and into the Red Deer sub-basin.
- ⑧ This reach has a major extraction canal at its downstream limits (EID) and thus has much more water than the further downstream reach due to the license priority of the EID at Bassano Dam.



Bow River Reach #1

Bassano Dam to Grand Forks (South Saskatchewan River Confluence)



Reach Description: This reach drains a watershed of about 5200 km², or 21% of the Bow River basin, and includes the Lake Newell reservoir. The river flows along a fairly deep valley through mostly undulating prairie. Riparian vegetation consists of scattered clumps of trees and there are eroding cliff faces and exposed rocky outcrops. The river ends where it joins the Oldman River and forms the South Saskatchewan River. The Reach 1 watershed is located within the Mixedgrass and Dry Mixedgrass Subregions.

Human Uses: Land use adjacent to the Bow River in this reach is dominated by grazing, with a small amount in cropping (13%) and a smaller amount developed (<1%). The Eastern Irrigation

District and the Bow River Irrigation District cover a large portion of the watershed of this reach. The largest amount of water consumed from this reach is from the Bassano Reservoir at the start of the reach. Land use in the riparian zone along this reach is less intensive than other reaches. Angling for cool-water fish species (northern pike and walleye) occurs in the reach, and the river is important for wildlife and livestock watering.



Overall, water quality in this reach has been rated good in recent years, with fair ratings for nutrients and marginal ratings for pesticides some years.

- Ⓢ Flow in this reach is the lowest of any reach of the river, and this reach is considered the most highly degraded stretch of the Bow River sub-basin, with a declining trend.
- Ⓢ Flow and water quality are considered degraded, although water quality has improved in recent years.
- Ⓢ Reduced flows and impoundments have resulted in reduced sediment transport and increased temperatures.
- Ⓢ Irrigation return flows and tributaries contribute fertilizers, pesticides, and nutrients to the Bow River, and likely explain the marginal rating for pesticides in this reach.
- Ⓢ Silt and nutrients are likely trapped in the reservoir upstream from Bassano Dam



Overall, the riparian health is rated as unhealthy. This rating is based on three sample sites.

- Ⓢ Preferred tree and shrub communities are present, however the presence of tree



communities is very insignificant within; shrubs cover 46% of the area, while trees only cover 1%. Eight different plant communities were identified.

- ⑧ Regeneration of preferred shrubs is excellent, but cottonwood regeneration ranges from absent to excellent, with an overall rating of fair. Other tree species (e.g. Manitoba maple) are not found in the reach, but potential exists for them to use the area. Utilisation is moderate to heavy.
- ⑧ Invasive species do not provide extensive cover, but are widely distributed. Disturbance caused species cover over half of the area.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches below the Town of Banff during the calendar year, and as “At most risk of impact” during the open water season. The DHRAM rating during the open water season is higher compared to Reach 2 because of water withdrawals by the Eastern Irrigation District.



- ⑧ Water withdrawals are removing more than 25% of the average river discharge.
- ⑧ Withdrawals are impacting riparian health and 6 upstream dams are impacting the riparian health rating due to changes in peak flow and timing, with over 50% of the upstream watershed dammed (Kananaskis Falls Dam, Horseshoe Dam, Ghost Dam, Bearspaw Dam, Carseland Weir and Bassano Dam) (Cows and Fish).
- ⑧ Moderate water withdrawals and damming upstream do not appear to be impacting seedling establishment, but there could be future concerns with cottonwood (and other tree and shrub) regeneration (Cows and Fish).
- ⑧ Flow in this reach is the lowest of any reach of the river and it is considered the most highly degraded reach of the Bow River sub-basin, with a declining trend (SORAC).
- ⑧ Lowest average and monthly flows occur during the summer diversion period, and reduced flood events (SORAC).
- ⑧ Reduced flows and impoundments have resulted in reduced sediment transport and increased temperatures. (SORAC).

South Saskatchewan River Sub-Basin Overview

The South Saskatchewan River is divided into two reaches for ARCA (see map). The following sections first give an overview, then a reach-by-reach assessment of water quality, riparian health and hydrology for the South Saskatchewan River main stem.

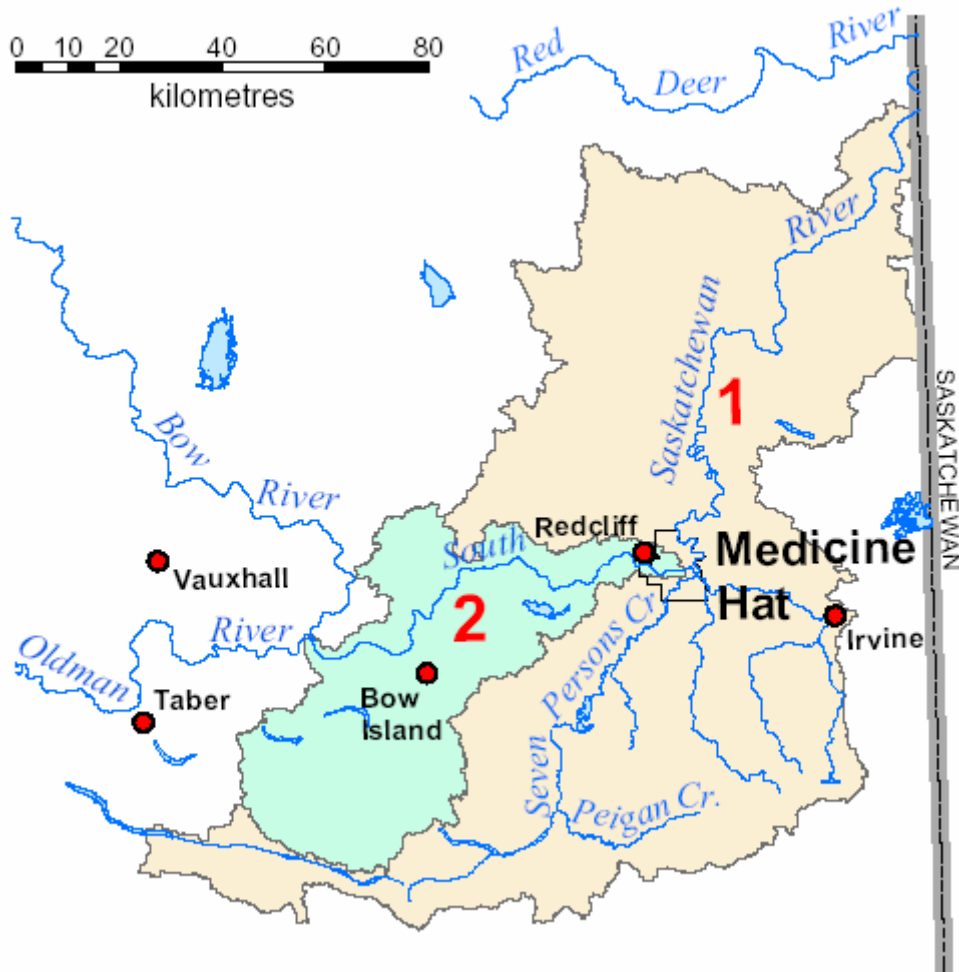


Figure 5. Map of South Saskatchewan River Sub-basin

Water quality ratings

Water quality in the South Saskatchewan River upstream from Medicine Hat has been rated good overall using the Water Quality Index (WQI) for 1998-2003 (GOA 2004) (D. McDonald, personal communication), with fair ratings most years for nutrients, excellent bacteria levels all years except 2003 (then good), and marginal ratings for pesticides some years.

These ratings are based on (a) the number of water quality variables (various nutrients, bacteria, metals) that exceed specific guidelines (AENV 1999), and (b) the frequency and (c) magnitude of the guideline exceedances. The resulting scores (index results) are given the following values: 100-96 excellent; 95-81 good; 80 – 66 fair; 65-46 marginal; 45 – 0 poor. In the case of pesticides alone, any detection of pesticides has been treated as a guideline exceedance. This conservative approach likely accounts for the marginal ratings for pesticides in the South Saskatchewan River above Medicine Hat some years, and does not indicate that pesticides exceeded accepted guidelines in this reach.

Overall expected trend in the River

Future water quality in these reaches of the South Saskatchewan River will likely depend on water quality, dilution rates, and management activities in the Bow and Oldman basins, which are each described in separate sections of this report.

South Saskatchewan ARCA Summary

Tables SS1 and SS2 contain a summary of ARCA indicators for the South Saskatchewan River. The degree of hydrological alteration is relatively moderate due to a combination of Dam Operations and Irrigation Diversions on the Oldman and Bow Rivers (Tables SS1 and SS2). The individual reach reports and the charts at the end of this report provide more detailed information about water quality, riparian health and hydrological change along the South Saskatchewan River.

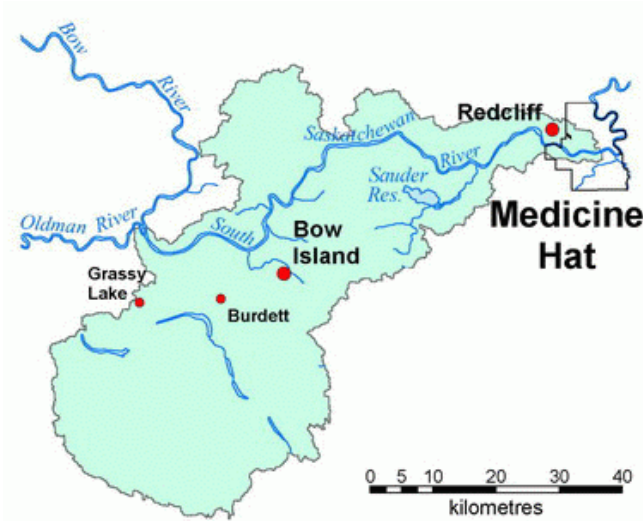
Table SS1. South Saskatchewan ARCA Summary

Reach #	Degree of Hydrological Change (DHRAM)			
	Water Quality	Riparian Health	Calendar Year	Open Water Season
2 (SSask)	Good	Unhealthy	Moderate	Moderate
1 (Ssask)	--	Healthy with problems	--	--

Table SS2. South Saskatchewan RVA Analysis

Reach #	Degree of Hydrological Alteration	
	Calendar Year	Open Water Season
1 Ssask	Near natural	Near natural

**South Saskatchewan River Reach #2
Grand Forks to Upstream of Medicine Hat Gauging Station**



Reach Description: This reach drains a watershed of about 2600 km², or 22% of the South Saskatchewan River basin. Key tree species in the riparian zone in this reach is the plains cottonwood. Key fish species in the river include sauger, walleye, northern pike, and lake sturgeon. The reach is located within the Dry Mixedgrass Subregion.

Human Uses: Land use adjacent to the river in this reach is dominated by livestock grazing, however also includes a limited amount of crops.



Overall, the water quality in this reach has been rated as good, but with fair to marginal ratings for nutrients and pesticides.

- Ⓢ Water quality in this reach is influenced by activities in the Bow and Oldman basins, in particular municipal wastewater discharged by major urban centers and land use in each basin
- Ⓢ This site is well downstream of the zone of enrichment from those urban centers and there have been few complaints to AENV about water quality in this reach in recent years.
- Ⓢ Nuisance periphytic algal growth has been occasionally reported in downtown Medicine Hat during low flows in early spring, due to thermal impacts of discharge from a thermal generating station, upstream of the gauging station.



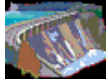
Overall, the riparian health of the South Saskatchewan River in this reach is rated as unhealthy. This rating is based on two sample sites.

- Ⓢ This reach has considerably less tree and shrub cover than many of the other reaches examined in the South Saskatchewan River Basin, with 28% covered by shrubs, and 16% by trees. Regeneration of cottonwoods, preferred trees and shrubs is poor to absent, and is a concern.
- Ⓢ There is no regeneration of preferred trees (other than cottonwoods), although the site has potential to support such trees (e.g.,



Manitoba maple). Utilisation on preferred trees and shrubs is light to heavy, and may be influencing regeneration. There are slightly elevated levels of dead and decadent standing woody plants at one site, which may link to both on site management and water availability.

- ⑧ Invasive and disturbance species are of concern, with extensive distribution of invasive species and 66% cover by disturbance species. Native graminoid cover is poor, with less than 5% cover in each polygon examined.

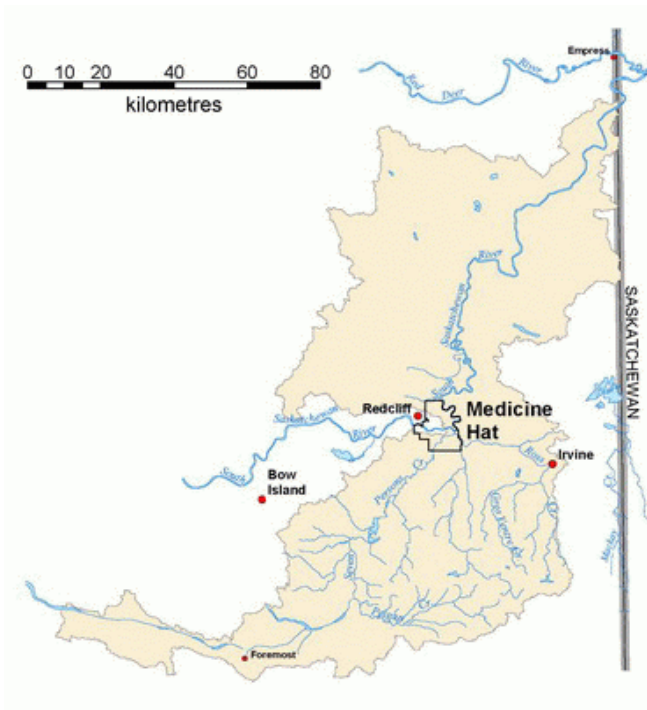


RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Near natural” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Bow River (below the Town of Banff), the Oldman River (below the Oldman River Dam) and the southern tributaries during the calendar year, and as “At most risk of impact” during the open water season.

- ⑧ Human-caused structural alterations impacting riparian health are very variable between the two polygons examined, with more than 50% impacted at one site, but less than 10% altered at the other. Livestock activities are the main causes of the alterations in this reach. There are some concerns with riverbank root mass protection in this reach, with moderate to poorly protected banks.
- ⑧ Within this reach, dewatering is having negative impacts on overall riparian health ratings, with 25-50% of the average river discharge removed from this reach (Cows and Fish).
- ⑧ Dams on major tributaries upstream result in more than 50% of the watershed controlled by dams, introducing modifications to flood timing and intensity.



**South Saskatchewan River Reach #1
Medicine Hat Gauging Station to Alberta-Saskatchewan Border**



Reach Description: This reach drains a watershed of about 9500 km², or 78% of the South Saskatchewan River basin. Key species in the riparian zone is the plains cottonwood. Key fish species in the river include sauger, walleye, northern pike, and some lake sturgeon. The reach is located within the Dry Mixedgrass Subregion.

Human Uses: Land use adjacent to the South Saskatchewan River in this reach dominated by grazing. A quarter of the length was identified as undeveloped and less than 10% as developed lands.



To date, water quality indices have not been calculated for the Prairie Provinces Water Board (PPWB) site on the South Saskatchewan River at HW 41, downstream of Medicine Hat, the only water quality-sampling site in this reach. In 2003, water quality met all the objectives of the PPWB at this site, and there were seldom any of these objectives not met in previous years. However, fewer variables are sampled at PPWB sites than in the AENV long-term river network.

- Ⓢ Municipal effluent from Medicine Hat has had a relatively small impact on the South Saskatchewan River, as the flow discharged is relatively small and there is a high rate of dilution.



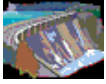
Overall, the riparian health of the South Saskatchewan River in this reach is rated as varying from healthy but with problems, to unhealthy. This rating is based on six sample sites.

- Ⓢ This reach has nearly twice the tree and shrub cover compared to Reach 2, with 57% covered by shrubs, and 29% by trees. Regeneration of cottonwoods and preferred shrubs is good in most polygons, but poor or moderate in a



few. There is almost no regeneration of preferred trees (other than cottonwoods), although the area has potential to support such trees (e.g., Manitoba maple). Utilisation on preferred trees and shrubs is quite variable, from light to heavy, and may be influencing regeneration.

- ⑧ Invasive and disturbance species are of concern, with extensive infestations of invasive species and 62% cover by disturbance species. Native graminoid cover is good, with 25-50% cover in each polygon examined.



No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ Human-caused structural alterations are present in half of the polygons examined, with 10 – 25% of the banks altered, with livestock activities being the main cause of the alterations. Riverbank root mass protection in this reach is highly variable; with excellent to poorly protected banks (Cows and Fish).



Oldman River Sub-Basin Overview

The Oldman River is divided into ten reaches for ARCA (see map), including the upper portions of the Crowsnest River and the Castle River. The Waterton, Belly and St Mary Rivers (Southern Tributaries), which are described in a separate section of this report, also occupy part of this basin. The following sections first give an overview, then a reach-by-reach assessment of water quality, riparian health and hydrology for the Oldman River main stem.

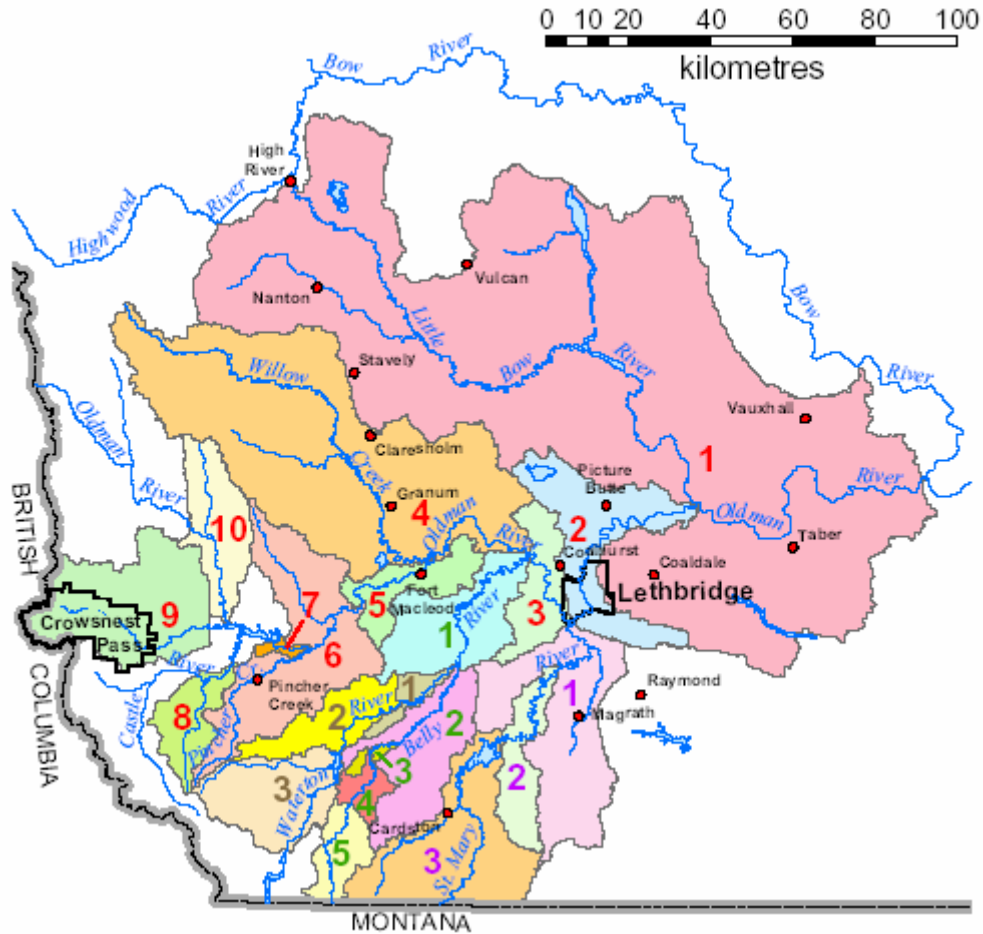


Figure 6. Map of Oldman River Sub-basin

Water quality ratings

Throughout most of the Oldman reaches, the water quality is given a general rating of good to excellent (with a few fair ratings). Primary stressors in the Oldman River that drive the index down include nutrient loading from point and non-point sources, as well as bacteria and occasional pesticides. The Oldman basin is the setting of the most intensive agriculture activities in the province.

Overall expected trend in the River

Due to continued water abstractions and reduced instream flows, we expect a downward trend in water quality as existing water abstraction licences are used to their fullest potential. Lower flows will result in less dilution of the various loadings of contaminants. With time, the moratorium placed on new water licences will stop the current downward trend caused by the abstractions.

Oldman River ARCA Summary

Tables OM1 and OM2 contain a summary of ARCA indicators for the Oldman River. The degree of hydrological alteration is relatively moderate in Reaches 6 and 7 due to operation of the Oldman River Dam (Table OM1). Compared to other reaches, Reach #2 also exhibits a high degree of hydrological change due to water supply storage and irrigation diversions on the southern tributaries (Table OM1). The individual reach reports and the charts at the end of this report provide more detailed information about water quality, riparian health and hydrological change along the Oldman River.

Table OM1. Oldman River ARCA Summary

Reach #	Water Quality	Riparian Health	Degree of Hydrological Change (DHRAM)	
			Calendar Year	Open Water Season
10	Excellent	Healthy	--	--
9	Excellent	Healthy with problems	--	--
8	Excellent	Healthy	--	--
7	Excellent	Healthy with problems	Moderate	Moderate
6	Good	Healthy with problems	Moderate	Moderate
5	Good	Healthy with problems	Moderate	Moderate
4	Good	Healthy with problems	Moderate	Moderate
3	Good	Healthy with problems	Moderate	Moderate
2	Good	Healthy with problems	At most risk of impact	At most risk of impact
1	Good	Unhealthy	Moderate	Moderate

Table OM2. Oldman River RVA Analysis

Reach #	Degree of Hydrological Alteration	
	Calendar Year	Open Water Season
7	Moderate	Moderate
6	Moderate	Moderate
5	Moderate	Moderate
4	Moderate	Moderate
3	Moderate	Moderate
2	Moderate	Moderate
1	Near natural	Moderate

Oldman River Reach #10

Waldron's Corner Gauging Station on Oldman River to Upstream of Oldman River Reservoir



Reach Description: This reach drains a watershed of about 450 km², or about 2% of the Oldman River basin, and is located within the Foothills Fescue Subregion. Balsam poplar and cottonwoods are common along this reach. The key fish species in the river is bull trout.

Human Uses: This reach flows primarily through agricultural land. Land uses within the riparian zone of this reach are minimal, but include livestock grazing. The watershed also contains some oil and gas and recreational use.



Overall, the water quality in this reach is rated good to excellent.

- Ⓢ Occasional high TSS from high runoff events.
- Ⓢ Some impacts from cattle grazing in riparian areas, oil and gas, recreation.
- Ⓢ Forestry and road development are influences in the form of linear corridors (Golder Assoc. 2003).
- Ⓢ There is a long history of coal mining in this area.
- Ⓢ Little water removed in these reaches apart from some local allocations.



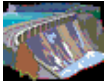


Overall, the riparian health of the Oldman River in this reach is rated as varying from healthy (1/3 of sample area), to healthy but with problems (2/3 of sample area). This rating is based on three sample sites.

- ⑧ Channel movement and depositional processes have restricted vegetative cover of portions of the riparian areas along this reach. The vegetation is growing on large areas of gravel and cobble. Mature balsam poplar communities along with recently established communities of seedlings along the gravel-based alluvial bars are common. Tree species other than cottonwoods are present but scarce, however regeneration of cottonwoods and preferred shrub species generally is excellent. Native grasses and forbs are also present; however their overall coverage is limited.



- ⑧ The existing tree and shrub communities show normal amounts of dead and decadent branches as well as mostly high levels of regeneration, indicating current land uses (primarily grazing) are not generally impacting woody plant health. The only site with moderate browse was also the only site with low shrub regeneration.
- ⑧ Disturbance-caused species have moderate to widespread coverage in this reach.

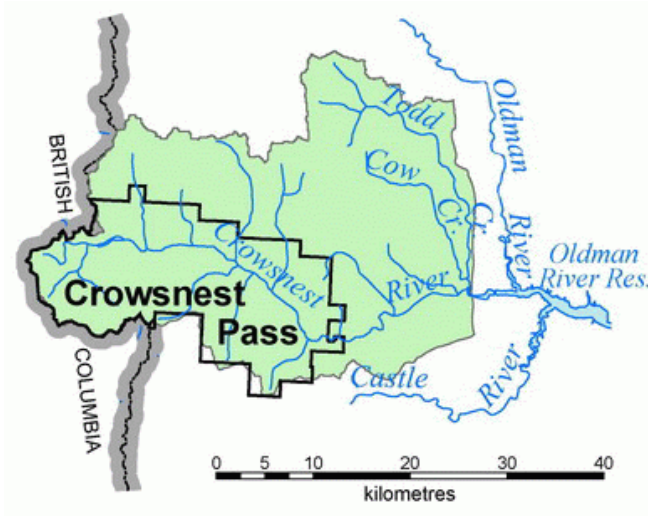


The hydrology of this reach is in a more or less natural state.

- ⑧ There are currently no concerns with altered flow or timing and the river readily accesses its floodplain (Cows and Fish)

Oldman River Reach #9

Crowsnest River at B.C./ Alberta Border to Upstream of Oldman River Reservoir



Reach Description: This reach drains a watershed of about 1200 km², or about 3% of the Oldman River basin, and is located within the Foothills Fescue and Montane Subregions. Much of the watershed itself is forested. Key riparian woody species include beaked willow and water birch. Fish species include brown, bull and rainbow trout, and mountain whitefish.

Human Uses: Livestock grazing is the dominant land use in the riparian zone of this reach, especially in the lower part, and developed lands adjacent to the riparian zone are common. Developed areas include several small towns, roads and bicycle paths. Highway 3 parallels the river for

several miles. Although the Municipality of Crowsnest Pass obtains its drinking water from groundwater sources, it also withdraws a substantial amount of water from the river for commercial and industrial use. The Crowsnest River also is one of the most productive and best-known recreational fishing streams in southwestern Alberta. This reach is adjacent to several abandoned coal mines.



Overall, the water quality in this reach is rated good to excellent.

- Ⓢ Some impact from logging, urban development, treated domestic wastewater
- Ⓢ Some impacts from recreation, past coal mining, cattle grazing, linear corridors, and access roads.



Overall, the riparian health of the Crowsnest River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ Shrub community and habitat types are abundant, covering 98% of the assessed area. Tree communities cover only 2% of the area, with no areas classified as grass community or habitat (although grass is a significant understory, covering 96% of the total area). The diversity within these vegetative communities provides excellent wildlife habitat, while maintaining riparian function. The presence of beaked willow (*Salix bebbiana*) and water birch (*Betula occidentalis*) is significant in

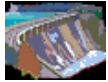


this reach. There is good to excellent regeneration of preferred trees and shrubs with minor to normal amounts of dead and decadent material.

- ⑧ Ground cover and the distribution of invasive species are of concern. Invasive species have a scattered distribution and also occur in patches. Disturbance-caused species cover approximately a third of the area examined. These species are of concern because they have shallow, inadequate root systems to stabilize riverbanks; these species often displace native vegetation.



- ⑧ Human-caused bare ground is not impacting riparian health. However, human activities have caused extensive alterations to the banks of the river in this reach. In the upper polygon, the Crowsnest River has been re-routed and channelised, while in the lower polygon, construction of weirs to improve fish habitat has altered the natural structure of the riverbank.
- ⑧ Bank stability is poor to very poor, which can be associated with the abundance of disturbance-caused species. Areas of the banks that have been modified have lost vegetation, reducing the coverage by deeply rooted species, in turn increasing instability along these sections.

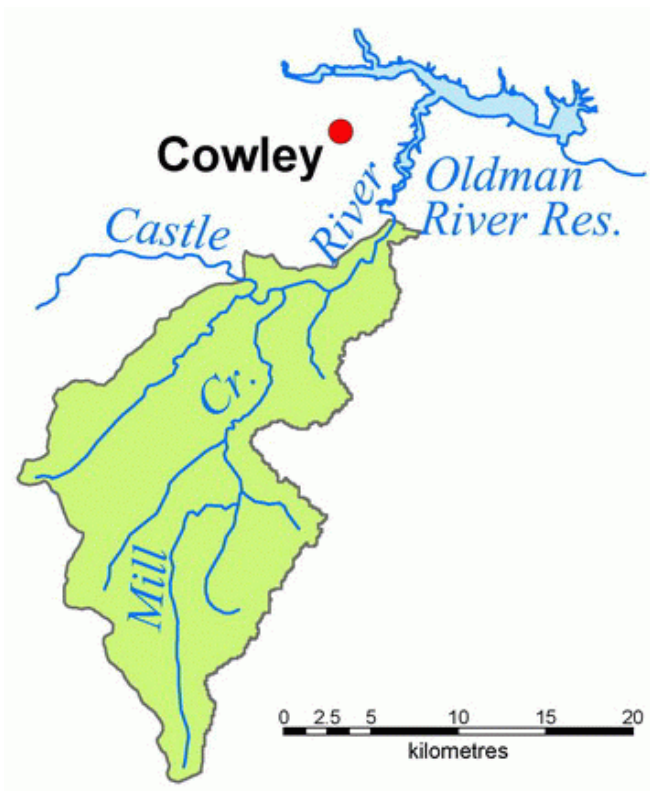


The hydrology of this reach is in a more or less natural state.

- ⑧ There are no dams altering the flow of the river upstream of this reach and water extractions are minimal (<10%).
- ⑧ Floodwater has full access to the floodplain in one of the sites with minor restrictions to floodplain access in the upstream site due to re-routing of this portion of the river (Cows and Fish).

Oldman River Reach #8

Castle River gauging station to Upstream of Oldman River Reservoir



Reach Description: This reach consists of the lower main stem of the Castle River and drains a watershed of about 450 km², or about 2% of the Oldman River basin. The reach is located within the Foothills Fescue and Montane Subregions. Much of the watershed itself is forested. Key woody species in the riparian zone are beaked willow and water birch, and the dominant tree is balsam poplar. White spruce also is common. Key fish species include brown and rainbow trout, mountain whitefish and bull trout.

Human Uses: Part of this reach is located within the Rocky Mountains Forest Reserve. Livestock grazing occurs within the riparian zone of this reach and rural residential development can be found adjacent to the reach in the lower part.



Overall, the water quality in this reach is rated good to excellent.

Impacts include:

- Ⓢ There is some impact from logging, recreation, linear corridors, access roads, and oil and gas facilities.
- Ⓢ Cattle grazing occurs in open areas.



Overall, the riparian health of the Oldman River in this reach is rated as varying from healthy to healthy but with problems. This rating is based on two sample sites.

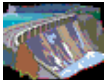
- Ⓢ Five different tree communities were identified, with balsam poplar the dominant tree species found in this reach. White spruce is common in the upper part of this reach within the forest reserve. Other tree species include aspen, lodgepole pine and Douglas-fir.



Tree and shrub cover of these sites is extensive with 56% of the area assessed covered by trees and shrubs. There is excellent regeneration of trees and shrubs and other trees have excellent regeneration in one site and poor in the site downstream of the forest reserve. Utilisation is light to moderate and levels of dead and decadence within the woody communities are normal.



- ⑧ Invasive species are relatively low in number, but are widely distributed. Disturbance-caused species cover 14% of the area examined, resulting in decreased bank stability, however native species are abundant.
- ⑧ Riverbank root mass protection is moderate to poor within this reach. The presence of disturbance-caused species along the riverbank may be reducing bank stability along sections of this reach.

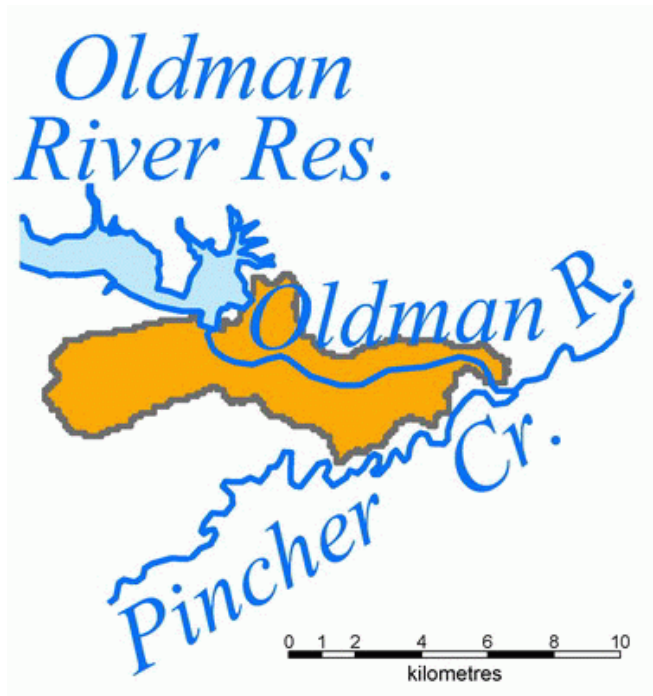


The hydrology of this reach is in a more or less natural state.

- ⑧ Currently within this reach there are no significant water extractions or dams present, therefore the natural flow of the river has not been disturbed. Floodwaters have full access to the floodplain (Cows and Fish).
- ⑧ Within the sites assessed there are no restrictions to movement of floodwaters.

Oldman River Reach #7

Oldman River Dam to Upstream of Pincher Creek Confluence



Reach Description: This reach drains a watershed of about 35 km², or about 1% of the Oldman River basin, and is located within a transition zone between the Foothills Fescue and Mixedgrass Subregions. Key tree species in the riparian zone of this reach are balsam poplar and cottonwood. Key fish species in the river include brown and rainbow trout.

Human Uses: Livestock grazing is the dominant land use within the riparian zone of this reach. Most of the reach is devoid of land use; however the adjacent Oldman River dam has caused significant physical changes to this reach.



Overall, the water quality in this reach is rated good to excellent.

The water quality index results for this reach (as recorded from sampling above the Summerview Bridge near Brocket), 2000-2004, are between 86 – 100, the majority of the results being 100 (AENV files). Waterborne bacteria levels can reduce the overall index results. Nutrient and pesticide levels are very low. Impacts include:

- Ⓢ Impact of dam on stream temperature (delayed spring-summer warming and fall cooling) and sediment sink (Golder Assoc. 2003)
- Ⓢ Loss of spring high flows combined with higher stabilized winter flows has reduced the natural mortality of attached (epilithic) algae and resulting atypical accumulation (Golder Assoc. 2003)
- Ⓢ Cattle grazing.



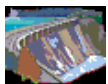
Overall, the riparian health of the Oldman River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ Balsam poplar and cottonwood communities are common within this reach. Trees and shrubs combined cover 77% of the area assessed, with 100% of the area classified as poplar community types. Grass and grass-like plants make



up a considerable understory component (covering 60% of the area). Regeneration of cottonwood and preferred shrubs is excellent. Overall utilisation of preferred trees and shrubs is light and there are normal to minor additional levels of dead and decadence occurring within the woody communities.

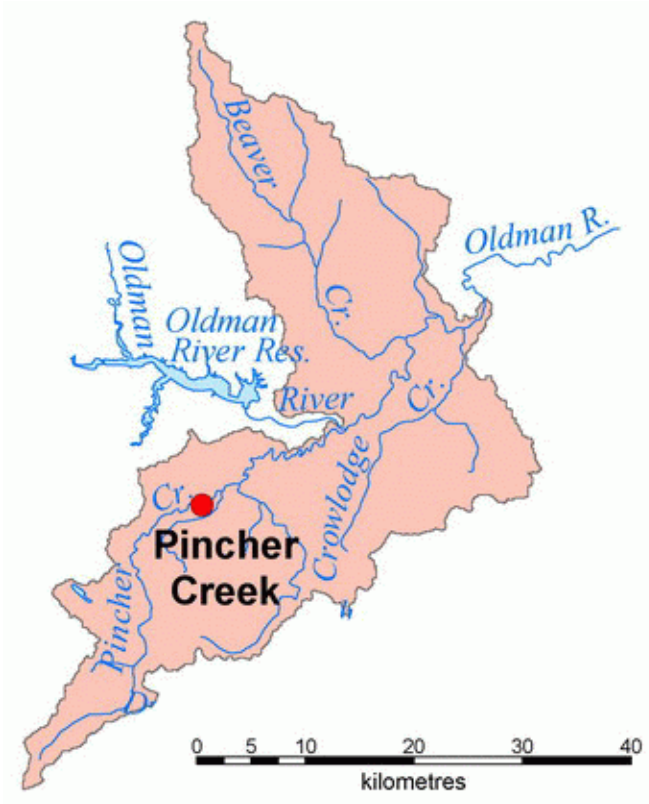
- ⑧ Invasive species do not occupy a large part of the plant cover; however their wide distribution is a concern.
- ⑧ Disturbance-caused species are poor for bank stability and tend to out-compete native plant communities. In addition, native graminoids are reduced, and only cover 5%-25% of the assessed area.
- ⑧ Disturbance-caused plants have noticeably reduced the amount of deep binding roots along the riverbank. Currently, deep binding roots are stabilising 65%-85% of the polygon length in both of the areas assessed.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.

- ⑧ Water extractions are very minimal from this reach with less than 10% of the average river discharge removed.
- ⑧ This reach extends from the Oldman Dam downstream to the Pincher Creek confluence and therefore is significantly impacted by the Oldman Dam. More than 50% of the watershed upstream of this reach is dammed, altering the natural flow of the river.
- ⑧ Currently water extractions are having no significant impacts on the overall riparian health rating of this reach (Cows and Fish).

**Oldman River Reach #6
Pincher Creek Confluence to Upstream of LNID Weir**



Reach Description: This reach drains a watershed of about 1100 km², or about 8% of the Oldman River basin, and is located within a transition zone between the Foothills Fescue and Mixedgrass Subregions. Cottonwood is the key tree species in the riparian zone of this reach. Key fish species in the river include brown and rainbow trout.

Human Uses: This reach is located within the Piikani First Nations Indian Reserve. There are almost no signs of land use within this reach, but livestock grazing occurs.



Overall, the water quality in this reach is rated good to excellent.

- Ⓢ Cattle grazing along main stem and along Pincher Creek
- Ⓢ Urban impacts from Town of Pincher Creek (storm water runoff, treated domestic effluent)
- Ⓢ Urban, rural impacts from Piikani First Nation.
- Ⓢ Impact of dam as per Reach #5. Loss of spring high flows for flushing sediments, removing macrophytes, and epilithic algae (Golder Assoc. 2003).



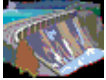
Overall, the riparian health of the Oldman River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- Ⓢ Balsam poplar communities are common within this reach. Grass and grass-like



plants make up a considerable understory component.

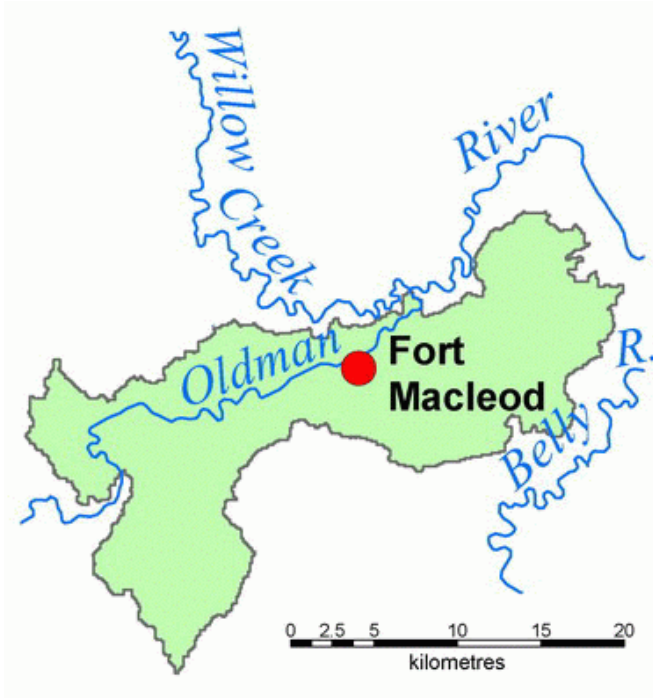
- ⑧ Regeneration of cottonwood and preferred shrubs is excellent, and overall utilisation of preferred trees and shrubs is light. There are normal levels of dead and decadence occurring within the woody communities.
- ⑧ Invasive species have limited, yet noticeable coverage of the areas assessed.
- ⑧ Disturbance-caused species cover 50% of disturbed areas.
- ⑧ Riverbank root mass protection from deep-binding roots is substantial, primarily due to the abundance of trees.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological in change this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.

- ⑧ This reach extends from the Oldman River-Pincher Creek confluence to above the LIND confluence, and consequently is significantly impacted by the Oldman Dam. More than 50% of the watershed upstream of this reach is dammed, altering the natural flow of the river.
- ⑧ Water extractions are minimal with less than 10% of the average river discharge removed.
- ⑧ Currently water extractions are having no significant impacts on the overall riparian health rating of this reach (Cows and Fish).
- ⑧ Extensive flooding and deposition in the spring and summer of 2005 resulted in about 10% of one site being devoid of vegetation.

Oldman River Reach #5
LNID Weir to Upstream of Willow Creek Confluence



Reach Description: This reach drains a watershed of about 344 km², or 2% of the Oldman River basin, and is located within the Mixedgrass Subregion. Key species in the riparian zone is cottonwood. Key fish species in the river include brown and rainbow trout.

Human Uses: Land use in this reach is dominated by livestock grazing, but there are also smaller areas that are influenced by cropping, and development (e.g., Town of Fort Macleod). Water for the Lethbridge Northern Irrigation District is taken at the LNID Weir, and consequently this reach is significantly dewatered compared to upstream reaches.



Overall, the water quality in this reach is rated good to excellent.

Impacts include:

- Ⓢ LNID is the first major abstraction of water from the river.
- Ⓢ Loss of flushing flows.
- Ⓢ There may be some improvement in water quality compared to historical conditions, due to a year-round increase in minimum flows as a result of operation of the Oldman Reservoir (Golder Assoc. 2003).
- Ⓢ Cattle grazing occurs in open areas.



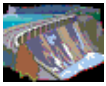
Overall, the riparian health of the Oldman River in this reach is rated as varying from healthy to healthy but with problems. This rating is based on three sample sites.

- Ⓢ Eight different plant communities were identified in this reach. Trees and shrubs are diverse and abundant. Narrow-leaf cottonwood is the dominant tree in this reach, although balsam poplar is also



present. Native grasses cover about 25-50% of the areas assessed.

- ⑧ There is good to excellent regeneration of cottonwood trees and preferred shrubs. Utilisation of preferred trees and shrubs is light overall and there are normal to minor additional amounts of dead and decadent branches occurring within the woody communities.
- ⑧ Invasive plants are widespread throughout the areas inventoried. Spotted knapweed, a restricted species, was also identified in this reach. Exotics include Russian olive, Kentucky bluegrass, and leafy spurge.
- ⑧ Human-caused bare ground is limited to small areas, but occurs throughout the reach in the form of roads, paths, bridges, and to a lesser extent, livestock activity. Root mass protection is variable throughout this reach with excellent stability (>85% of the bank) in one area, 65-85% stability in another, and less than 35% of the riverbank stabilised in the remaining polygon. In this last area, riprap is impeding the growth of deeply rooted vegetation and therefore riverbank deep binding roots are very low.



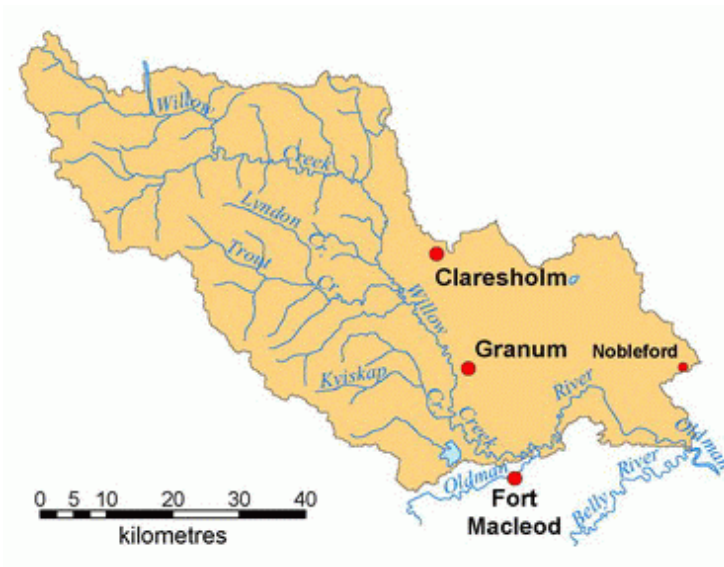
RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.



- ⑧ Diversion of water from the river increases within this reach with about 32.2% of the river flow withdrawn at the LNID weir. In spite of this diversion, regulated flow below the Oldman River Dam during the open water season is higher than natural, which probably explains why the degree of hydrological change is rated as moderate for this reach.
- ⑧ The Oldman River Dam upstream of this reach controls the flow of more than 50% of the watershed, and is rated as significantly impacting riparian health (Cows and Fish).
- ⑧ Floodwaters flowing through this portion of the Oldman River have no impediments to access the entire floodplain.

Oldman River Reach #4

Willow Creek Confluence to Upstream of the Belly River Confluence



Reach Description: This reach drains a watershed of about 3300 km², or 16% of the Oldman River basin. The reach is located within the Mixedgrass Subregion. Mud Lake, which is a large slough, and Chain Lakes Reservoir (located on Willow Creek) are located within this watershed. Cottonwood is the key tree species in the riparian zone. Key fish species in the river include brown and rainbow trout.

Human Uses: Livestock grazing is the dominant land use in this reach, but there are also small areas influenced by cropping and development. Withdrawals and the

alterations to the natural flow of the river by the Oldman Dam are modifying the overall riparian health rating of this reach.



Overall, the water quality in this reach is rated good to excellent.

Impacts include:

- Ⓢ Impacts of Fort Macleod (urban storm water runoff, treated effluent)
- Ⓢ Cattle grazing occurs along main stem and along Willow Creek
- Ⓢ Loss of spring high flows; reduction in low and medium flood peaks (Golder Assoc. 2003).
- Ⓢ There may be some improvement in water quality due to a year-round increase in minimum flows as a result of operation of the Oldman Reservoir.



Overall, the riparian health of the Oldman River in this reach is rated as varying between unhealthy but with problems, and unhealthy. This rating is based on three sample sites.

- Ⓢ Six different plant communities were observed in this reach. Trees and shrubs are abundant with shrubs covering a larger area (77%) than the area occupied by trees (57%). Narrow-leaved cottonwood is the only

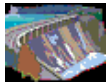


tree species observed in this reach. Native grasses have variable coverage, ranging from 5% to more than 50% cover.

- ⑧ There is excellent regeneration of cottonwoods and preferred shrubs within this reach. Browse utilisation of preferred woody species ranged from light to moderate, which may influence the levels of woody regeneration if moderate browse levels continue. Similar to reaches upstream, the level of dead and decadence is minor, suggesting utilisation, disease, and hydrology are not having significant impacts on the woody plant communities.



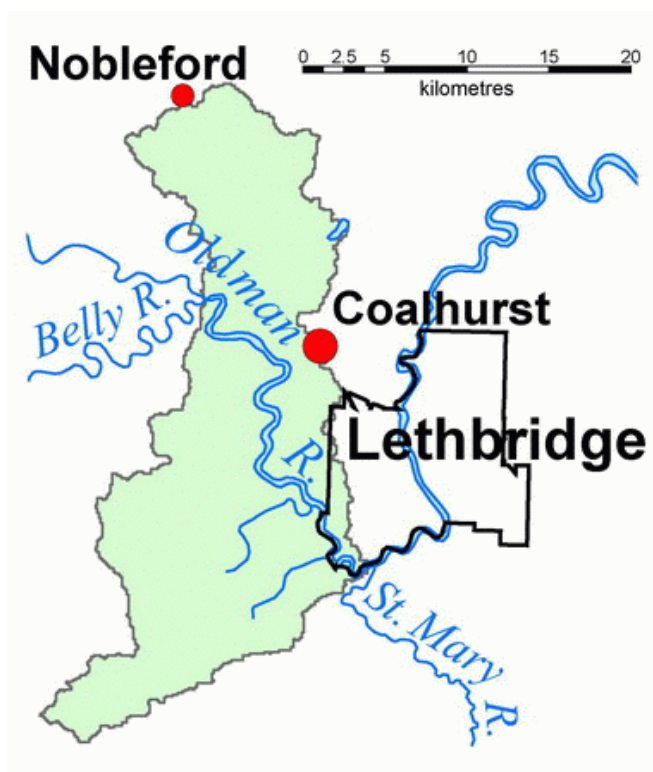
- ⑧ Invasive plant coverage is small; however their relatively widespread distribution (more than 50% of sample area) may be a concern. Exotics include Russian olive, Kentucky bluegrass, and leafy spurge.
- ⑧ Riverbank root mass protection is variable, ranging from excellent to poor stability along the banks.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.

- ⑧ About 31.6% of the average river discharge is being removed from this reach.
- ⑧ Dewatering is having significant impacts on the riparian health of this reach. The close proximity of the Oldman Dam is also influencing riparian health by altering the natural flow of the river (Cows and Fish).
- ⑧ More than 50% of the watershed upstream of this reach is controlled by the Oldman Dam.
- ⑧ The majority of the floodplain within the areas assessed is not obstructed to flood water; one site has some reduced access, with 65%-85% of the floodplain available.

Oldman River Reach #3
Belly River Confluence to Upstream of St. Mary Confluence



Reach Description: This reach drains a watershed of about 380 km², or 2% of the Oldman River basin, and is located within the Mixedgrass Subregion. The key tree species in the riparian zone of this reach is cottonwood. Key fish species in the river are brown and rainbow trout.

Human Uses: Land use in this reach is divided mainly between grazing and undeveloped areas, such as recreational land. There are also small areas influenced by cropping and development within this reach. Part of the Blood First Nations Indian Reserve (south of river) and an area known as feedlot alley (north of river) are located within the watershed of this reach.



Overall, the water quality in this reach is rated good to excellent.

- Ⓢ Impacts from intensive agriculture, irrigation, cattle grazing, CFO's
- Ⓢ Loss of flushing flows due to dam, loss of flows due to significant water abstraction in the Belly / Waterton rivers.
- Ⓢ There is some improvement in water quality due to a year-round increase in minimum flows (due to the dam operation).



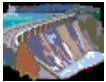
Overall, the riparian health of the Oldman River in this reach is rated as unhealthy. This rating is based on one sample site.

- Ⓢ Four different plant community types were identified. Twelve species of shrubs occupy 80% of the inventoried area, with 50% covered by two tree species
- Ⓢ Similar to reaches upstream, cottonwoods are the only tree species



observed in this reach. Browse is moderate and may be influencing the reduced level of cottonwood regeneration in this reach. There are minor levels of dead and decadent branches in the woody communities.

- ⑧ Invasive plants are covering more than 15% of the assessed area and they are widely distributed. Disturbance-caused species are also of concern, covering 25%-50% of the area assessed. The presence of disturbance-caused and invasive plants is limiting the ground occupied by native species, especially native grasses. The presence of native grasses is similar to the two nearest upstream reaches, with 25%-50% coverage by native grasses.
- ⑧ For the most part, the riverbank in this reach has not been affected by human alterations. However, vehicle trails have resulted in limited patches of bare soil. Bank stability, based on deep-binding roots, is poor.

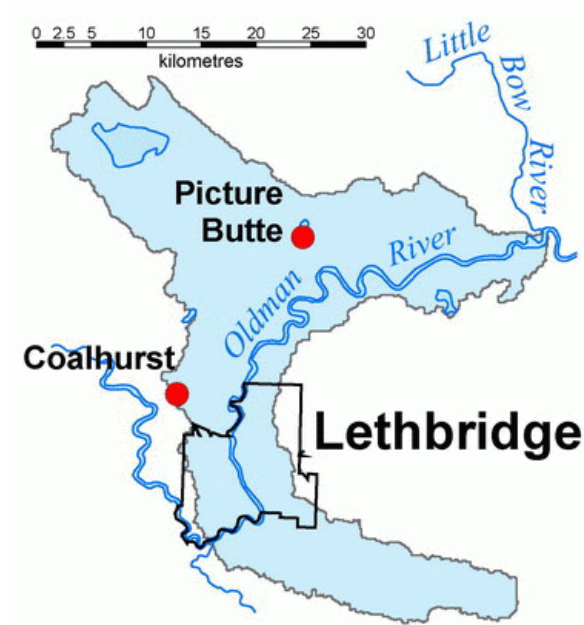


RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.

- ⑧ About 43.1% of the average river discharge is removed from this reach.
- ⑧ Dewatering is significantly impacting the riparian health rating (Cows and Fish). The Oldman Dam is also still impacting the riparian health rating, but due to increased distance, the level of impact is less for this reach, with 25%-50% of the watershed upstream controlled by dam (Cows and Fish).
- ⑧ Floodwaters are somewhat restricted from accessing the entire floodplain in the single polygon assessed for this reach.

Oldman River Reach #2

St. Mary Confluence to Upstream of Little Bow River Confluence



Reach Description: This reach drains a watershed of about 825 km², or 4% of the Oldman River basin, and is located within the Mixedgrass Subregion. Cottonwood is the key riparian tree species in this reach. Key fish species in the river include walleye, sauger and sturgeon.

Human Uses: There are a variety of land uses in this reach, but the primary activity in the riparian zone is livestock grazing. Undeveloped areas occupy a significant portion of the area within this reach and small areas of cropping and development are also found. The City of Lethbridge obtains its drinking water from this reach of the river, and also discharges its treated wastewater into it. Part of the Lethbridge Northern Irrigation District and the area known as feedlot alley are located within the watershed of this reach.



Overall, the water quality in this reach is rated fair to good, to excellent. The water quality index results 1996-2004 range between 77 and 97, the majority of the results being in the 90's (GOA 2004). Pesticide residues are detected more frequently here than in the upstream reaches.

- ⑧ Impacts include:
 - ⑥ Impact of City of Lethbridge treated wastewater effluent, and stormwater runoff,
 - ⑥ Loss of flushing flows,
 - ⑥ Intensive agriculture, irrigation, cattle grazing, CFO's,
 - ⑥ Irrigation return flows are often of poor quality,
 - ⑥ Significant water abstraction from the St. Mary River has resulted in a loss of discharge to the Oldman River,
 - ⑥ Loss of spring high flows for flushing sediments and removing macrophytes.
- ⑧ The upstream dam increases summer minimum flows and this dilution effect results in better summer time water quality.
- ⑧ The City of Lethbridge is the greatest single source of impact on Oldman River water quality.
- ⑧ The uptake of water by the City of Lethbridge and its return as treated waste effluent supplemented by storm water have made water quality an issue in the lower two reaches.
- ⑧ Recent upgrades to the municipal wastewater treatment plant have led to an improvement in water quality (Golder Assoc. 2003).

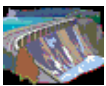




Overall, the riparian health of the Oldman River in this reach is rated as varying from healthy but with problems, to unhealthy. This rating is based on six sample sites.



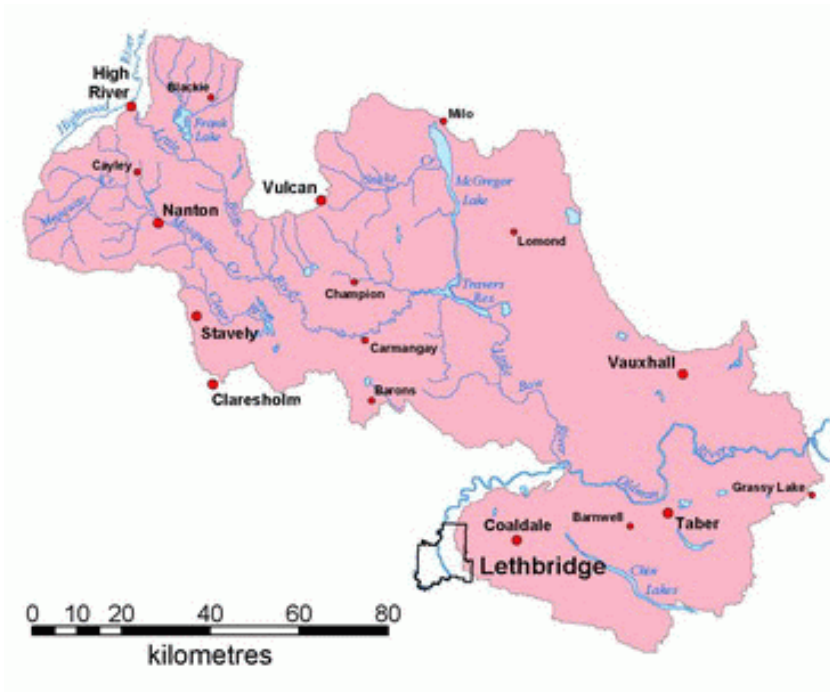
- ⑧ Nine different plant community types were identified in this reach. Shrub diversity is high, and occupies 52% of the inventoried area. Tree species have slightly more coverage than shrubs. The presence of native grasses is variable in this reach, with half of the six sites having moderate coverage, but the remaining three sites with very poor to poor coverage of native grasses. Trees other than cottonwoods occur in this reach (mainly Manitoba maple).
- ⑧ Cottonwood regeneration is variable but mainly excellent, with two sites ranging from poor to good. Regeneration of Manitoba maple is poor to excellent. Overall, there was excellent regeneration of preferred shrubs, with two areas that had poor to good regeneration. Browse utilisation was generally light, with one area not subjected to any browse pressure and another that was experiencing moderate levels of utilisation. Regeneration may be influenced by a combination of browse pressure as well as hydrologic limitations.
- ⑧ For the majority of sites assessed, there were normal levels of dead and decadent branches within the woody communities. One site had minor levels of above normal dead and decadent trees and shrubs.
- ⑧ There are a wide variety of invasive species observed within this reach including one restricted species, spotted knapweed. The distribution of invasive species is of concern. Disturbance-caused species are abundant and occupy more than 50% of the inventoried area—a concern for bank stability and erosion protection.
- ⑧ Grazing and recreation are the primary causes of the structural bank alterations and human-caused bare ground within this reach.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “At most risk of impact” during the open water season. The higher DHRAM ratings for this reach reflect the flows received from the southern tributaries, which are heavily impacted.

- ⑧ Annual withdrawals are about 47.6% of the average river discharge from this reach.
- ⑧ Damming is affecting riparian health with 25%-50% of the watershed upstream of the reach controlled by the Oldman Dam (Cows and Fish).
- ⑧ Floodwaters have minor restrictions from accessing the entire floodplain in four of the six areas assessed in this reach.

**Oldman River Reach #1
Little Bow River Confluence to the Bow River Confluence (Grand Forks)**



Reach Description: This reach drains a watershed of about 10,200 km² or 38% of the Oldman River basin and is located within the Dry Mixedgrass Subregion. Several lakes and reservoirs are located within this watershed, including Frank Lake, McGregor Lake, Travers Reservoir and Chin Lakes. Much of the watershed is drained by the Little Bow River, which empties into the Oldman River east of Picture Butte. Cottonwood is the key tree species in the riparian zone of this reach. Key fish species in the river include walleye, sauger and sturgeon.

Human Uses: Land use in the riparian zone within this reach is dominated by livestock grazing and secondly by cropping, which is more prevalent in this furthest downstream reach. Development and undeveloped lands (mainly recreational areas) are also occupying a small portion of this reach. Several irrigation districts are located within the watershed of this reach, including the St. Mary, Taber, and parts of the Lethbridge Northern and Bow River Irrigation Districts. The only significant water diversion in this reach is at Taber, which contains a major food processing industry.



Overall, the water quality in this reach is rated fair to good.

- Ⓢ The water quality index results 1996-2004 range between 75 and 95, the majority of the results being in the 80's score range, which signifies, on average, "good" water quality (GOA 2004). Pesticide residues are detected most frequently here than in the upstream reaches.
- Ⓢ Intensive agriculture, irrigation, cattle grazing, CFO's.

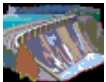


- ⑧ Irrigation return flows and some tributaries are often of poor water quality.
- ⑧ Loss of flushing flows.



Overall, the riparian health of the Oldman River in this reach is rated as unhealthy. This rating is based on two sample sites.

- ⑧ Three different plant community types were identified during sampling. The only tree species observed was plains cottonwoods. Woody species coverage is small compared to upstream reaches, with only 20% shrub cover and 13% tree cover. Native grasses cover 5-25% of the assessed area.
- ⑧ Trees and preferred shrubs have excellent regeneration. Browse is rated at light to heavy; heavy browse maybe impacting the coverage of woody communities in affected area, although regeneration at that site is still excellent. There are normal levels of dead and decadent branches found within the woody communities in this reach.
- ⑧ Invasive plants cover 1-15% of the reach. Despite the overall low coverage of these species, their distribution is of concern. Disturbance-caused species provide somewhat less coverage than some upstream reaches with 25-50% of the reach occupied by these species.
- ⑧ Bank stability, based on deep-binding roots, is very poor, directly relating to the lack of tree and shrub cover within this reach.



RVA analysis rates the degree of hydrological change in this reach as “Near natural” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other reaches along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season.

- ⑧ Annual average withdrawals from this reach are about 47.2%.
- ⑧ Dewatering is significantly impacting overall riparian health (Cows and Fish).
- ⑧ The Oldman Dam continues to impact riparian health rating in this reach, controlling 25-50% of the watershed upstream of the areas assessed. The overall coverage of woody species may be linked to one or both of browse or hydrologic parameters in this reach (Cows and Fish).
- ⑧ Floodwaters are not prevented from accessing the floodplain from manmade barriers.



The Southern Tributaries of the Oldman River Sub-basin: Overview

The Waterton, Belly and St Mary Rivers are divided into three, five and three reaches respectively for ARCA (see map). The following sections first give an overview, then a reach-by-reach assessment of riparian health, water quality and hydrology for the Southern Tributaries River main stems.

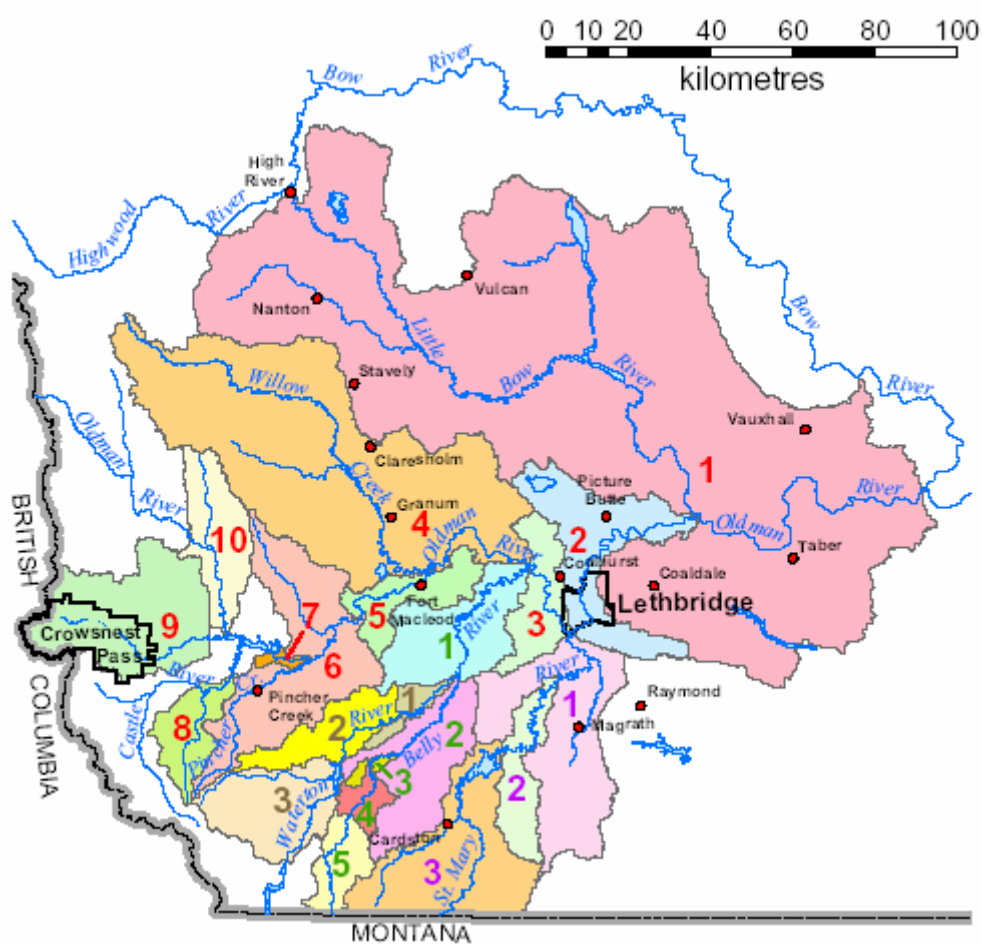


Figure 7. Map showing location of Southern Tributaries Sub-basin

Water quality ratings

Throughout most of the reaches of the Southern tributaries, the water quality is given a general rating of good to excellent.

Waterton River

Throughout most of the Waterton reaches, the water quality is good. Primary stressors include nutrient loading from non-point sources, as well as bacteria and occasional pesticides. There are no provincial WQI sites on this river, so quantitative ratings are not routinely available.

Belly River

Throughout most of the Belly reaches, the water quality is good. Primary stressors include nutrient loading from non-point sources, as well as bacteria and occasional pesticides. There are no provincial WQI sites on this river, so quantitative ratings are not routinely available.

St. Mary River

Throughout most of the St Mary reaches, the water quality is good. Primary stressors include nutrient loading from non-point sources, as well as bacteria and occasional pesticides. There are no provincial WQI sites on this river, so quantitative ratings are not routinely available.

Overall expected trend in the Southern Tributaries

Due to continued water abstractions, reduced instream flows, we expect a downward trend in water quality as existing water abstraction licences are used to their fullest potential. Lower flows will result in less dilution of the various loadings of contaminants. With time, the moratorium placed on new water licences will stop the current downward trend caused by the abstractions.

Southern Tributaries ARCA Summary

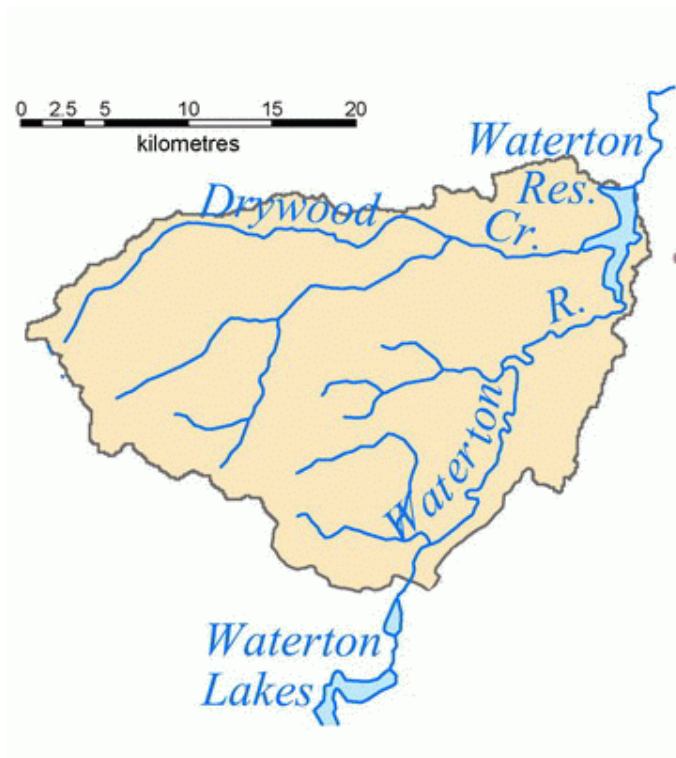
Tables ST1 and ST2 contain a summary of ARCA indicators for the southern tributaries. On the St Mary River, the degree of hydrological change in Reach #3 is “at most risk of impact” because of diversion from the St. Mary River to the Milk River upstream of the International Boundary (Table ST1). Reach # 1 exhibits a high degree of hydrological change because of water supply storage and irrigation diversions in other southern tributaries (Table ST1). On the Belly River, the degree of hydrological change is relatively moderate in Reach #1 and 3 because of the Belly River Diversion (there is no storage on the Belly River). On the Waterton River, Reach #1 exhibits a high degree of hydrological change because of the Waterton Dam Operation and diversion to the Belly River (Table ST1). The individual reach reports and the charts at the end of this report provide more detailed information about water quality, riparian health and hydrological change in the southern tributaries.

Reach #	Water Quality	Riparian Health	Degree of Hydrological Change (DHRAM)	
			Calendar Year	Open Water Season
3 (St Mary)	Excellent	Healthy with problems	Moderate	Moderate
2 (St Mary)	Good	Unhealthy	--	--
1 (St Mary)	Good	Healthy with problems	At most risk of impact	At most risk of impact
5 (Belly)	Excellent	Healthy-Unhealthy	Negligible	Negligible
4 (Belly)	Excellent	Healthy with problems	--	--
3 (Belly)	Good	Healthy with problems	At most risk of impact	At most risk of impact
2 (Belly)	Good	Healthy with problems	--	--
1 (Belly)	Good	Healthy with problems	At most risk of impact	At most risk of impact
3 (Waterton)	Excellent	Healthy with problems	--	--
2 (Waterton)	Excellent	Unhealthy	--	--
1 (Waterton)	Good	Healthy with problems	At most risk of impact	At most risk of impact

Table ST2. Southern Tributaries RVA Analysis

Reach #	Degree of Hydrological Alteration	Open Water Season
3 St Mary	Moderate	Moderate
1 St Mary	Moderate	At most risk from impact
5 Belly	Near natural	Near natural
3 Belly	Moderate	Moderate
1 Belly	Moderate	Moderate
1 Waterton	Moderate	At most risk from impact

Waterton River Reach #3 Waterton Park Gauging Station to the Waterton Reservoir



Reach Description: This reach drains a watershed of about 480 km², or 9% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river is bull trout. This reach of the Waterton River is located within the Foothills Fescue and Foothills Parkland Subregions.

Human Uses: Currently, grazing is by far the dominant land use in this reach. The remainder of the reach is divided into small areas of cropland, developed and undeveloped land.



Water Quality

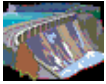
- Ⓢ This section of river is used for some agriculture and forestry and comprises a significant portion of Waterton National Park.
- Ⓢ There is limited water extraction.
- Ⓢ A major source of water is sent from the Waterton system to the Belly River and eventually via a canal to the St. Mary Reservoir to the east.
- Ⓢ As the water extraction is at the lower end of this reach, the flow is still intact and this can be considered a reasonable reference reach.





Overall, the riparian health of the Waterton River in this reach is rated as varying from healthy, to healthy but with problems. This rating is based on two sample sites.

- ⑧ Trees and shrubs combined cover 64% of the area assessed in this reach. Trees and shrubs have almost equal cover with trees covering 43% and shrubs occupying 42% of the area assessed. There is moderate to excellent regeneration of cottonwoods and there are no other trees than cottonwood species present. Preferred shrubs also have excellent regeneration with normal amounts of dead and decadent branches in both the shrub and tree communities. Overall utilisation of preferred trees and shrubs is light and at this level of browse, woody communities should be maintained.
- ⑧ The overall cover of invasive species is not significant (one site each with <1% and 1%-15% cover), however the widespread distribution of these species is of concern. Disturbance-caused species are covering over 50% of the area assessed at one site, with 25%-50% at the other site. These species are of concern because they are limiting the overall coverage of native species. Native grasses are significantly reduced due to abundance of disturbance-caused species and are occupying 25%-50% of the area in one site and less than 5% in the other.
- ⑧ There are some concerns with riverbank root mass protection in this reach, with moderate to poorly protected banks.

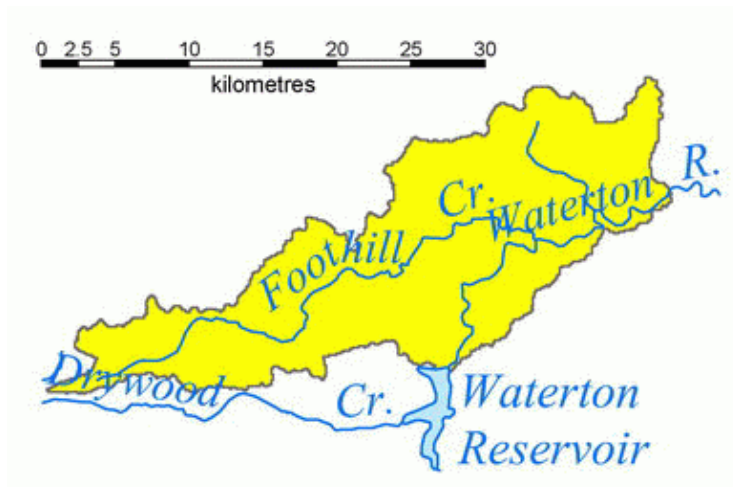


There are no dams within or upstream of this reach, and there are no significant water withdrawals. No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ This reach is located upstream of the Waterton Reservoir, and consequently peak flows and timing have not been modified.
- ⑧ Floodwaters have unrestricted access to the floodplain, an important factor for moisture on the floodplain and energy dispersal during flood events.

Waterton River Reach #2

Waterton Reservoir to 45 km Upstream of Belly River Confluence



Reach Description: This reach drains a watershed of about 370 km², or 6% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river include mountain whitefish and rainbow trout. This reach of the Waterton River is located within the Foothills Fescue Subregion.

Human Uses: Currently, grazing is the dominant land use in this reach, including wintering sites for cattle. Riparian health ratings are

significantly impacted by withdrawals and damming upstream.



Water Quality

- Ⓢ Upstream reservoir has resulted in loss of frequency and magnitude of higher flows that naturally occur during snow melt and summer storms, which scour accumulating sediments from the stream bed, reduce potential buildup of algal and aquatic weed growth on the substrate, and add oxygen into the sediments (important in fish spawning beds).
- Ⓢ Sediment collection in the reservoir has established a new equilibrium downstream; sediment transport is now inadequate to maintain channel processes.
- Ⓢ Low flows and the resulting shallow water are significantly affecting water temperature resulting in a shift from cold water fish species to cool water fish species.



Overall, the riparian health of the Waterton River in this reach is rated as unhealthy. This rating is based on two sample sites.

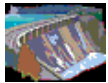
- Ⓢ Trees are covering slightly more area than shrubs in this reach with 49% of the area occupied by trees and 38% by shrubs. There is excellent cottonwood regeneration in all of the sites assessed with seedlings and sapling providing more than 15% of the cottonwood cover. Cottonwoods are the only trees present in this reach. Preferred shrubs



also have excellent regeneration, with minor additional to normal levels of dead and decadent branches in the tree and shrub communities. Utilisation on preferred trees and shrubs is variable, from light to heavy, and may influence future success of the woody communities if heavy use persists.



- ⑧ There is minimal cover of invasive plants, however their widespread distribution facilitates further infestation of these species and therefore is of concern. Disturbance-caused plants have very poor root systems and perform poorly most riparian functions (e.g., stabilising riverbanks). The presence of disturbance-caused plants is somewhat better in this reach, compared to adjacent reaches, but is still a concern, as they are covering 38% of the assessed area. Disturbance-caused species also compete with native plants and have significantly reduced the native grass cover in this reach.
- ⑧ Riverbank root mass protection is poor along the areas assessed in this reach, resulting in some areas of instability along the bank.



Dams and diversions on hydrology have impacted this reach; however no hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ There are significant withdrawals, with about 65.3% of the average river discharge removed from this reach.
- ⑧ The Waterton Dam is also located at the upper end of this reach, resulting in more than 50% of the watershed upstream controlled by the dam. Water withdrawal and damming both alter the natural flow and water available for riparian vegetation as well as altering the processes of sediment deposition and ground water recharge (SORAC).
- ⑧ There are no obstructions along the river that prevent floodwaters from accessing the floodplain in this reach.

Waterton River Reach #1

A Point 45 km Upstream from the Belly River Confluence to the Confluence



Reach Description: This reach drains a watershed of about 108 km², or 2% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river include mountain whitefish and rainbow trout. This reach of the Waterton River is located within the Foothills Fescue Subregion.

Human Uses: Grazing is the dominant land use adjacent to the river in this reach with a small area of cropland. Some developed land is also found. Water withdrawals and dams are negatively impacting riparian health.



Water Quality

- Ⓢ Agriculture, irrigation and cattle grazing affect water quality within this reach.
- Ⓢ Sediment collection in the reservoir has established a new equilibrium downstream; sediment transport is now inadequate to maintain channel processes.
- Ⓢ Reduced flood peaks.
- Ⓢ Low flows and shallow water have significantly raised water temperature resulting in a shift from coldwater fish species to cool water fish species.
- Ⓢ Bull trout seen incidentally in this reach (those surviving passage through the dam have no area to spawn).



Overall, the riparian health of the Waterton River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

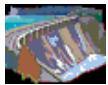
- Ⓢ Trees and shrubs combined are covering 75% of the area assessed in this reach, with trees more abundant than shrubs. There is excellent regeneration of



cottonwoods and preferred shrub species in this reach. There were only cottonwoods observed and no other trees present. There are normal levels of dead and decadence in the woody communities and overall preferred tree and shrub utilisation is moderate to heavy.



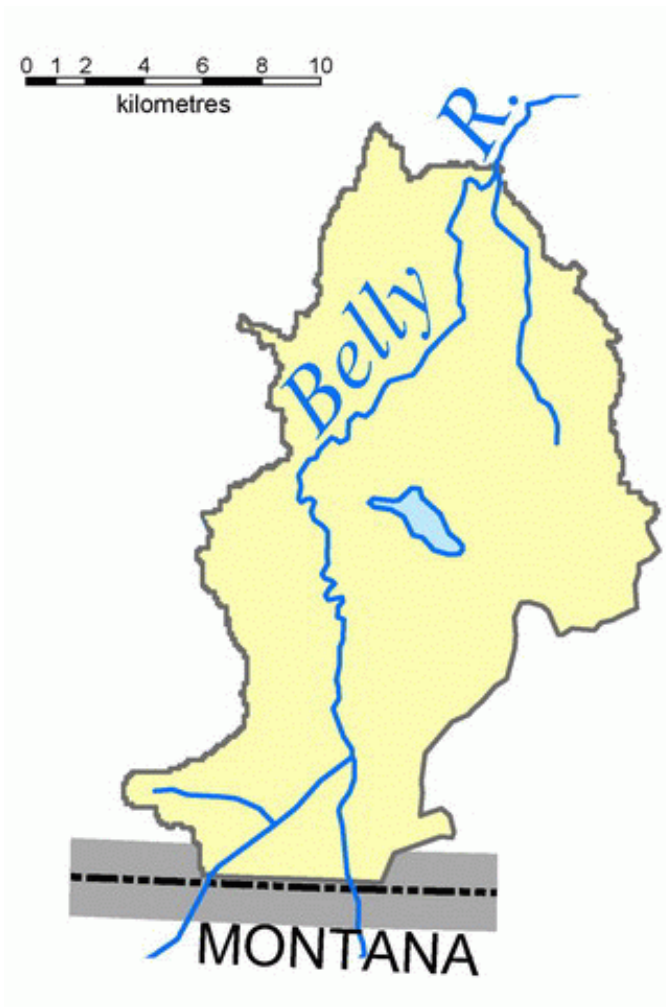
- ⑧ Invasive plants are present throughout the reach, with the continuous and wide spread distribution of these species of concern. Disturbance species are covering more than 50% of the areas assessed, competing with the vegetative cover of native plants. The abundance of disturbance-caused plants has significantly reduced the presence of native grasses, with 5%-25% of the area assessed occupied by native grasses. Leafy spurge is present within this reach.
- ⑧ Riverbank root mass protection is somewhat higher in this reach, compared to upstream, with 65%-85% of the reach protected in one of the sites and more than 85% of the bank covered by deeply rooted species in the other site- this is positive.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “At most risk from impact” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “At most risk of impact” during the open water season. The high RVA and DHRAM ratings are caused by the location of this reach downstream from Waterton Dam.

- ⑧ About 60.8% of the average river discharge is removed from this reach.
- ⑧ Water withdrawals are significantly impacting riparian health (Cows and Fish).
- ⑧ The Waterton Dam is also negatively impacting riparian health, damming and altering the flow of more than 50% of the river upstream of the sites in the reach. These alterations to the water available and natural flow of the river disrupt the natural processes of the river (sediment deposition, ground water recharge, cottonwood establishment) (Cows and Fish).
- ⑧ With 89% of average annual flow removed from this reach, dewatering is a major concern, having negative impacts on overall riparian health ratings. In addition, damming upstream by the Waterton Dam has resulted in over 50% of the watershed controlled by dams, introducing modifications to flood timing and intensity (Cows and Fish).
- ⑧ There are no obstructions along the river that prevent floodwaters from accessing the floodplain in this reach.

Belly River Reach #5
International Boundary U.S.A./Canada to Upstream of Mountainview Gauging Station



Reach Description: This reach drains a watershed of about 250 km², or 4% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river is bull trout. This reach of the Belly River is located within the Foothills Parkland Subregion.

Human Uses: The majority of the land within this reach is undeveloped. Grazing is the dominant land use in the remainder of the reach.



Throughout most of the Belly reaches, the water quality is good. Primary stressors include nutrient loading from non-point sources, as well as bacteria and occasional pesticides. There are no provincial WQI sites on this river, so quantitative ratings are not routinely available.

- Ⓢ This section of river is subject to impacts from some agriculture and some forestry.
- Ⓢ The Mountain View Irrigation District (MVID) is the first Canadian water withdrawal.



- ⑧ Low flows resulting from diversions and extractions result in a shift from coldwater fish species to cool water fish species.
- ⑧ High temperatures in summer can be limiting for trout species; bull trout are occasionally seen.
- ⑧ Riparian areas used as cattle wintering sites, resulting in non-point runoff from agricultural activities.
- ⑧ Gas bubble disease (gas super saturation) may be an issue at the Belly Chute.

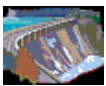


Overall, the riparian health of the Belly River in this reach is rated as varying from healthy, to unhealthy. This rating is based on two sample sites.

- ⑧ Currently, preferred tree and shrub communities are present and have excellent regeneration in one of the sites in this reach, but while they are present in the other site, regeneration of preferred trees is minimal. Two woody plant community types are observed in this reach, white spruce (*Picea glauca*)/ red osier dogwood (*Cornus stolonifera*) and balsam poplar (*Populus balsamifera*)/ snowberry/buckbrush (*Symphoricarpos occidentalis*). This site has the largest diversity of trees with 6 different species observed. Browse utilisation of preferred woody plants is variable ranging from light to heavy and may be restricting the regeneration of preferred trees and shrubs where seedlings and saplings are lacking. There are minor levels of dead and decadent branches within the woody communities in this reach.



- ⑧ There is excellent riverbank root mass protection along one of the areas assessed with very poor protection of the riverbanks at the other site, which directly corresponds to the large area affected by structural alterations.



RVA analysis rates the degree of hydrological change in this reach as “Near natural” during the calendar year, and “Near natural” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Negligible” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “Negligible” during the open water season. The amount of water diverted from this reach does not cause the RVA and DHRAM ratings to depart from “near natural” conditions.

- ⑧ Currently there are no dams altering the flow of the river or significant withdrawals from this reach.
- ⑧ There are no restrictions to floodwater access to the floodplain in the areas assessed.

Belly River Reach #4
Mountainview Gauging Station to Upstream of the St. Mary Canal



Reach Description: This reach drains a watershed of about 120 km², or 2% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river is bull trout. This reach of the Belly River is located within a transition zone between the Foothills Fescue and Foothills Parkland Subregions.

Human Uses: Grazing is the main land use in this reach; however there is a small amount of cropland that influences the reach.



Water Quality

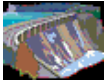
- Ⓢ There are some impacts from agriculture in this reach.
- Ⓢ United Irrigation District (UID) Canal removes water and causes fish losses down the canal.
- Ⓢ High temperatures in summer can be limiting for trout species; bull trout are occasionally seen.
- Ⓢ Riparian areas used as cattle wintering sites, resulting in non-point runoff from agricultural activities.



Overall, the riparian health of the Belly River in this reach is rated as varying from healthy, to healthy but with problems. This rating is based on two sample sites.

- Ⓢ Trees have significant cover (70%) of the inventoried area, with a smaller area covered by shrubs (24%). Non-cottonwood species were not observed in the assessed area; however there is excellent regeneration of preferred shrubs and cottonwood species. The diversity of trees and shrubs is considerably lower than reach BL-05, with 2 tree and 12 shrub species recorded in this reach.

- ⑧ Invasive plant species are covering 1%-15% of the area assessed in this reach. The distribution of these species is of concern with a variety of invasive plants found continuously with patches in their occurrence throughout the riparian area.
- ⑧ Of particular concern is the presence of spotted knapweed (*Centaurea maculosa*) a restricted plant species observed within this reach. Disturbance-caused plants are also a concern, with over 50% of one site and 25%-50% of the other site covered in these species. This cover has replaced native graminoids, which occupy only 5%-25% of the areas assessed.
- ⑧ The riverbanks are well protected with deep rooted species throughout one site, with moderate protection in the other.



No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ Water withdrawals increase in this reach, with 9.3% of the average river discharge withdrawn.
- ⑧ There are no dams present and there are no restrictions to floodwaters accessing the floodplain.

Belly River Reach #3

St. Mary Canal to Five Km Downstream of the St. Mary Canal



Reach Description: This reach drains a watershed of about 36 km², or 1% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river are mountain whitefish and rainbow trout. This reach of the Belly River is located within a transition zone between the Foothills Fescue and Foothills Parkland Subregions.

Human Uses: Livestock grazing occupies more than 50% of the land-use within this reach and remaining portion is undeveloped land.



Water Quality

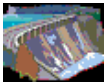
- ⑧ Water is sent from the Belly/Waterton system via this canal to the St. Mary Reservoir to the east.
- ⑧ Low flow throughout most of the year. These diversions affect fish distribution and composition.
- ⑧ Low flows resulting from diversions and extractions have resulted in a shift from coldwater fish species to cool water fish species.
- ⑧ High summer temperatures are limiting for trout species.
- ⑧ Riparian areas used as cattle wintering sites, resulting in non-point runoff from agricultural activities.





Overall, the riparian health of the Belly River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

- ⑧ Shrub species are covering a greater area (67%) than trees (38%) of the area assessed in this reach. There is excellent regeneration of both cottonwoods and preferred shrub species. No other trees besides cottonwoods were observed in this reach. Preferred trees and shrubs are receiving moderate utilization; however browse levels do not seem to be restricting the preferred woody regeneration.
- ⑧ There is good coverage of native grasses with 25%-50% of the assessed area covered by these species. Despite the presence of native plants, disturbance-caused grasses are abundant throughout the reach covering more than 50% of the assessed area. Invasive plants also have significant ground cover (1%-15%); however attention should be focussed on the distribution of these species. Invasive plants are widespread and found continuously with a few patches.
- ⑧ Deeply rooted species are providing excellent protection along the riverbank within this reach.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “At most risk of impact” during the open water season. Water diversion from the St. Mary canal causes the higher RVA and DHRAM ratings in this reach compared to reaches upstream.

- ⑧ Water withdrawals increase dramatically within this reach compared to upstream with more than 50% of the average river discharge removed. There are no dams present and therefore the natural flow of the river has not been altered.
- ⑧ There are currently no barriers along the river and floodwaters have full access to the floodplain (Cows and Fish).

Belly River Reach #2

Five Kilometers Downstream of the St. Mary Canal to Upstream of the Waterton River Confluence



Reach Description: This reach drains a watershed of about 650 km², or 12% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river is bull trout. This reach of the Belly River is located within the Foothills Fescue and Foothills Parkland Subregions.

Human Uses: Grazing is the dominant land use in this reach. There also is a small area of developed land.



Water Quality

- Ⓢ This reach experiences low flow throughout most of the year.
- Ⓢ Upstream diversions affect fish distribution and composition.
- Ⓢ Low flows resulting from diversions and extractions result in a shift from coldwater fish species to cool water fish species.
- Ⓢ Riparian areas used as wintering sites for cattle result in non-point runoff from agricultural activities.



Overall, the riparian health of the Belly River in this reach is rated as healthy but with problems. This rating is based on two sample sites.

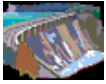
- Ⓢ Shrubs are covering a significant portion of the assessed area (91%) and trees are also present covering 65% of the area. Regeneration of cottonwoods and preferred shrubs is excellent throughout this reach, providing sustainability within these communities. Overall utilisation is

light, with current browse levels having no significant impact on the regeneration of preferred woody communities.

- ⑧ The presence of invasive species is lower in this reach than the previous reaches with invasive plants covering less than 1% of the assessed area. Invasive plants are found mainly in patches; however the distribution of these species facilitates further infestation, potentially increasing future ground cover. Disturbance-caused species are abundant and reducing the overall coverage provided by native grasses with only 5%-25% of the area assessed occupied by native grasses.



- ⑧ Riverbank root mass protection is excellent and supported by the abundance of deeply rooted tree and shrub species growing along the banks.



No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ Similar to the previous reach, there are major water withdrawals, with greater than 50% of the average river discharge removed from this reach.
- ⑧ Dams are not present along the river and the natural flow of the river is not altered. There are no obstructions along the riverbank and floodwaters have full access to the floodplain (Cows and Fish).

Belly River Reach #1
Waterton River Confluence to Oldman River Confluence



Reach Description: This reach drains a watershed of about 660 km², or 12% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river are mountain whitefish and rainbow trout. This reach of the Belly River is located within the Mixedgrass Subregion.

Human Uses: The majority of the land use in this reach is grazing. There is a small amount of cropland and developed land. Parts of the reach are used for overwintering cattle.



Water Quality

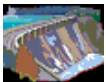
- Ⓢ Water extractions raise the water temperature in this reach, affecting water quality.
- Ⓢ Agriculture, irrigation, and cattle grazing impact this reach.
- Ⓢ This reach experiences low flows throughout most of the year. The upstream diversions affect fish distribution and composition.
- Ⓢ There are reduced flood peaks.
- Ⓢ Riparian areas used as wintering sites for cattle result in non-point runoff from agricultural activities.





Overall, the riparian health of the Belly River in this reach is rated as varying from healthy but with problems, to unhealthy. This rating is based on two sample sites.

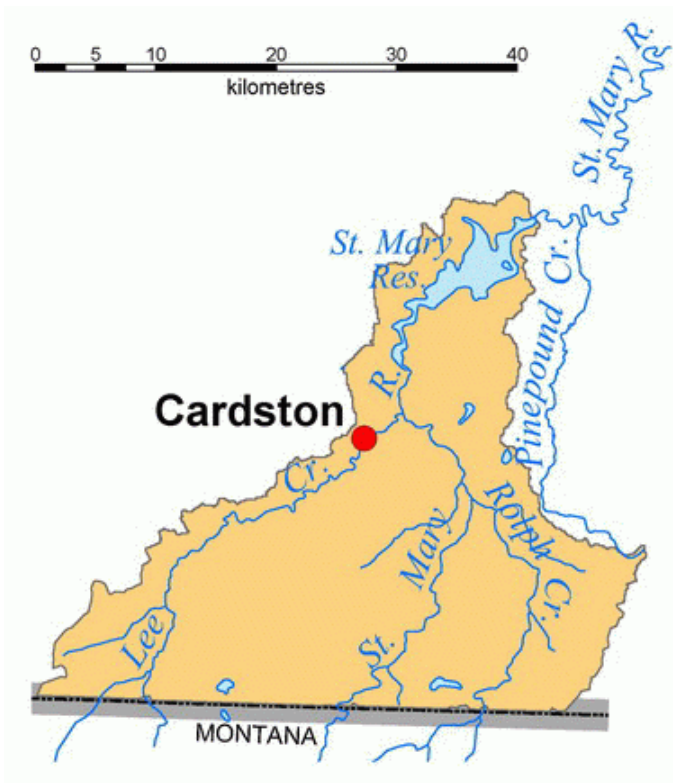
- ⑧ Two plant communities were identified, with total woody plants covering 88% of the reach. Cottonwood regeneration is excellent in one of the sites and poor in the other, with excellent regeneration and establishment of preferred shrub species in both sites. Browse utilisation of preferred trees and shrubs is light overall. There are normal amounts of dead and decadent branches at one of the sites, however at the other site there is moderate additions to dead and decadence in the woody plant community.
- ⑧ There is considerable coverage of invasive species, with invasive plants occupying 1%-15% of one site and greater than 15% of the other. There is also concern with the distribution of invasive plants, as they are widely spread throughout the reach in continuous occurrences with a few gaps in their distribution. Disturbance-caused plants are covering more than 50% of the assessed area and are reducing the amount of area occupied by native grasses, particularly at one of the sites. Native grasses are still reasonably prominent at the other site covering 25%-50% of the area.
- ⑧ Riverbank root mass protection is good to excellent, and results from the extensive woody plants along the banks.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “At most risk of impact” during the open water season. Upstream dams and diversions cause the relatively high RVA and DHRAM ratings on this reach.

- ⑧ The Waterton Dam is altering the natural flow of Waterton River, which is emptying into this reach. Therefore 25-50% of the watershed upstream is controlled by dams.
- ⑧ Similar to the upstream reaches, water withdrawals are significant and are negatively influencing riparian health ratings (Cows and Fish).
- ⑧ Currently, there are no structures along the area assessed in this reach restricting floodwaters from accessing the floodplain (Cows and Fish).

St. Mary River Reach #3
International Boundary (U.S.A./Canada) to the St. Mary Dam)



Reach Description: This reach drains a watershed of about 520 km², or 9% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river is bull trout. This reach of the St. Mary River is located mainly within Foothills Fescue Subregion.

Human Uses: Currently, grazing is the dominant land use in this reach. A small proportion of the length was identified as cropping and as undeveloped. Water withdrawal is occurring from this section of the St. Mary River (25-50% of the average river discharge) however it is not as severe as the reaches further downstream.



Water Quality

- Ⓢ The 1909 Boundary Waters Treaty allows American users to withdraw 25% of the first 18.9 m³/s and 50% of the remaining flow during the irrigation season (April through October) and 50% of the flow during the rest of the year (Golder Assoc. 2003).
- Ⓢ Heavily used for agriculture including irrigation.
- Ⓢ A major source of water comes from the Belly-Waterton system via canal to the St. Mary Reservoir.
- Ⓢ Low flow throughout most of the year, flood controls and water extraction on all US tributaries reduce competent flows. These diversions in Montana affect fish distribution and composition.
- Ⓢ Local irrigation diversions also remove some water.



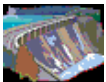


Overall, the riparian health of the St. Mary River in this reach is rated as varying between healthy but with problems, to unhealthy. This rating is based on two sample sites.

- ⑧ This reach has the best woody coverage (50%) of all the sections on the river. Shrubs have very minimal coverage (5%) with trees covering 48% of the area assessed. There is excellent cottonwood regeneration in one of the sites while cottonwood seedlings and saplings are absent from the other site. Preferred shrub regeneration is poor to excellent; there were only cottonwood trees observed. Utilisation on preferred trees and shrubs is moderate to heavy, and may be influencing regeneration. There are minor additional levels of dead and decadent standing woody plants in both sites.



- ⑧ Canopy cover of invasive plants is not significant however the widespread distribution of these plants is of concern. Because of the distribution of invasive plants the risk of these species spreading and covering a large area is greatly increased. Disturbance-caused species are present; however they occupy a relatively small area (5-25%) in one of the sites and have greater coverage (25-50%) in the other. There is fairly good cover provided by native graminoids (25-50%), which is important to prevent further spread of disturbance-caused and invasive species.
- ⑧ Riverbank root mass protection is very poor to good and directly linked to the amount of deeply rooted trees and shrubs located along the banks.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “Moderate” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “Moderate” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “Moderate” during the open water season. The St. Mary-Milk River diversion causes the moderate RVA and DHRAM ratings in this reach.

- ⑧ This reach is located upstream of the St. Mary Dam and therefore the natural flow has not been altered from damming. However, there is significant withdrawal of water from this reach with 32% of the average river discharge removed for irrigation and consumption.
- ⑧ The floodplain is fully accessible to floodwater within this reach (Cows and Fish).
- ⑧ Significant water withdrawals may be impacting seedling recruitment and success, and altering long-term cover of woody plants (Cows and Fish).

St. Mary River Reach #2

St. Mary Dam to 37 Km Upstream of the Oldman River Confluence



Reach Description: This reach drains a watershed of about 50 km², or 6% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river are walleye and rainbow trout. This reach of the St. Mary River is located within a transition zone between the Mixedgrass and the Foothills Fescue Subregion.

Human Uses: Grazing is the dominant land use in this reach, however there is a significant portion of the reach that is undeveloped. Cropping and development influence minor portions of the reach. This reach is downstream of the St. Mary Dam, altering the natural flow pattern of the river and significantly impacting riparian health.



Water Quality

- Ⓢ Allocation (water extraction for irrigation) issues (temperature).
- Ⓢ Loss of flushing flows.
- Ⓢ Sediment captured in the reservoir has established a new equilibrium resulting in inadequate sediment transport to maintain downstream channel processes.
- Ⓢ Riparian areas used as wintering sites for cattle; non-point runoff from agricultural activities.



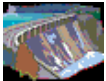


Overall, the riparian health of the St. Mary River in this reach is rated as unhealthy. This rating is based on two sample sites.

- ⑧ The presence of woody species dramatically decreases in this reach, with only 17% of the area assessed covered by woody plants. Shrubs are more abundant than trees covering 14% of the area; trees barely occupy 1% of the area assessed. Cottonwood regeneration is fair to excellent and there is also excellent regeneration of preferred shrub species. Cottonwoods are the only trees present. The levels of decadent and dead standing woody plants are normal and overall utilisation of preferred woody plants is light.



- ⑧ The canopy cover and distribution of invasive plant species is of concern with invasive species occupying more than 15% of the area of both sites. Disturbance-caused species are of concern in one of the sites with more than 50% of the area infested, but they are of minor concern in the other site. Native grasses are present; however the overall coverage of these species is poor.
- ⑧ Riverbank root mass protection is poor to very poor, due to the combined low presence of woody species and extensive invasive and disturbance-caused plants within this reach.

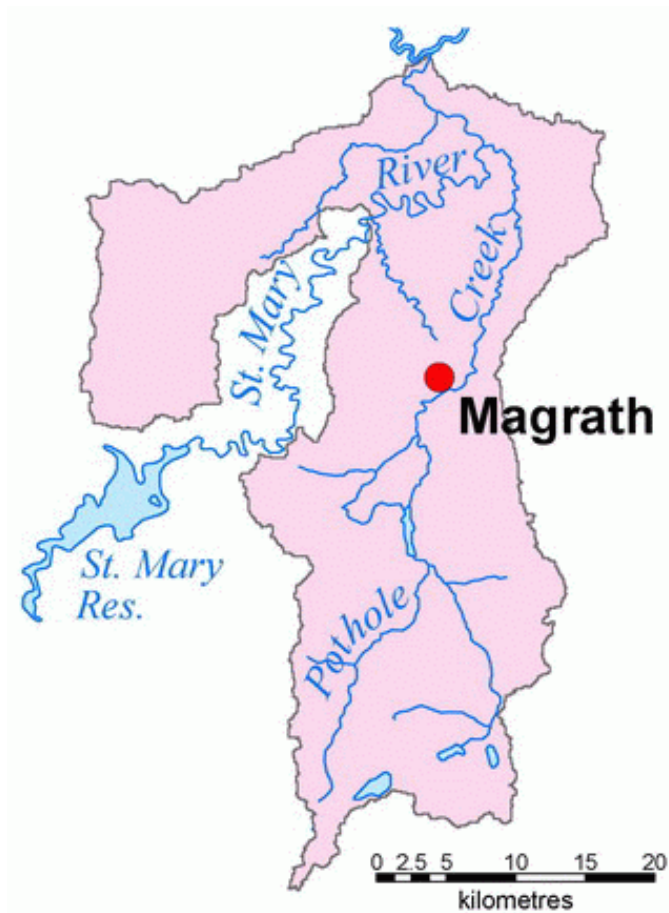


No hydrological data were available to perform RVA and DHRAM analyses for this reach.

- ⑧ More than 50% of the average river discharge removed from the system.
- ⑧ Dewatering is negatively impacting riparian health ratings in this reach (Cows and Fish).
- ⑧ The St. Mary Dam is also negatively influencing riparian health with more than 50% of the watershed upstream controlled by the St. Mary Dam. Removing water and adjusting the timing of flood events upsets the natural cycles of sediment deposition, ground water recharge and water availability for vegetative communities (Cows and Fish).
- ⑧ There are no restrictions to floodwaters to access the entire floodplain in the areas assessed in this reach.

St. Mary River Reach #1

Thirty-seven Kilometers Upstream of the Oldman River Confluence to the Confluence



Reach Description: This reach drains a watershed of about 1100 km², or 19% of the Oldman River Sub-basin. The key tree species in the riparian zone is narrow-leaved cottonwood. Key fish species in the river are walleye and rainbow trout. This reach of the St Mary River is located within the Mixedgrass Subregion.

Human Uses: Currently, grazing is the dominant land use in this reach. Very small portions of the reach were identified as cropping and undeveloped. Water withdrawals and the St. Mary Dam are both influencing the health of riparian areas within this reach.



Water Quality

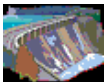
- Ⓢ Loss of flushing flows
- Ⓢ Impact of agriculture, irrigation, cattle grazing.
- Ⓢ Low flow throughout most of the year, with negative affect on summer instream temperatures (increased temperatures)
- Ⓢ Pothole Creek 'return flows' may adversely influence St. Mary River water quality (Golder Assoc. 2003).





Overall, the riparian health of the St. Mary River in this reach is rated as varying from healthy, to healthy but with problems. This rating is based on two sample sites.

- ⑧ Woody plants continue to have little coverage, similar to the adjacent upstream reach, with total woody plants only occupying 13% of the area assessed. Trees have very little coverage (0.5%) and therefore shrubs make up the majority of the woody plant cover. Seedlings and saplings made up a significant portion of the cottonwood cover and therefore cottonwood regeneration was considered excellent. Cottonwoods were the only tree species observed in this reach. Preferred shrubs also have excellent regeneration within their communities, with normal levels of dead and decadence found throughout the woody plant communities. Utilisation/browse of preferred trees and shrubs is variable and ranges from nil to heavy.
- ⑧ Invasive plants have significant cover of the riparian areas in this reach, 1%- 15% and are occurring in large continuous patches with breaks in their infestations. Disturbance-caused species are covering 50% of the area assessed and are competing with the native species in the reach. Native grasses have moderate coverage of one of the sites and poor coverage of the other.
- ⑧ The amount of deeply rooted trees and shrubs along the riverbanks is inadequate and therefore the protection along these areas is poor to very poor, directly correlated to the lack of woody cover in this reach.



RVA analysis rates the degree of hydrological change in this reach as “Moderate” during the calendar year, and “At most risk from impact” during the open water season compared to natural or pre-impact conditions. DHRAM analysis rates the degree of hydrological change in this reach as “At most risk of impact” when compared to other southern tributaries reaches and along the Oldman River below the Oldman River Dam during the calendar year, and as “At most risk of impact” during the open water season. This reach is downstream from the St. Mary reservoir, which causes the relatively high RVA and DHRAM ratings for this reach.

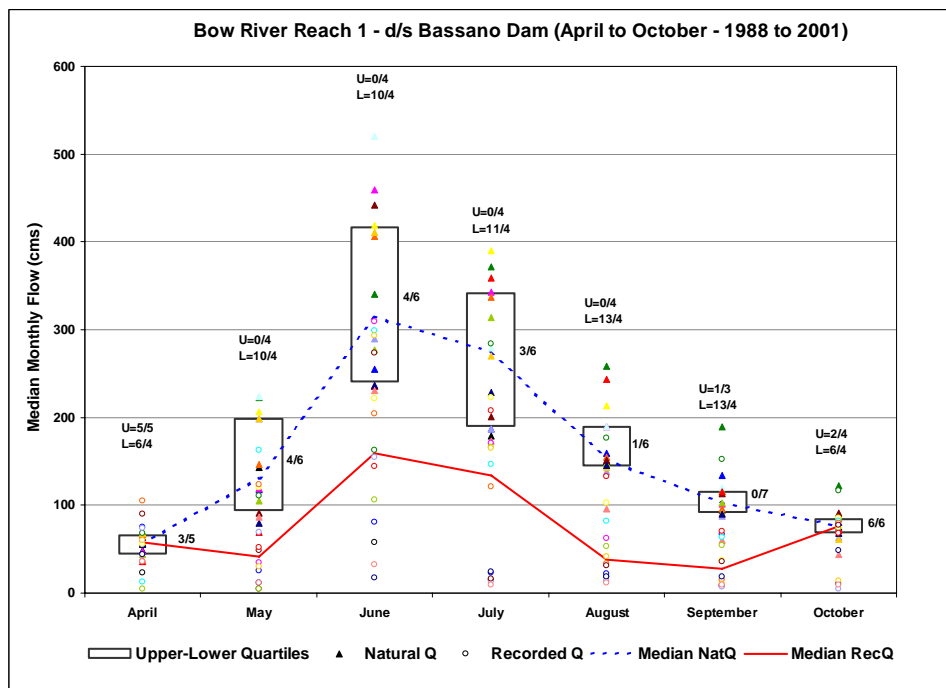
- ⑧ More than 50% of the average river discharge is removed from this reach.
- ⑧ Water withdrawals are negatively impacting riparian health (Cows and Fish).
- ⑧ The St. Mary Dam is also negatively influencing riparian health controlling more than 50% of the watershed upstream in one of the sites and 25-50% of the other site. Withdrawing and withholding water reduces water availability for riparian plant communities (Cows and Fish).
- ⑧ There are no obstructions along the river and flood water has full access to the entire floodplain.

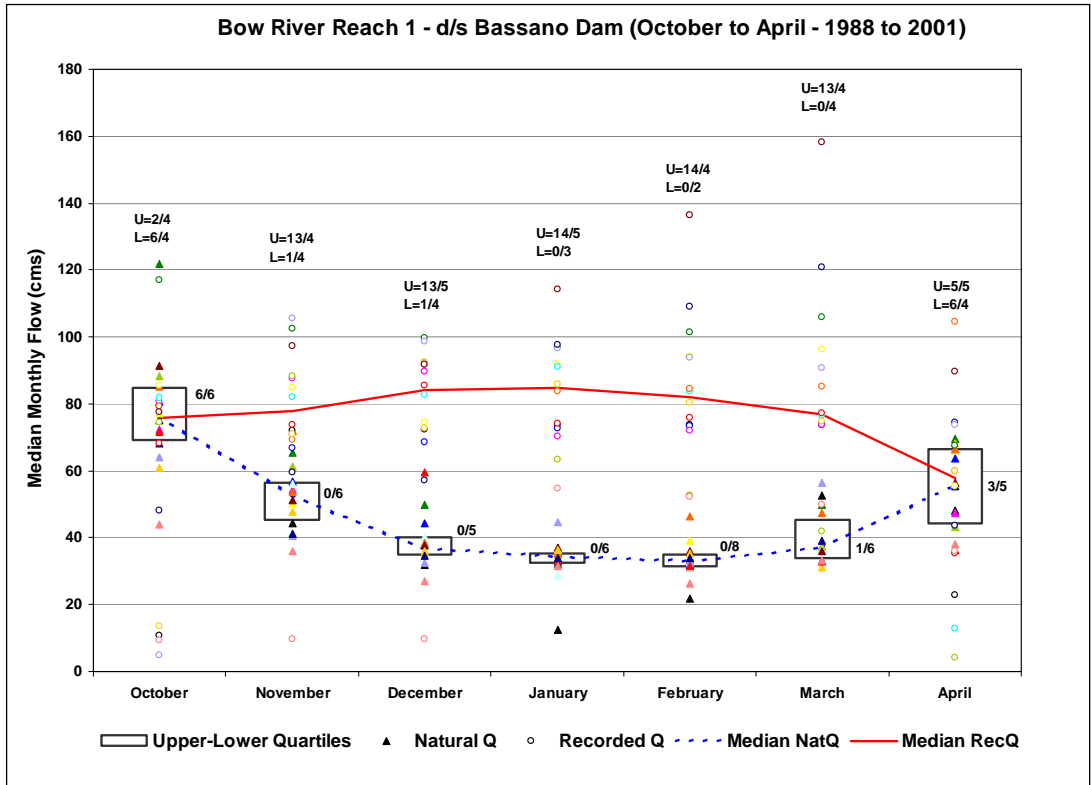
Median Monthly Flow Charts

Indices such as DHRAM and RVA are composite indicators that provide a general assessment of the degree of hydrological change in a river as a result of human impacts such as dams and diversions; however they do not give a detailed picture of how flow patterns have changed. To help in this understanding, reach charts were prepared comparing median monthly natural flow with recorded flow for both the open water season and the winter.

Each chart contains the data points for both median natural monthly flow and median recorded monthly flow for each year of the period of record (1988-2001). In addition to comparing the overall median natural and recorded monthly flows (dashed vs. solid red line), the charts contain the 25-75th percentile range of natural flows, shown as an “upper-lower quartiles” box. A pair of numbers is associated with each percentile box and also with the upper and lower range of flows. The numbers show how many times recorded monthly flow occurs within each range compared to natural flow. For example, in the reach chart for Bow River Reach 1 below (April to October – 1988 to 2001), median natural flow during the month of July occurred in the 75-100th percentile range four times during the period of record, while recorded flow did not occur within the range at all. In contrast, median natural flow during the month of July occurred within the 0-25th percentile range four times, while recorded flow occurred within this range eleven times. These data reflect the impact of reservoir filling and irrigation diversion on the Bow River during the month of July, resulting in a much greater frequency of lower flows from year to year. Note that hourly variation in flows caused by hydroelectric dam operations may result in even lower flows than shown in the chart.

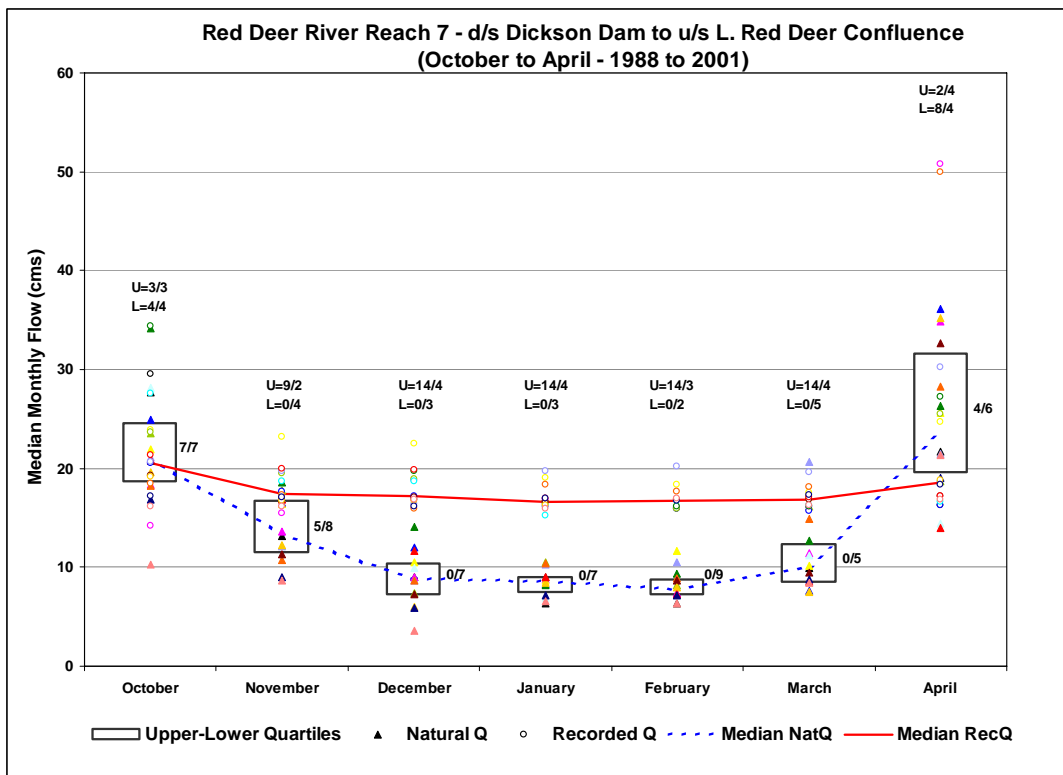
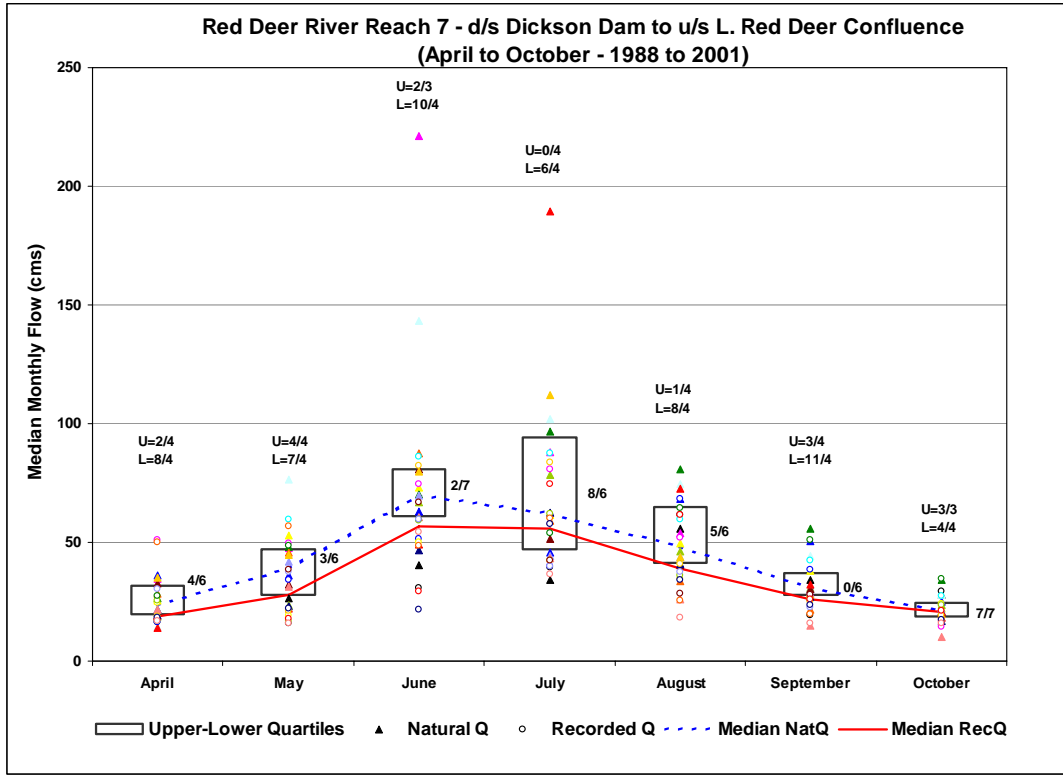
Comparison of the Bow River Reach 1 charts for summer and winter seasons reveals how dam operations cause the flow pattern for each river within the SSRB to reverse. During the summer season, recorded flow is less than natural flow, but during the winter season recorded flow exceeds natural flow.



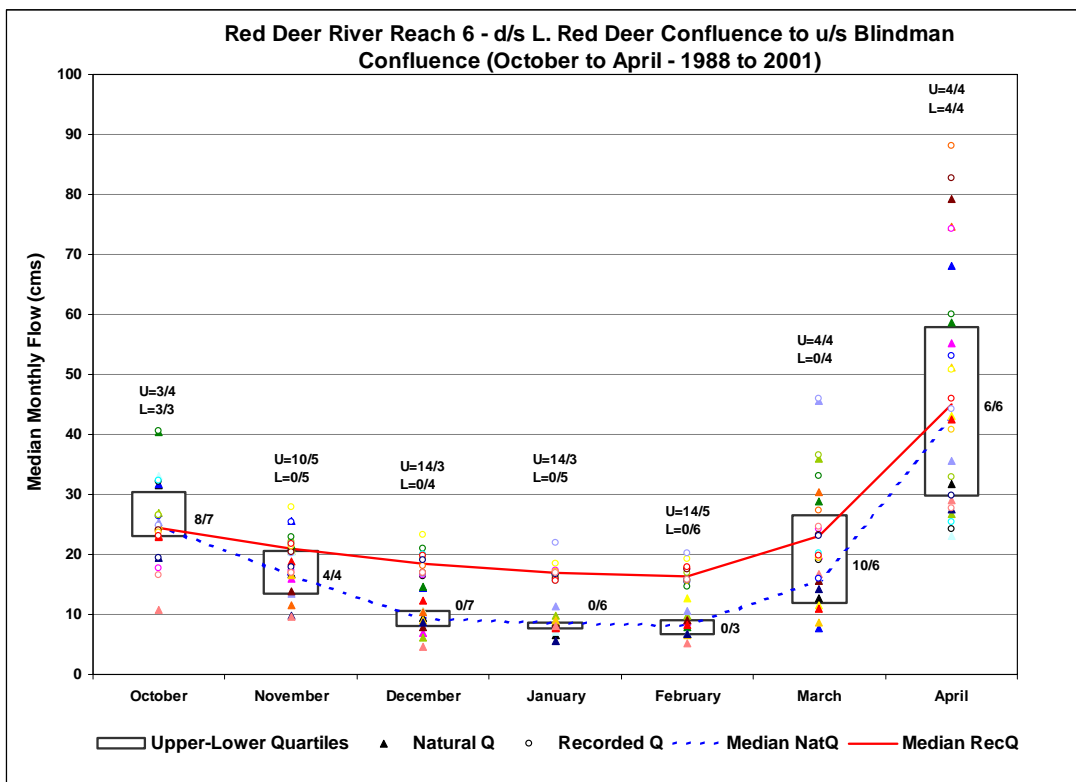
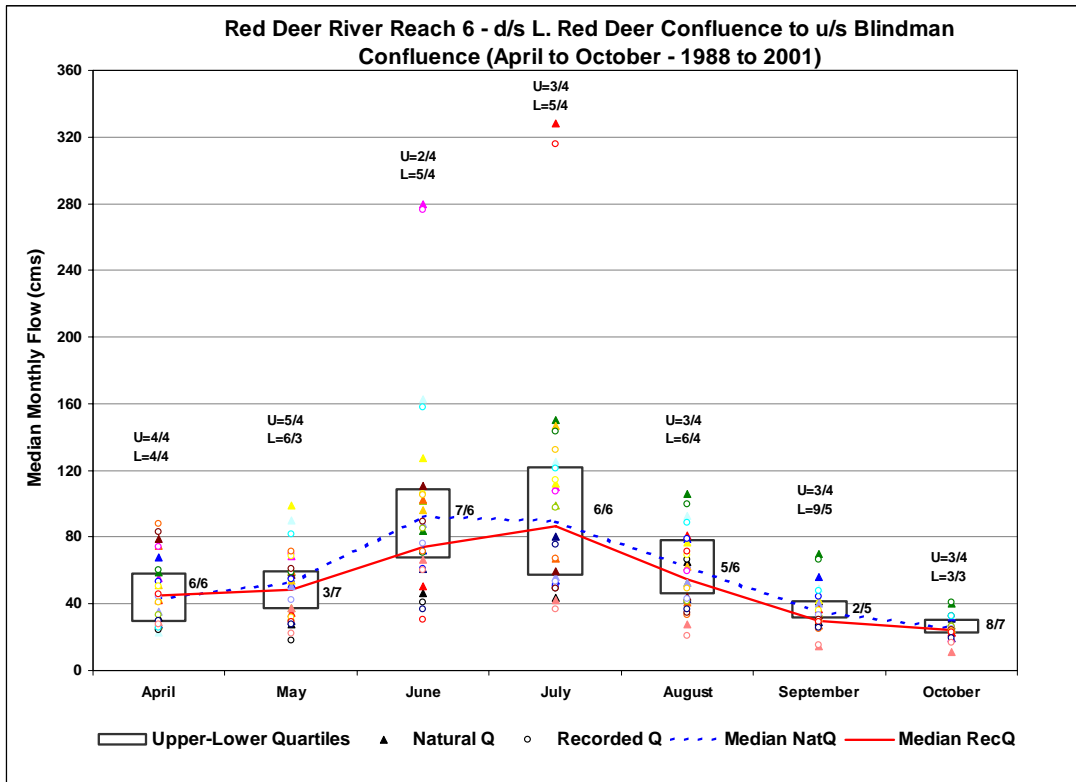


Alberta Environment and Alberta Sustainable Resource Development have derived IFN values for all main stem reaches within the SSRB (open water season only). Although the values vary by reach and by month, in general IFN flows are about 80% of natural flow.

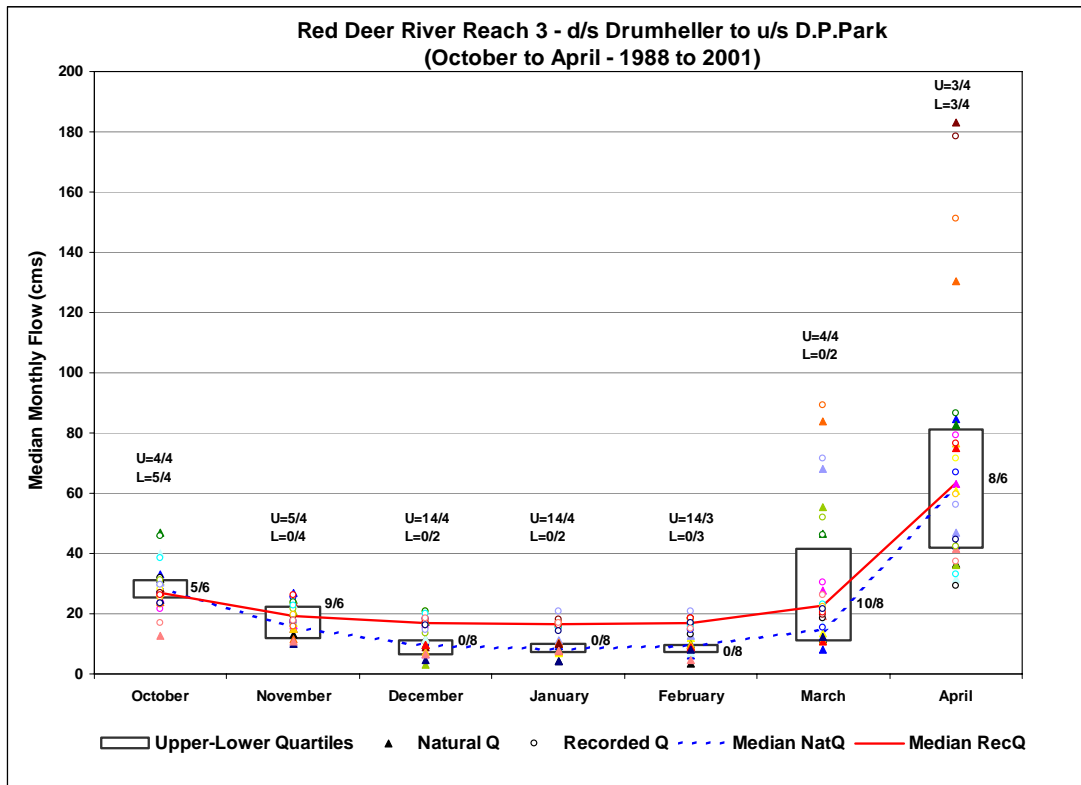
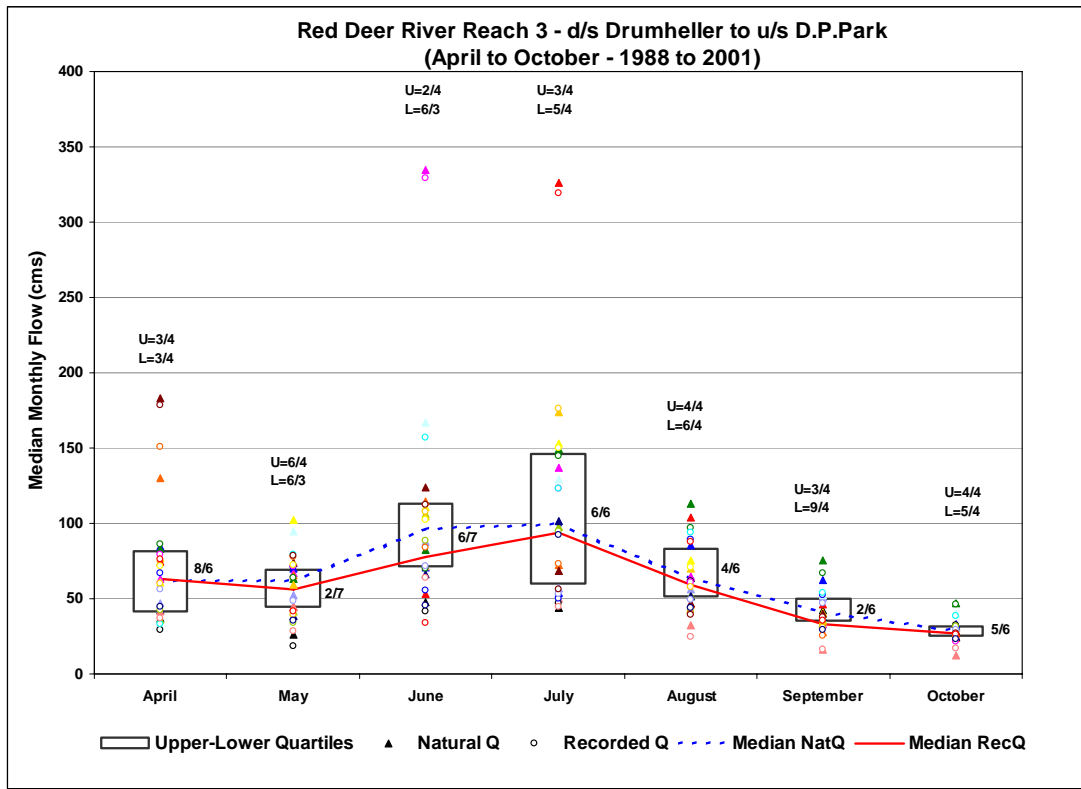
Red Deer River – Reach #7



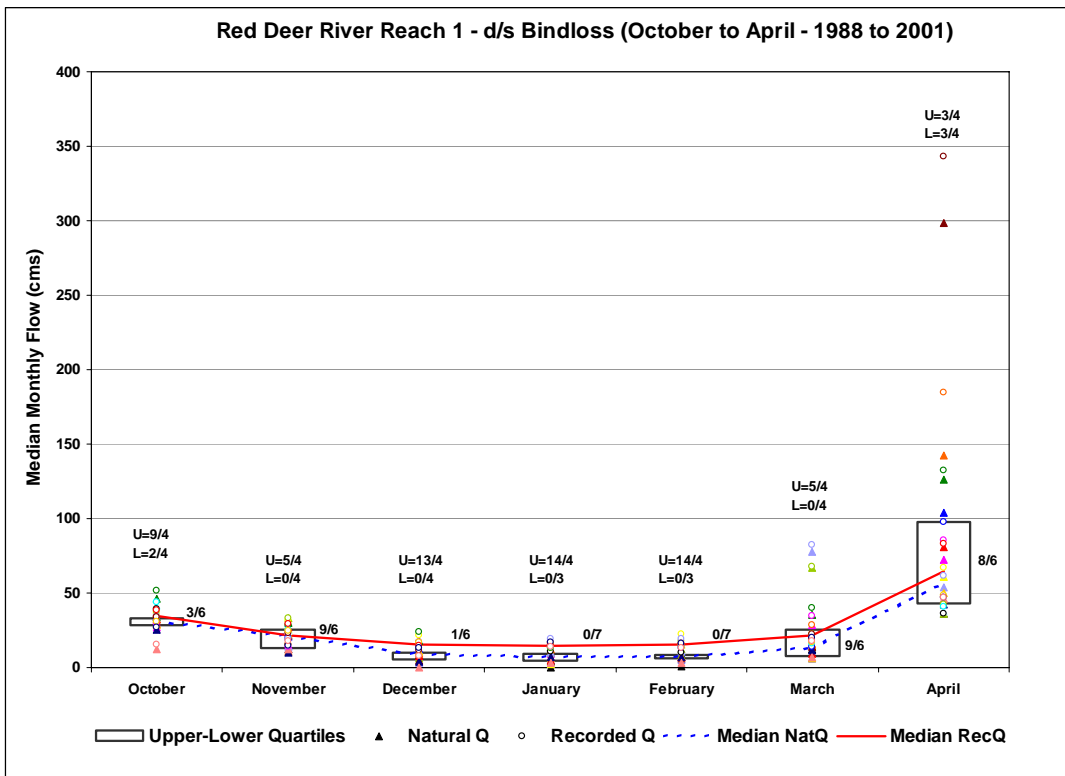
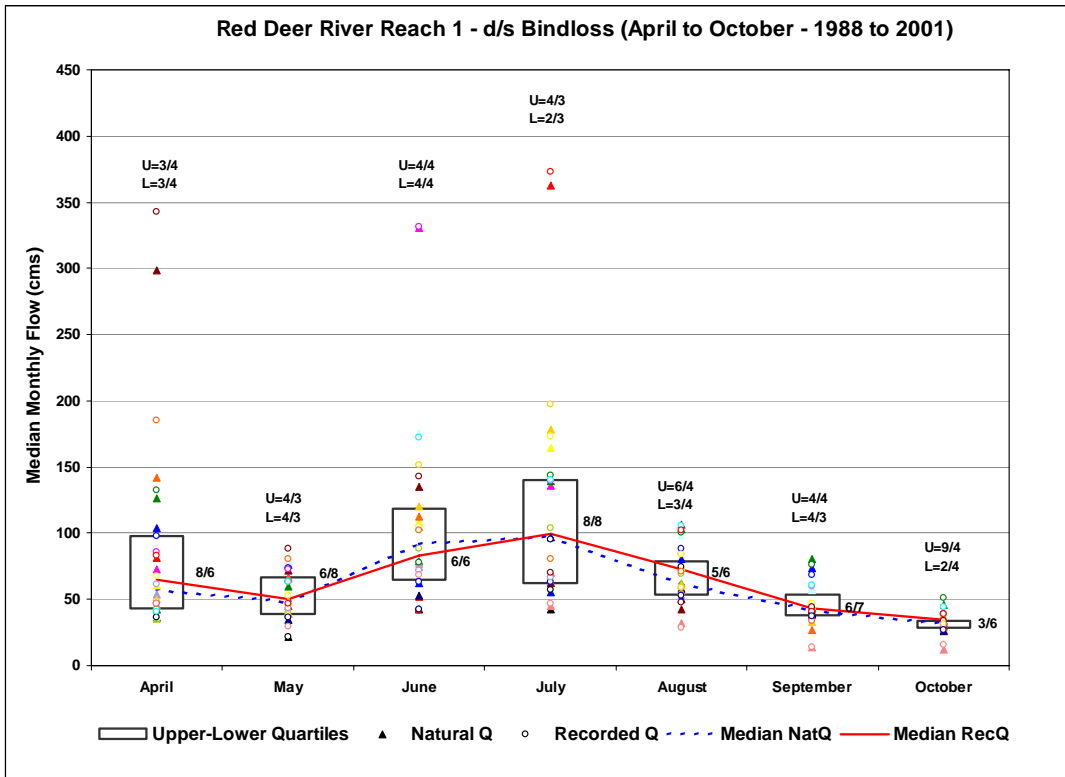
Red Deer River – Reach #6



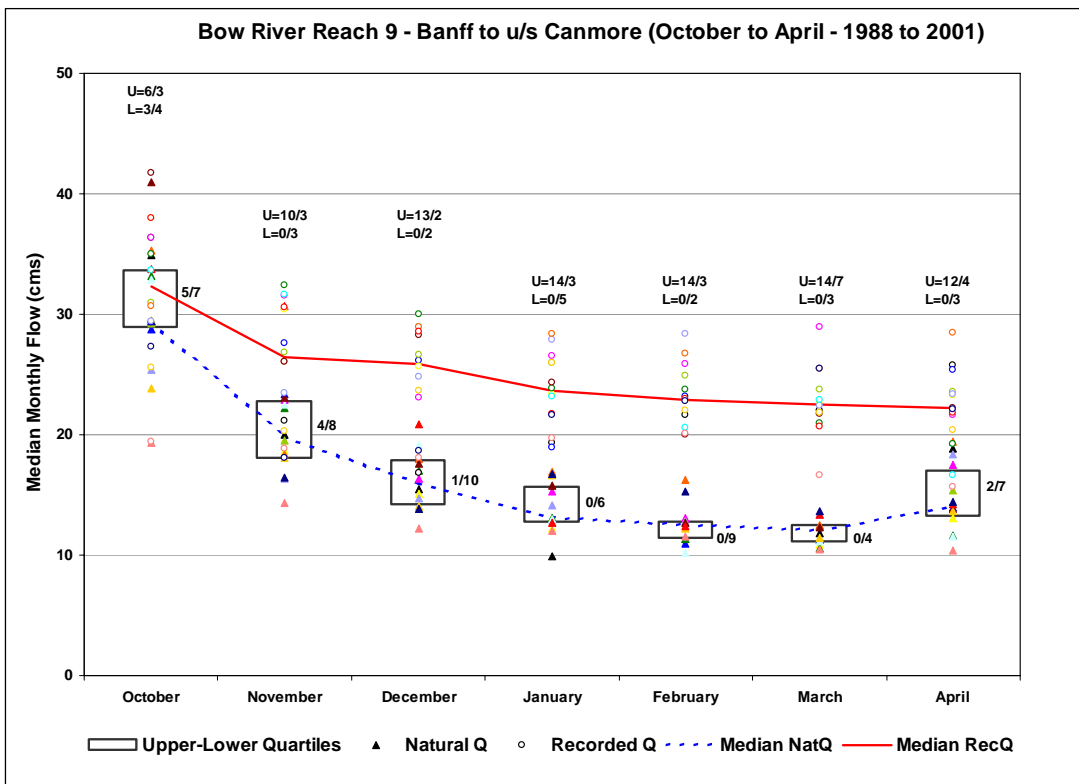
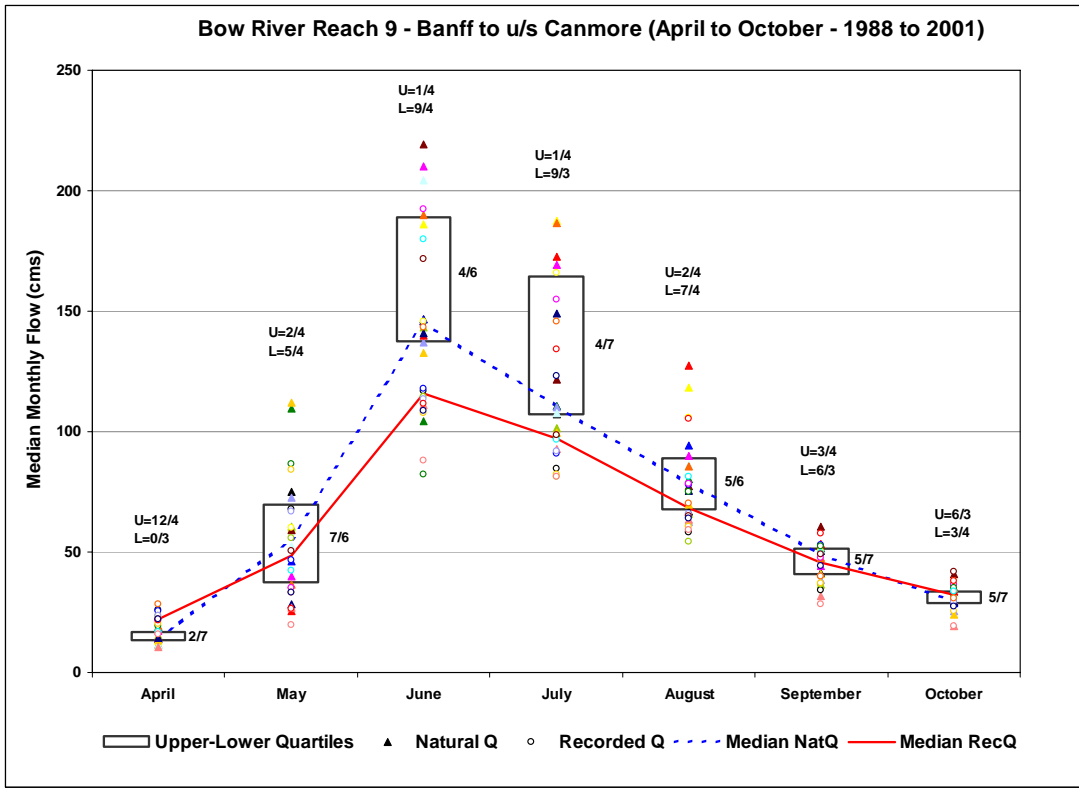
Red Deer River – Reach #3



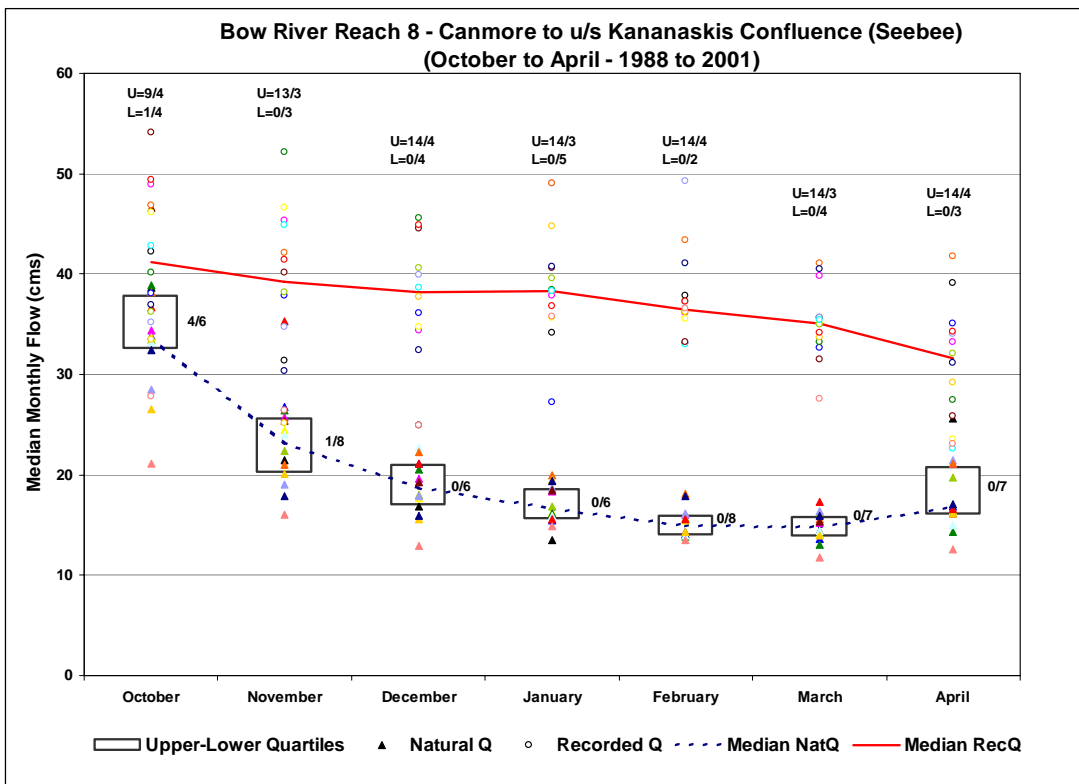
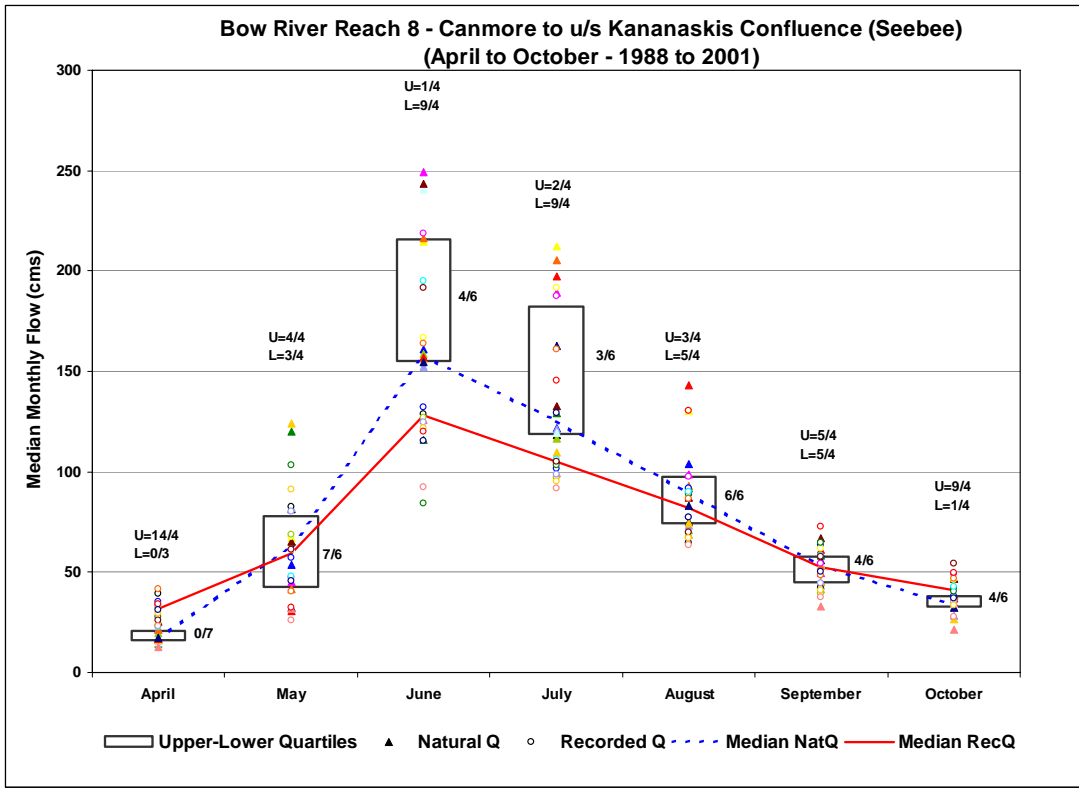
Red Deer River – Reach #1



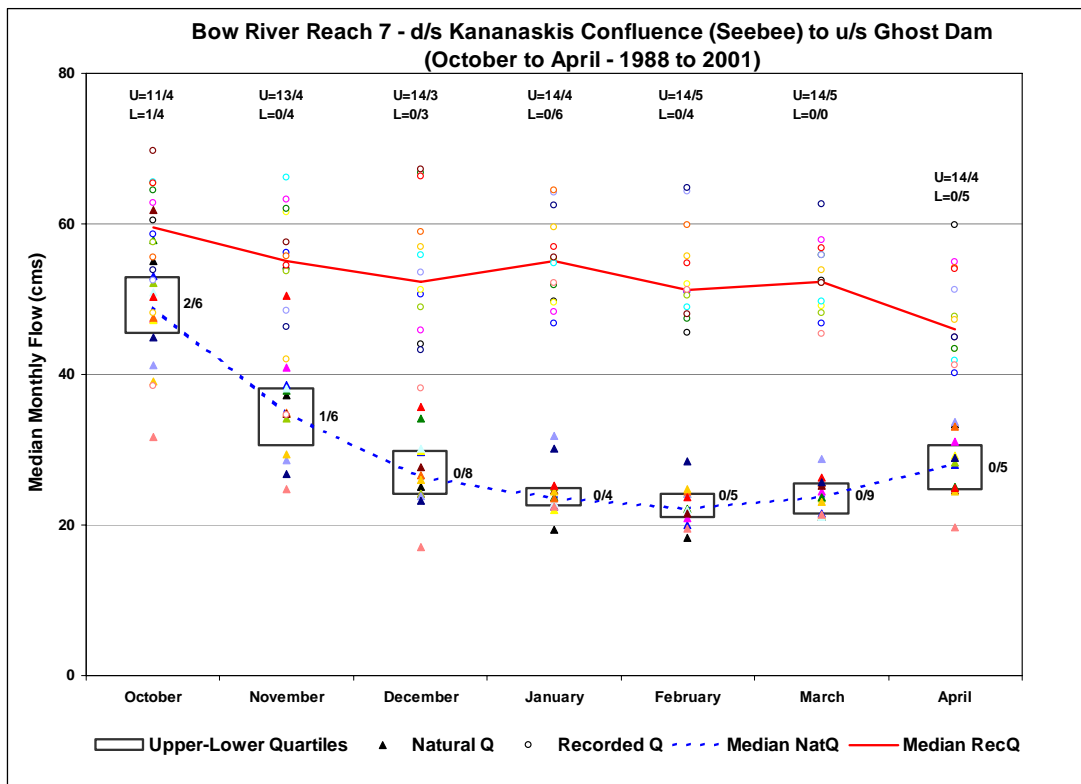
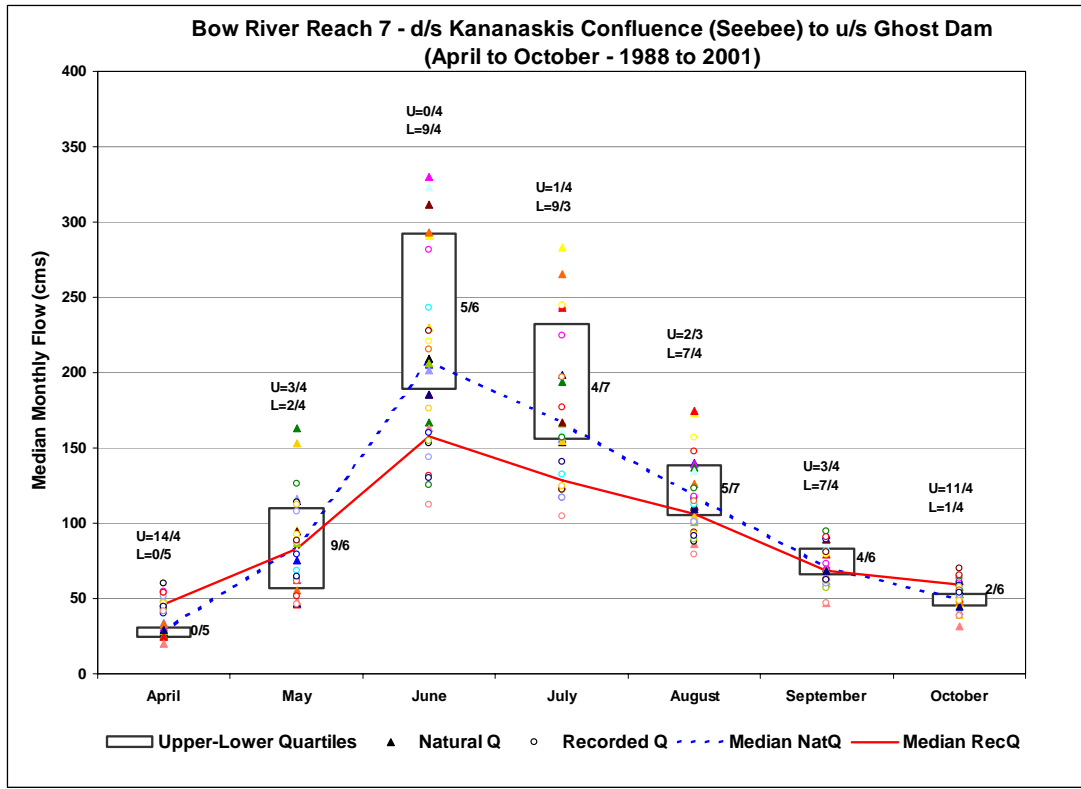
Bow River – Reach #9



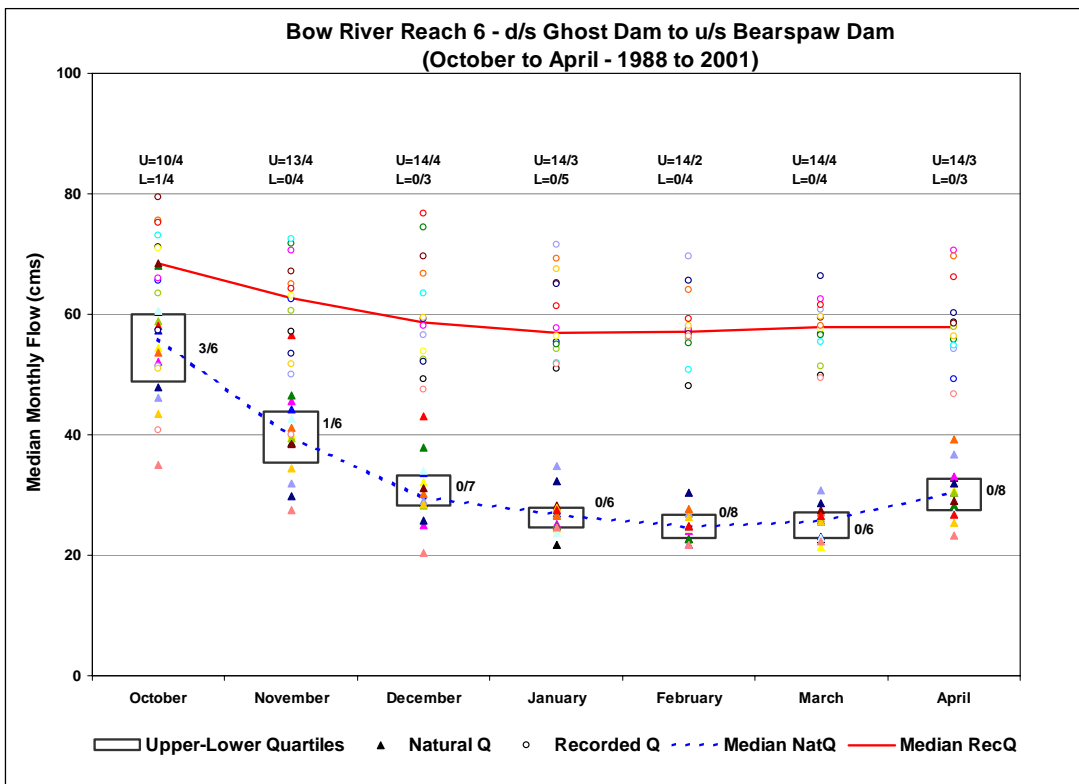
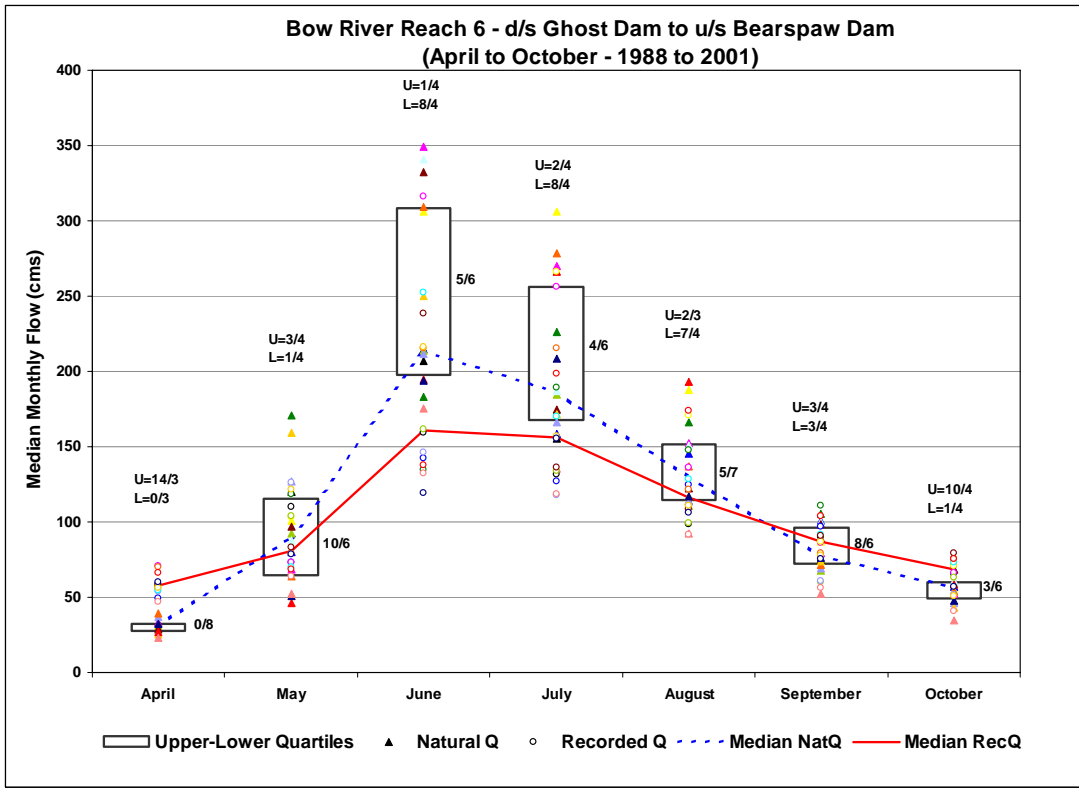
Bow River – Reach #8



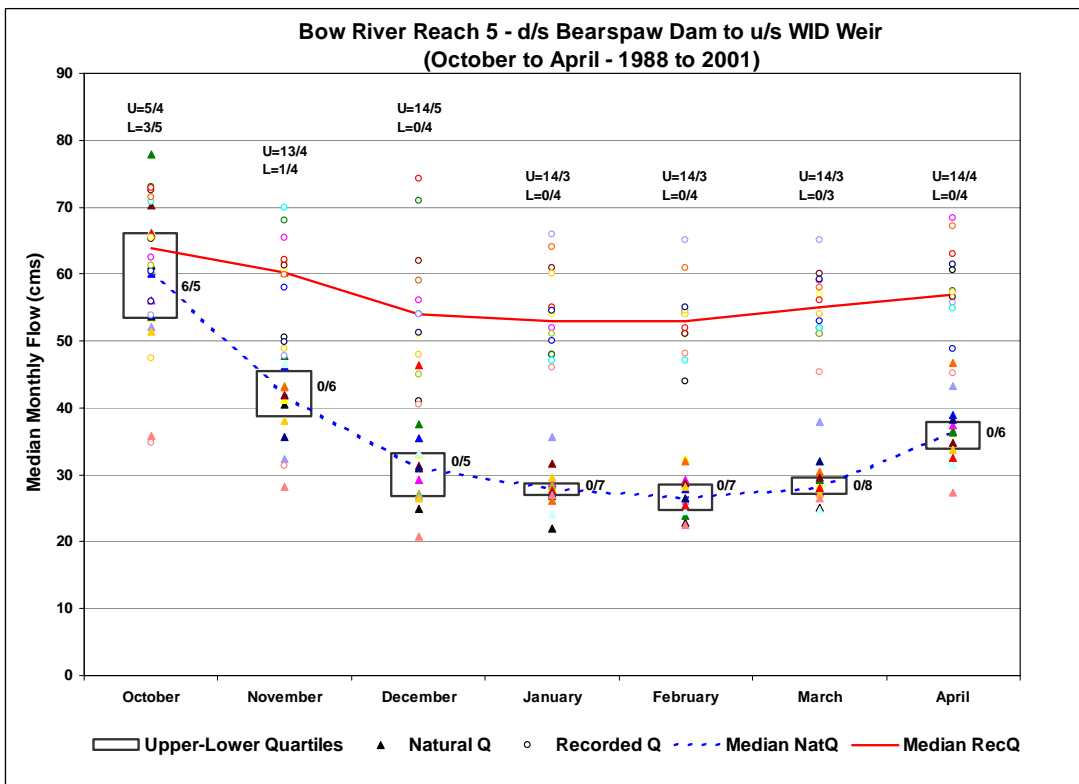
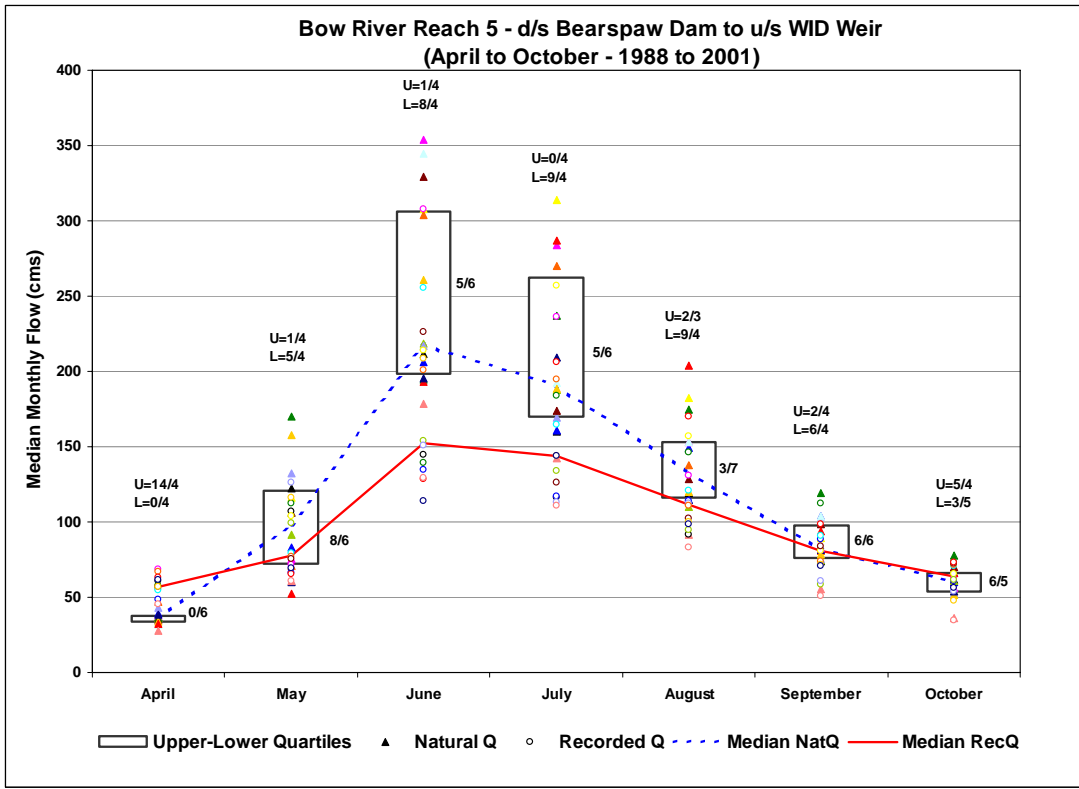
Bow River – Reach #7



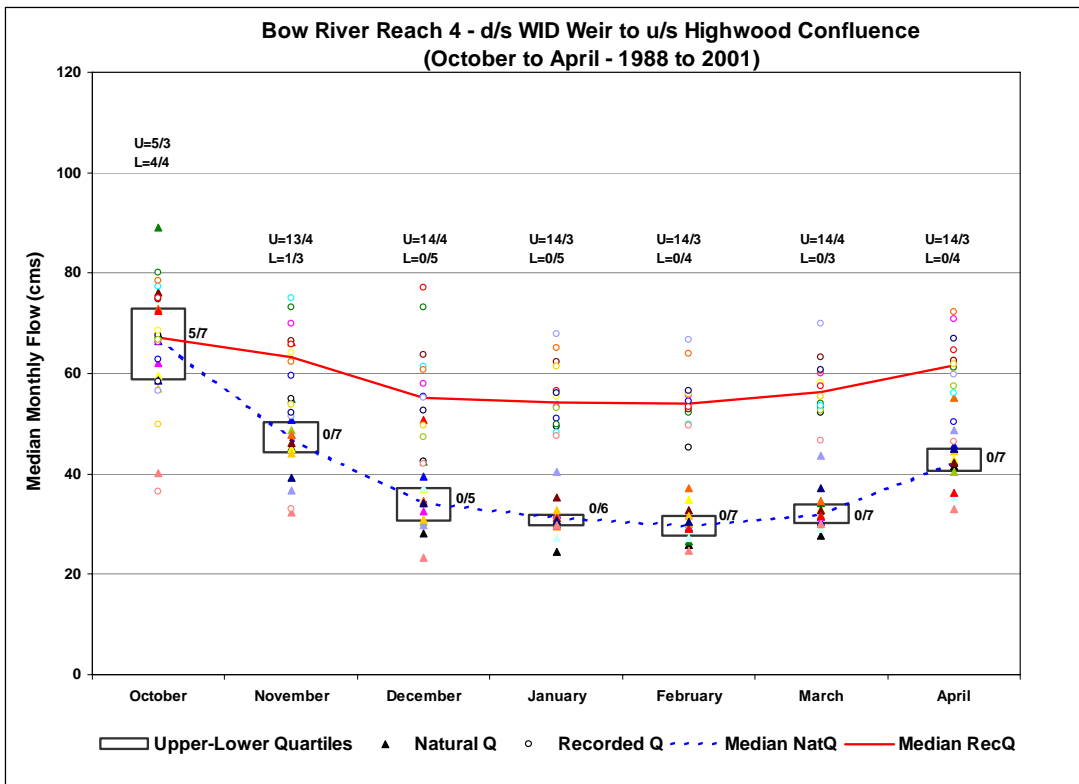
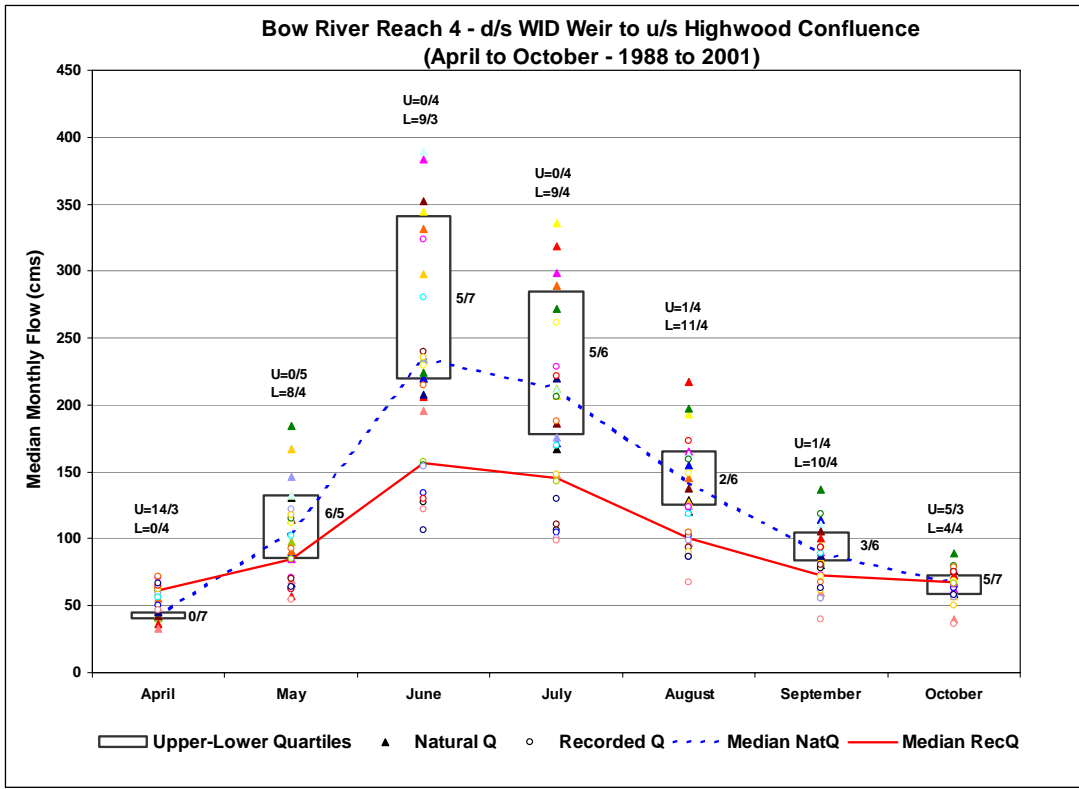
Bow River – Reach #6



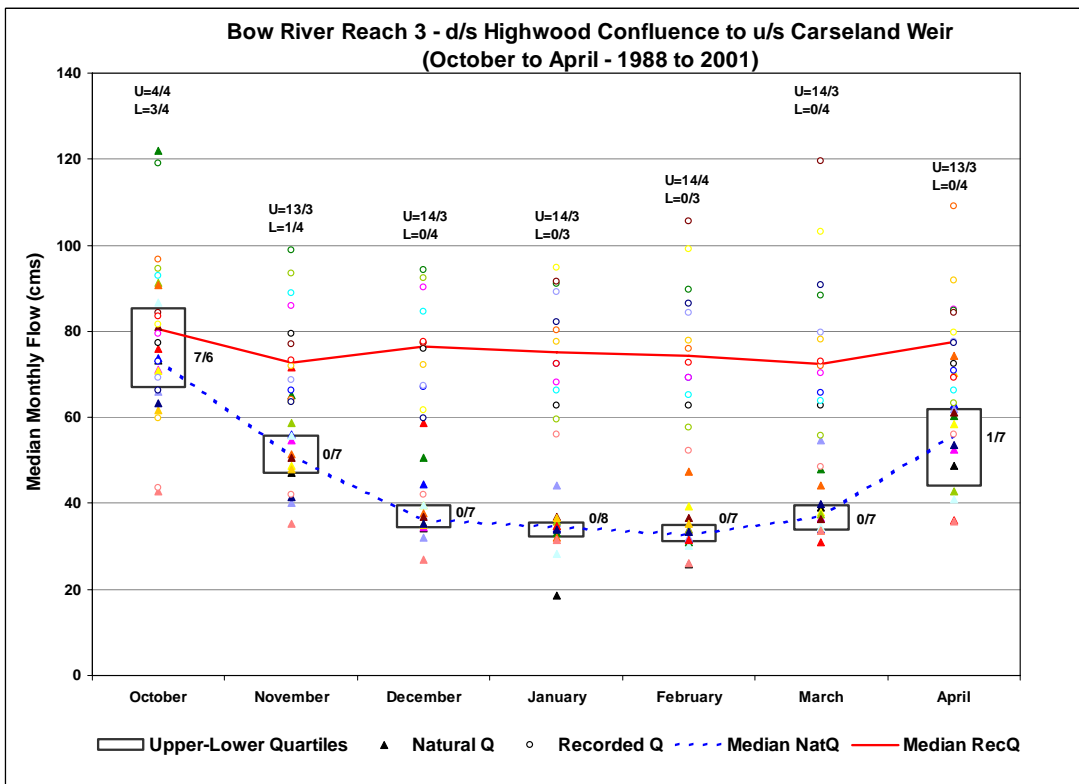
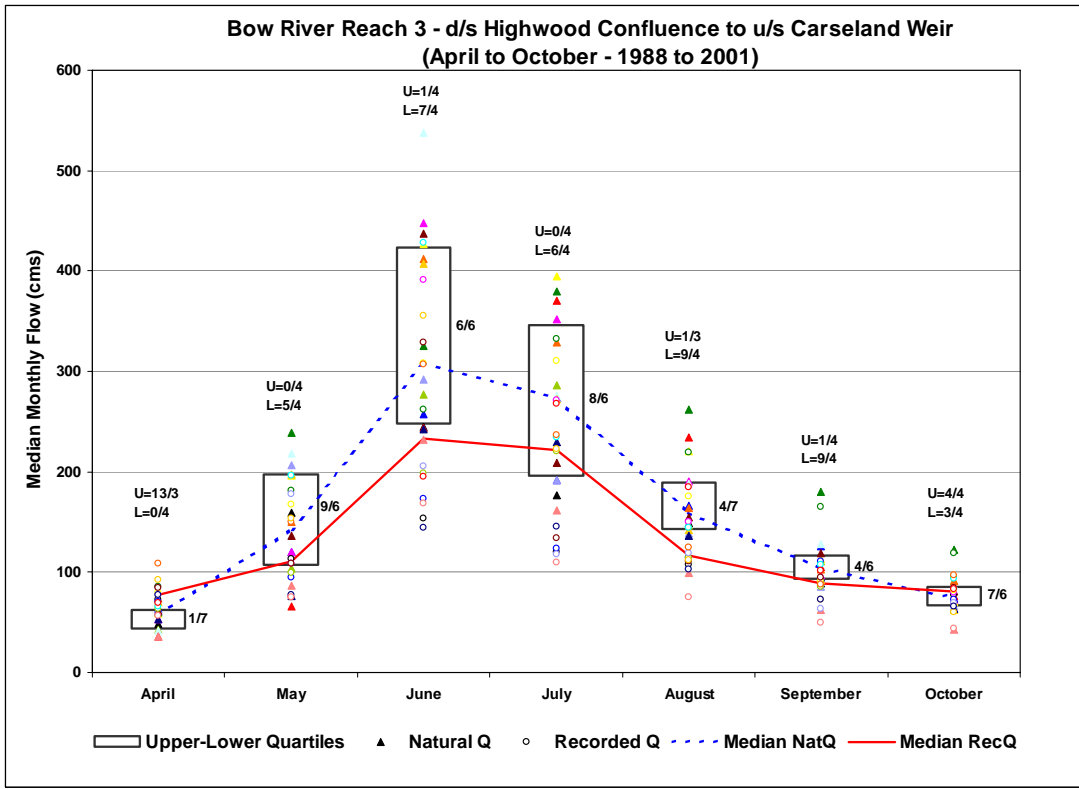
Bow River – Reach #5



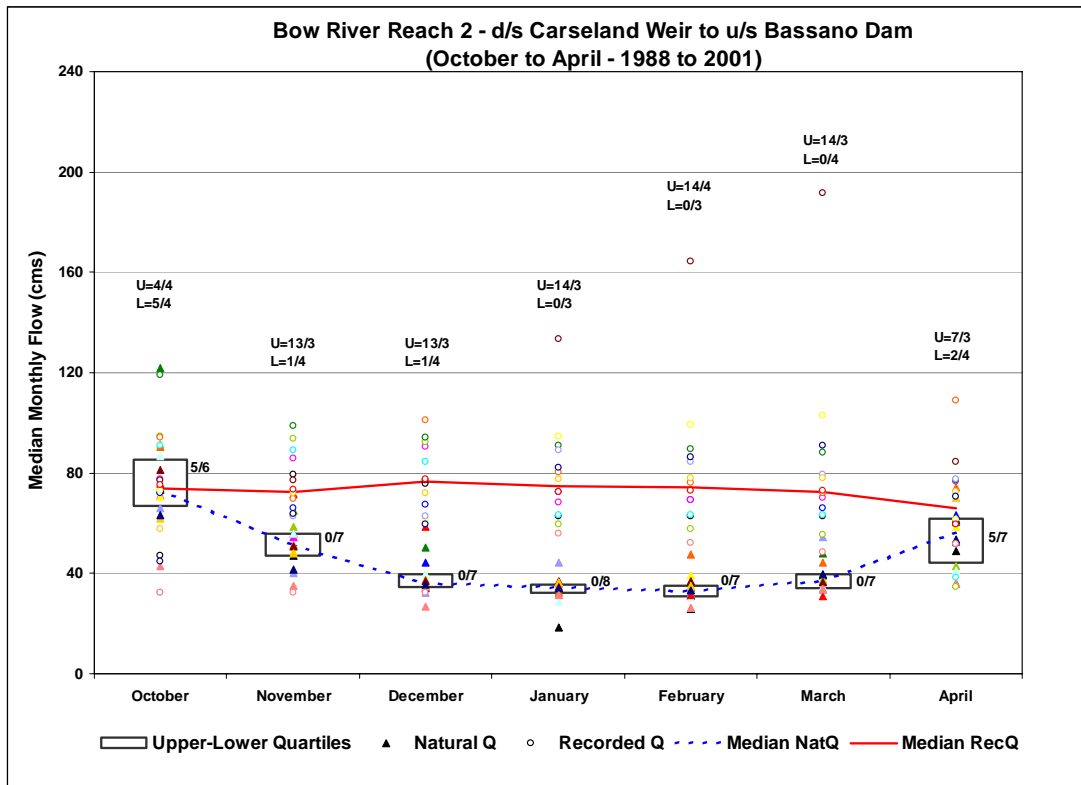
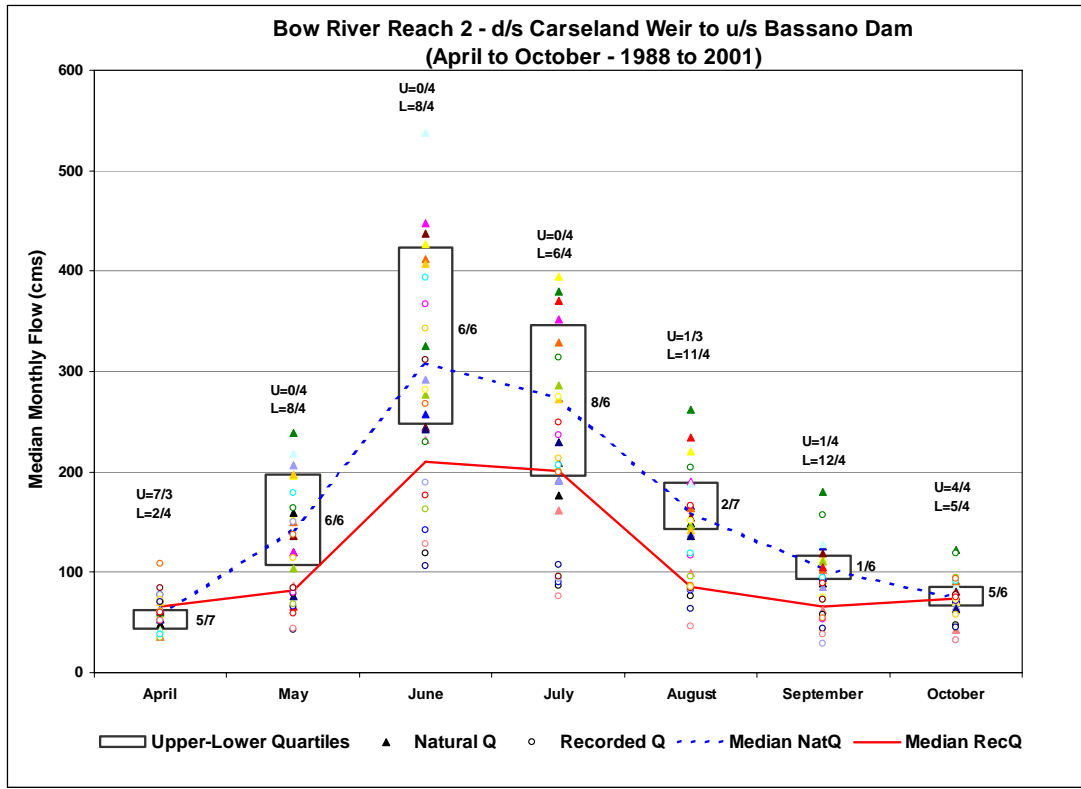
Bow River – Reach #4



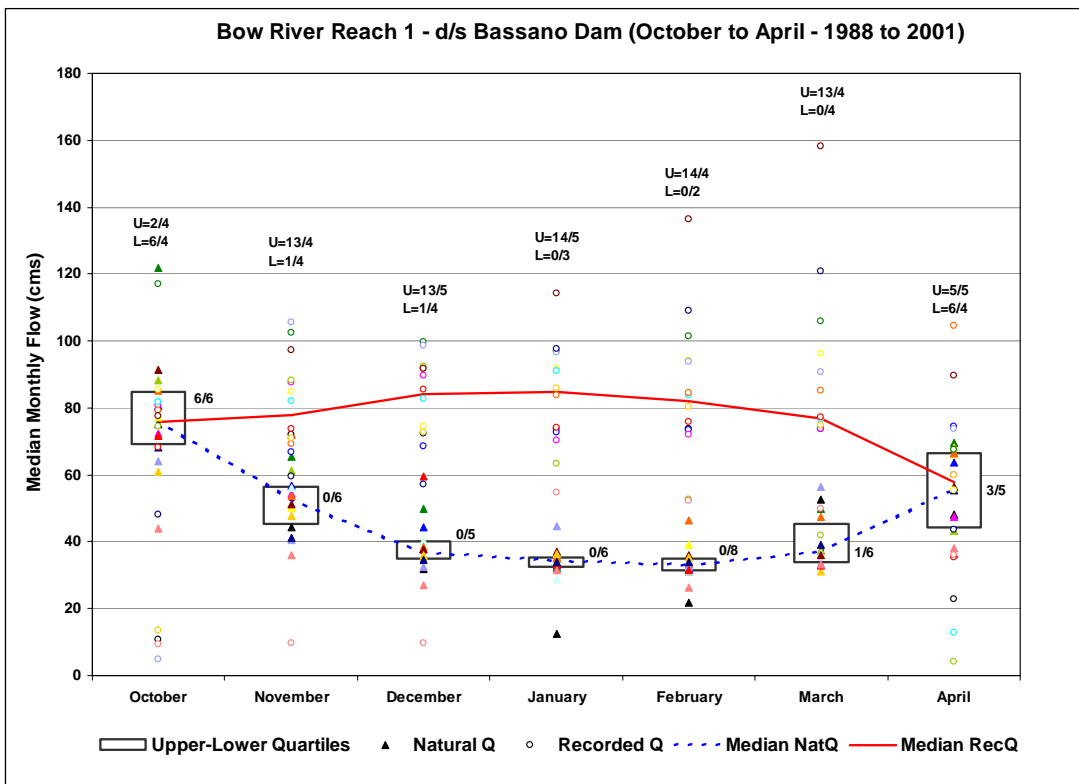
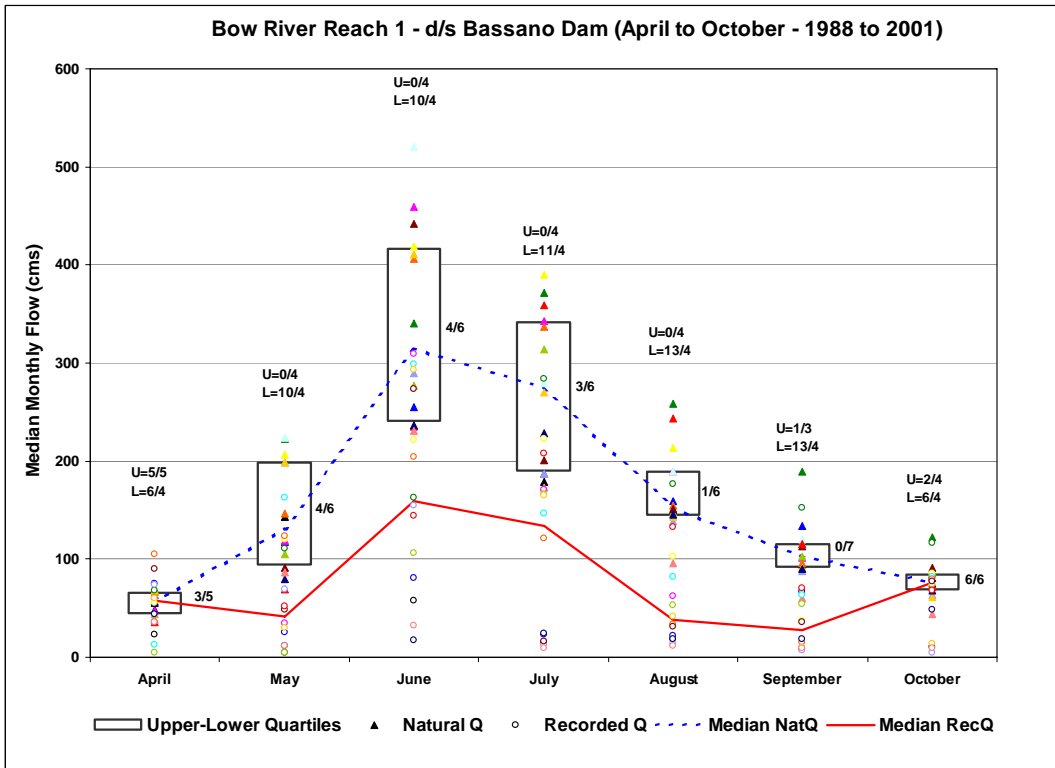
Bow River – Reach #3



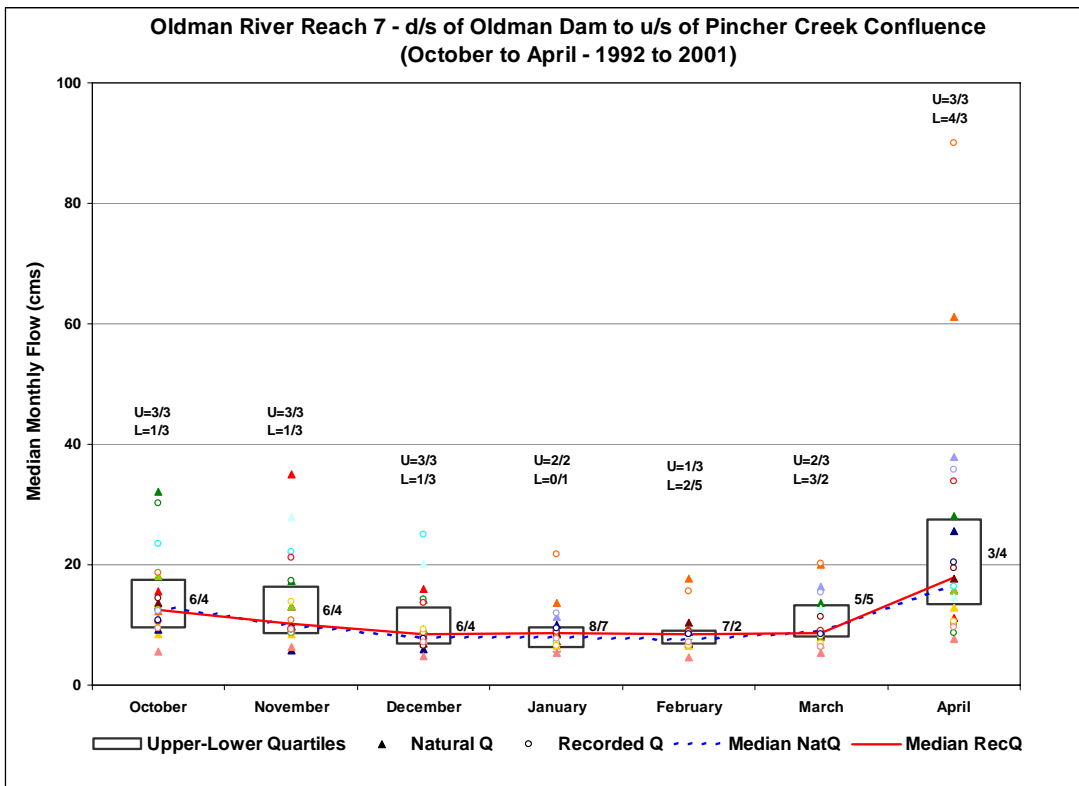
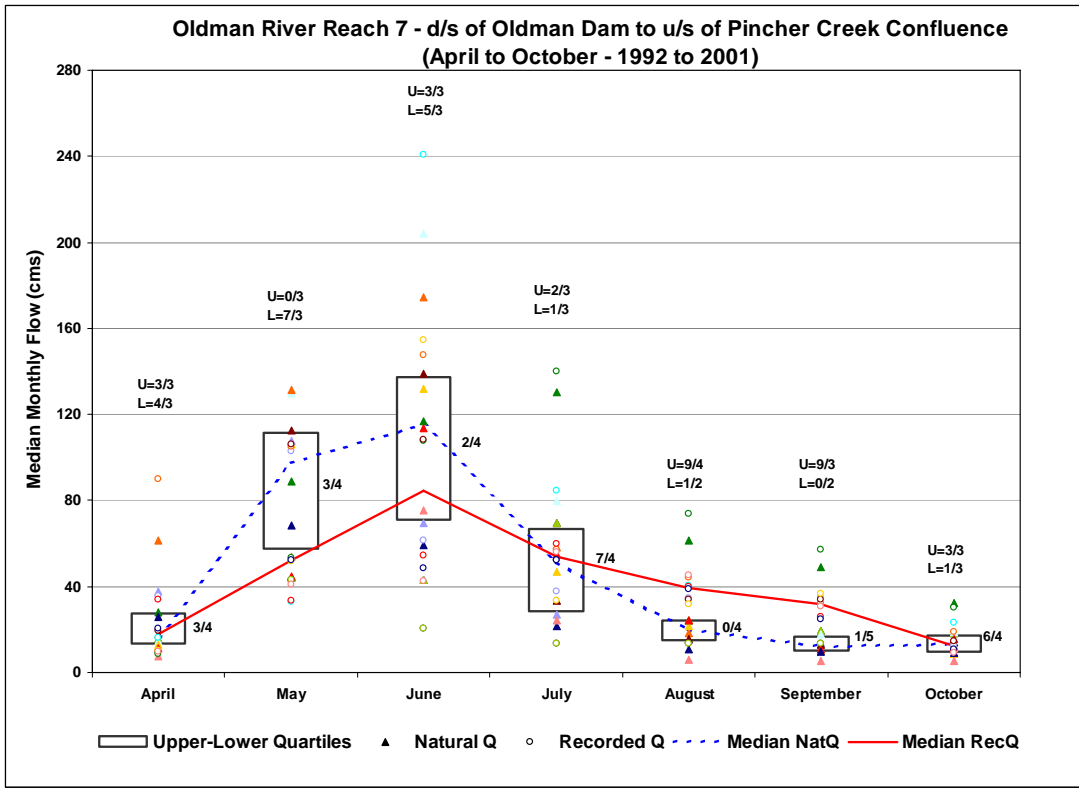
Bow River – Reach #2



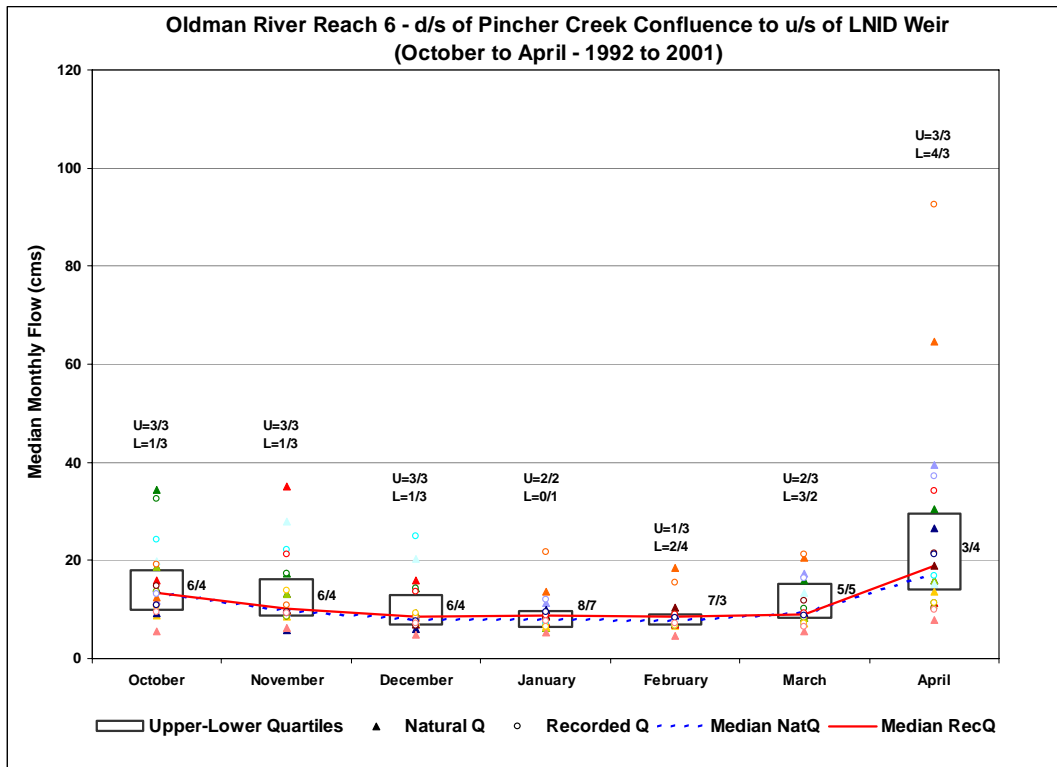
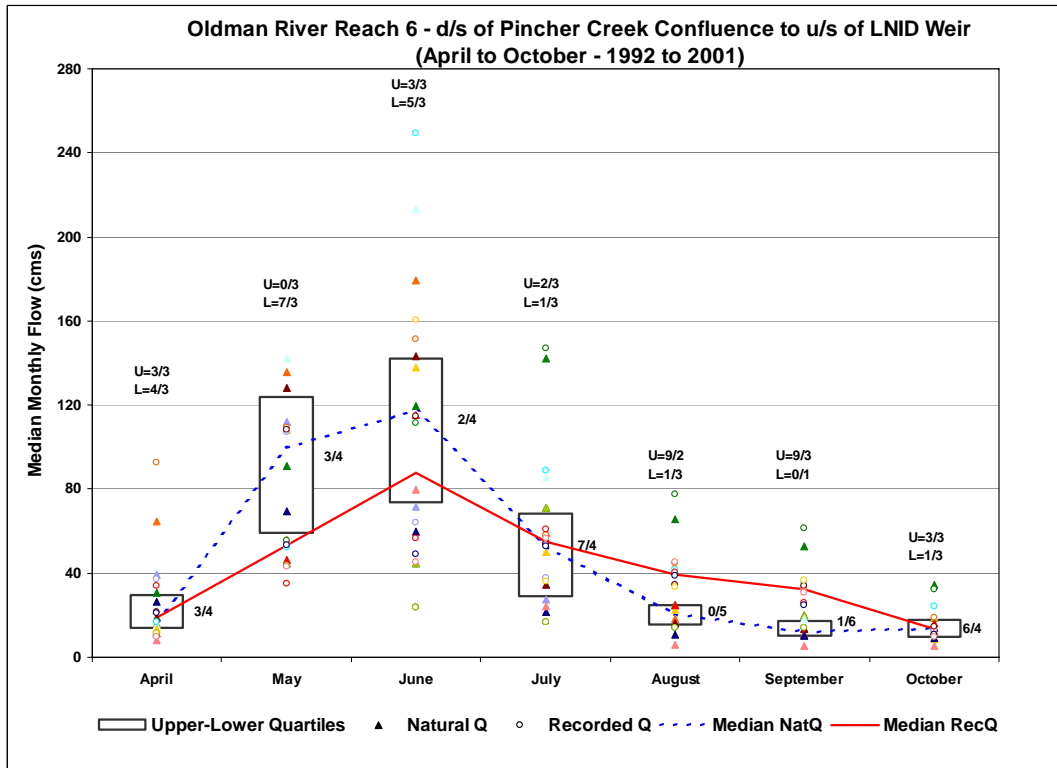
Bow River – Reach #1



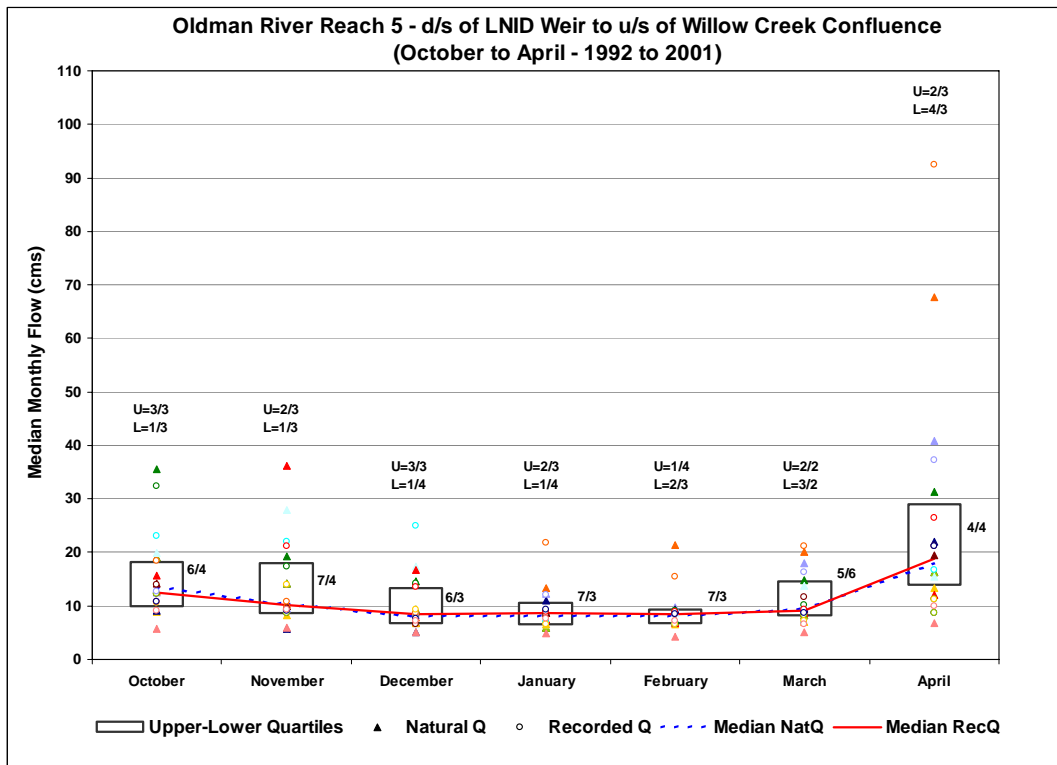
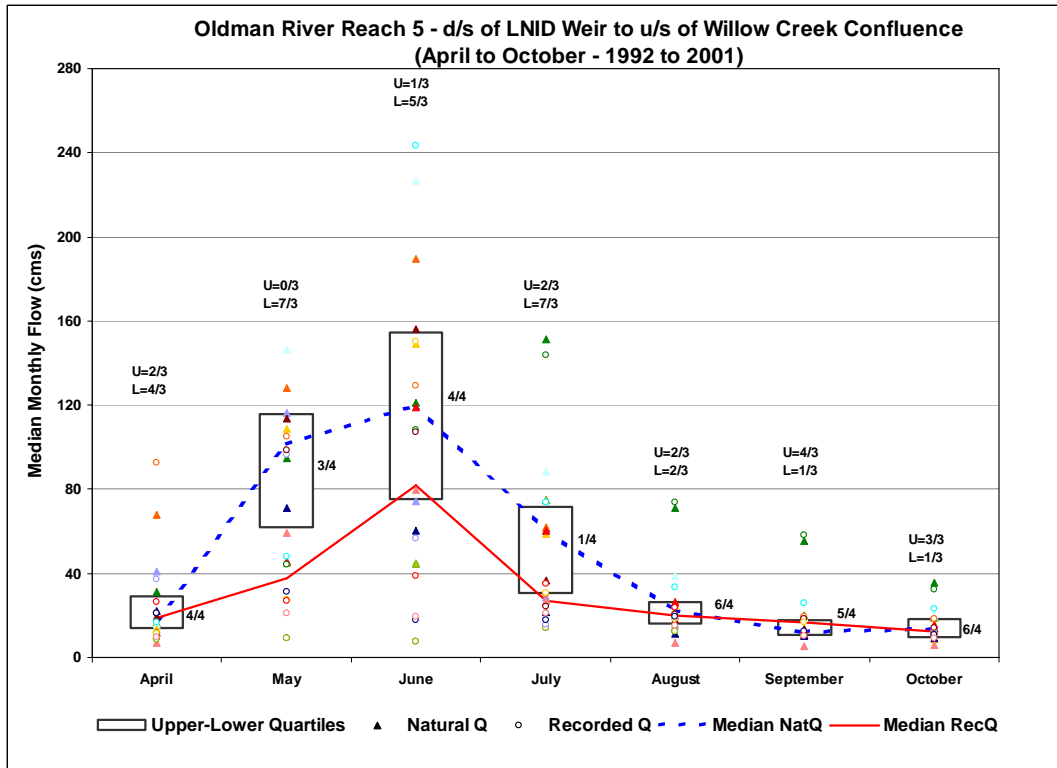
Oldman River – Reach #7



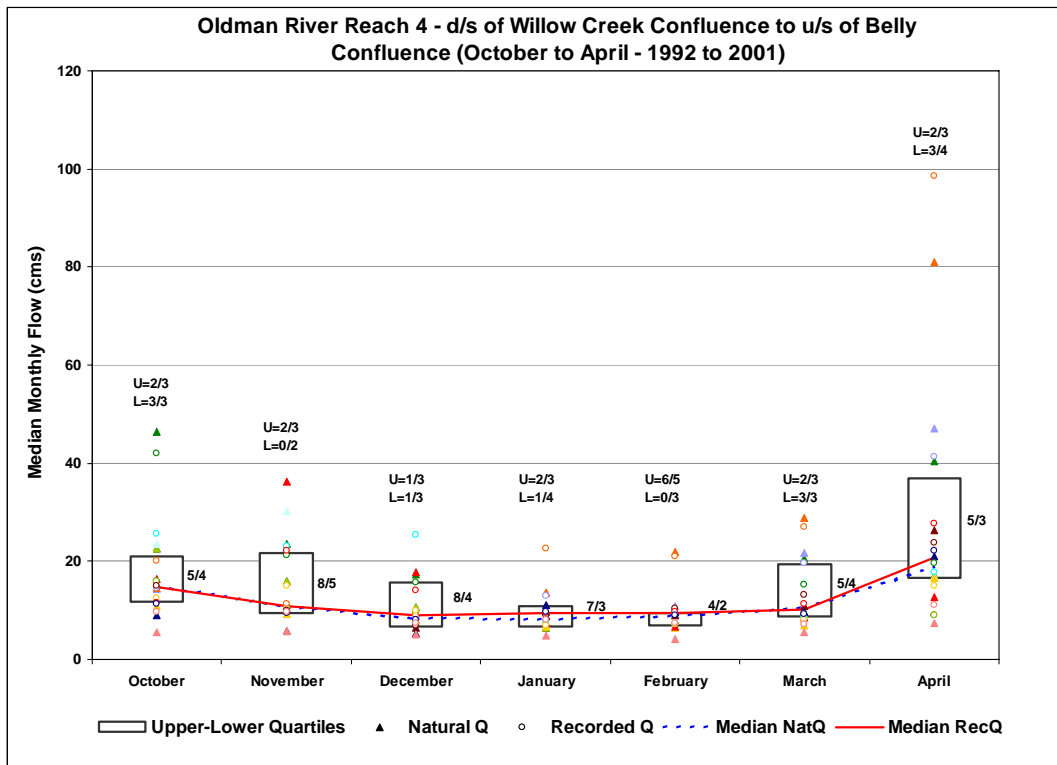
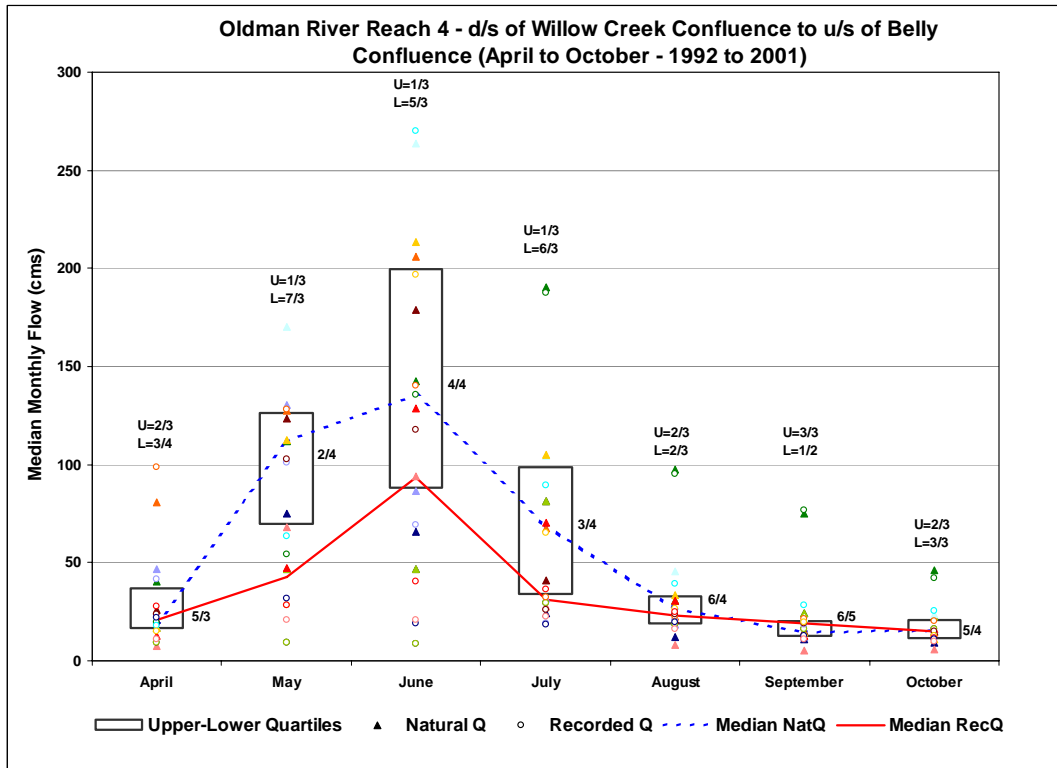
Oldman River – Reach #6



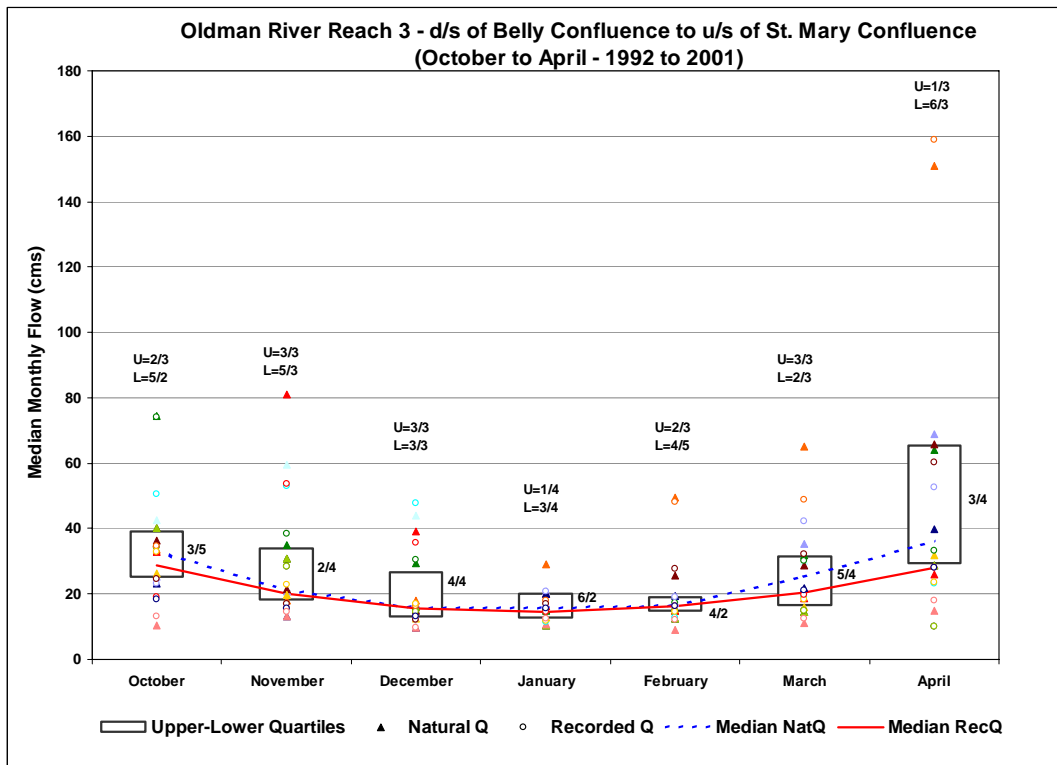
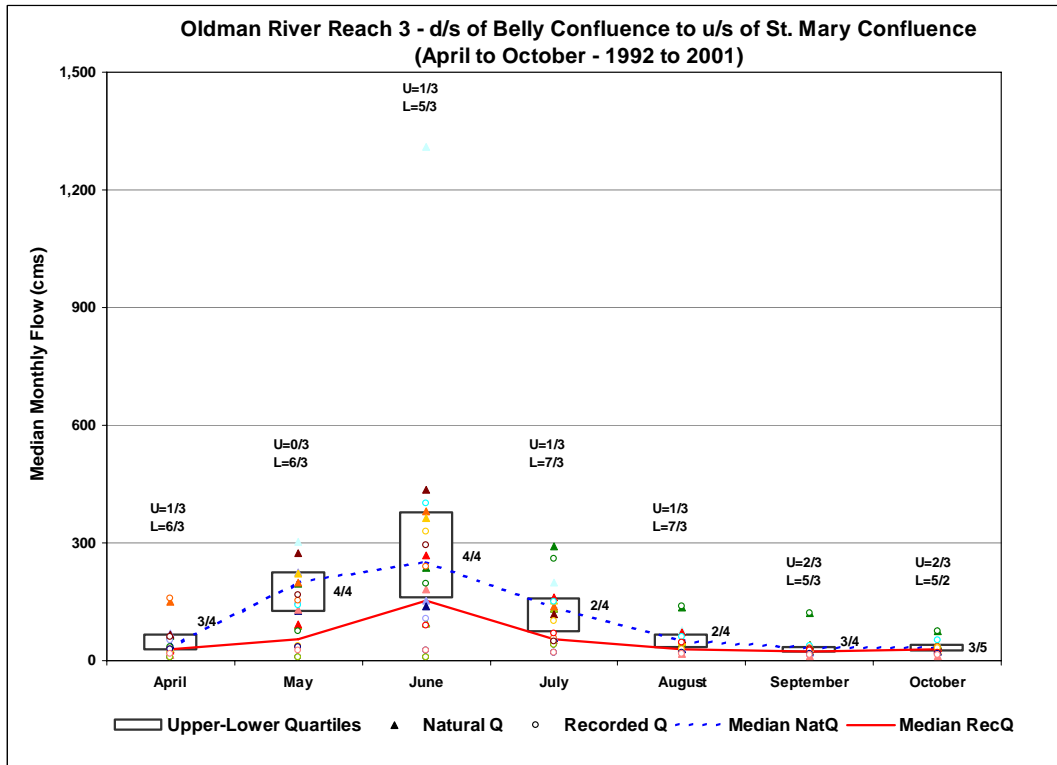
Oldman River – Reach #5



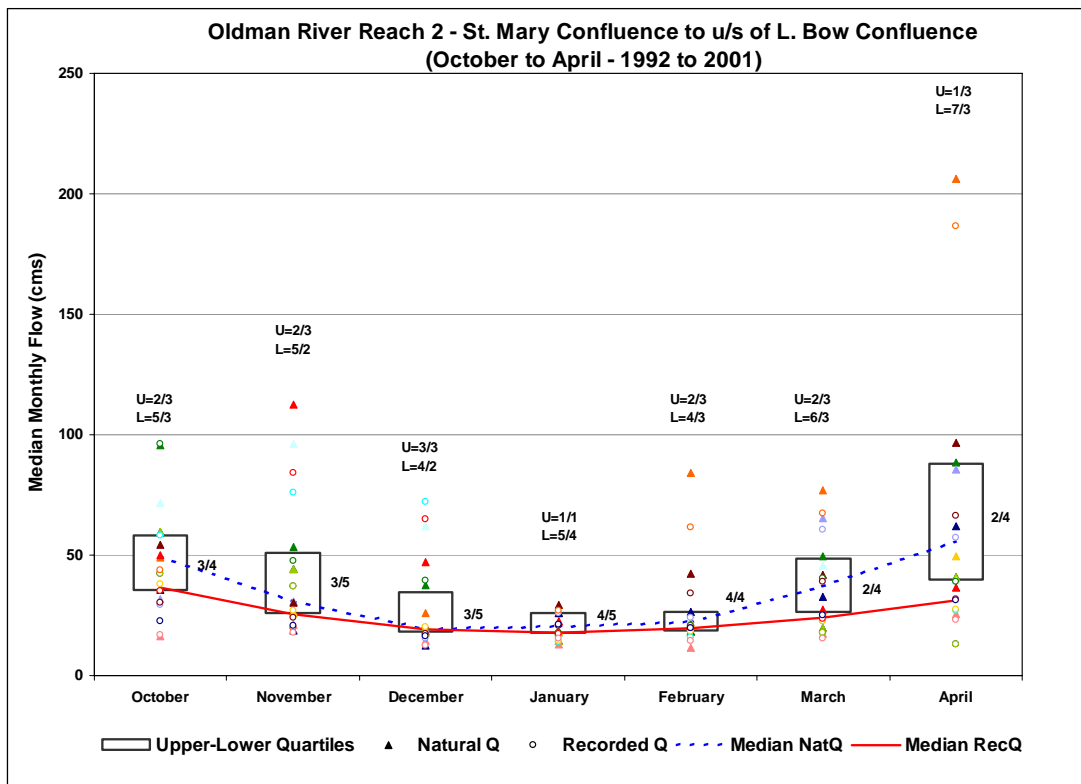
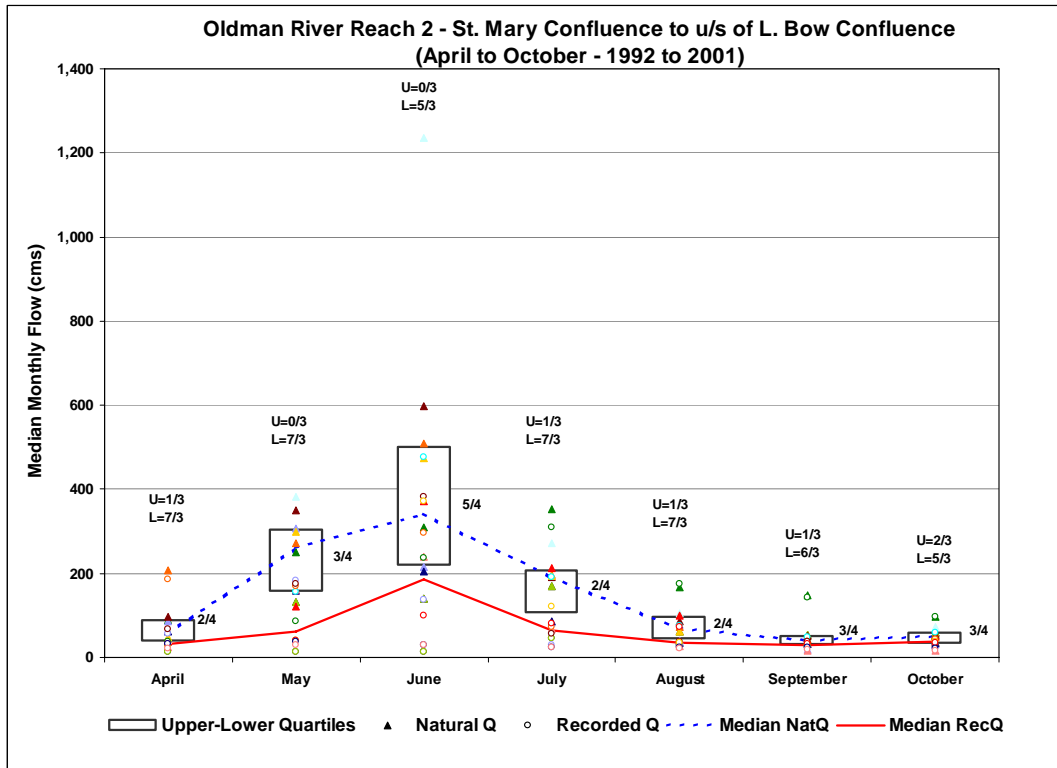
Oldman River – Reach #4



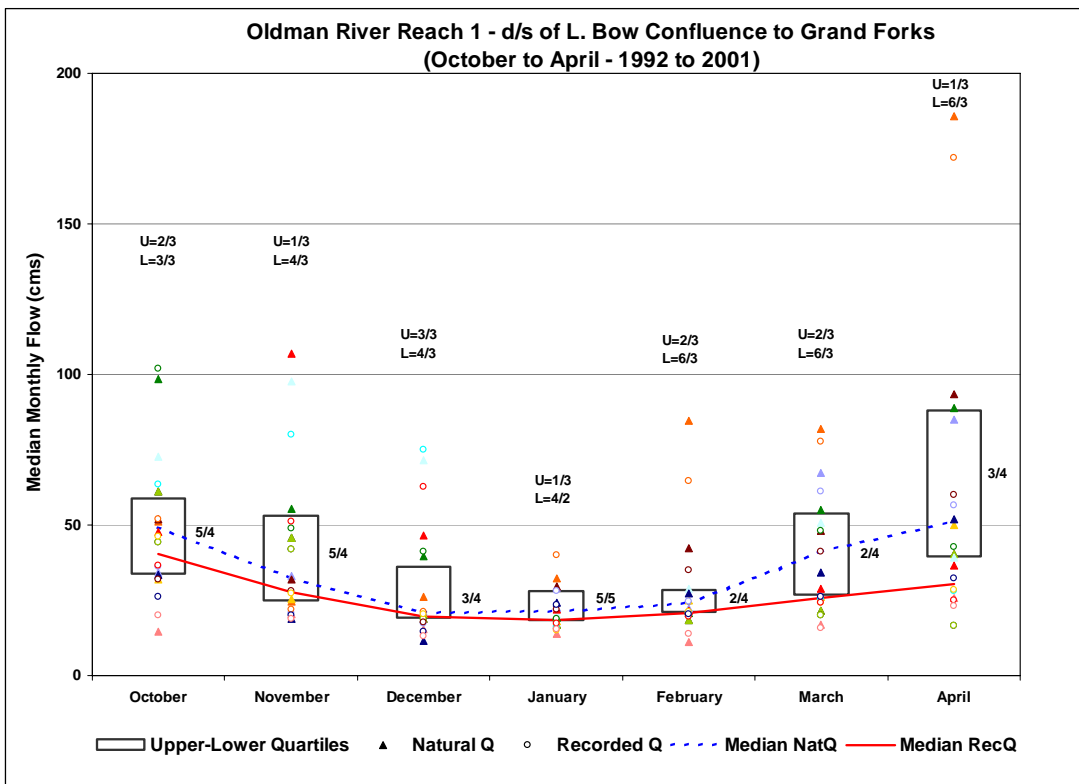
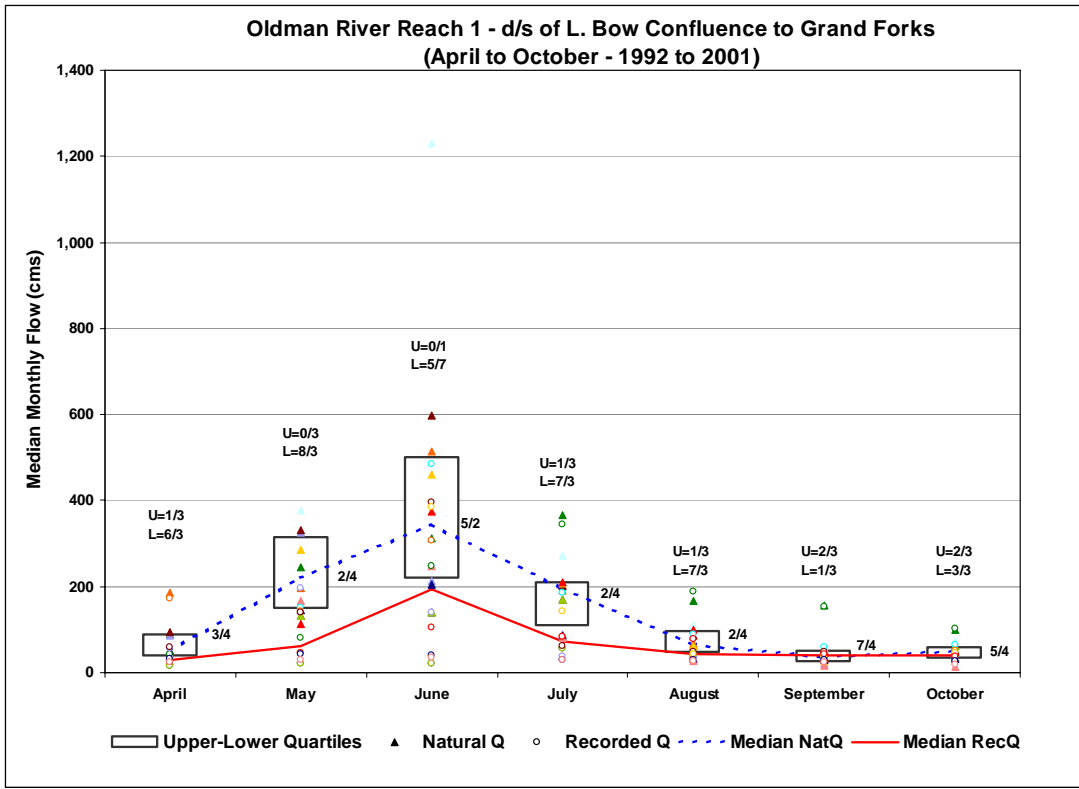
Oldman River – Reach #3



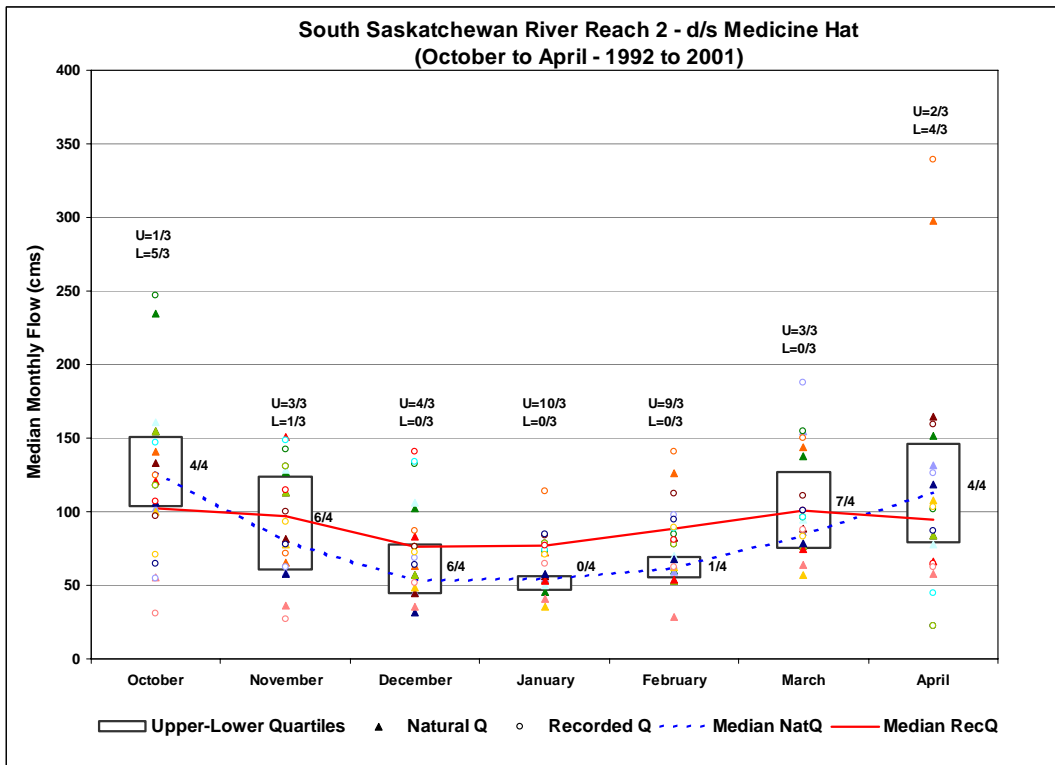
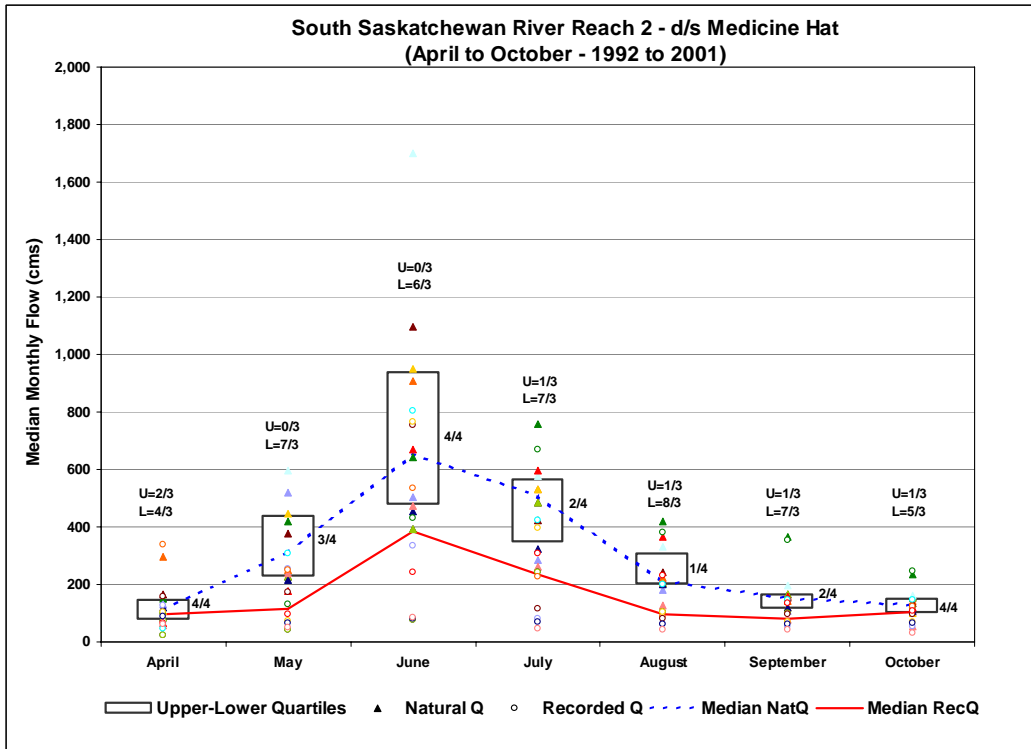
Oldman River – Reach #2



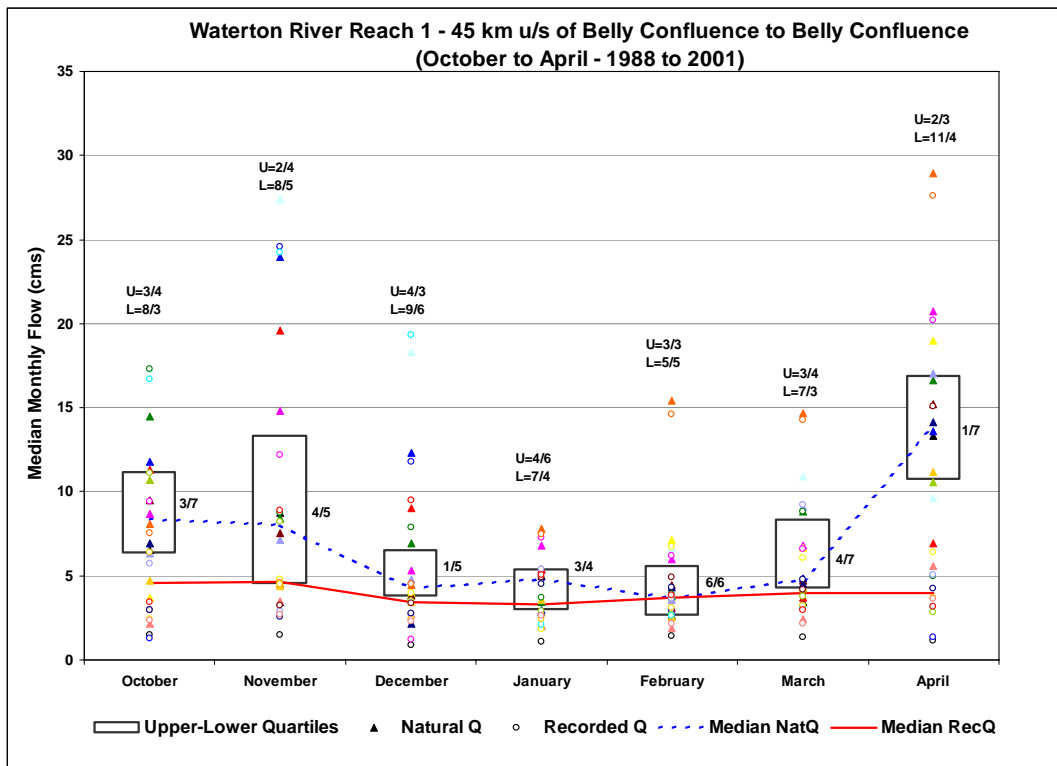
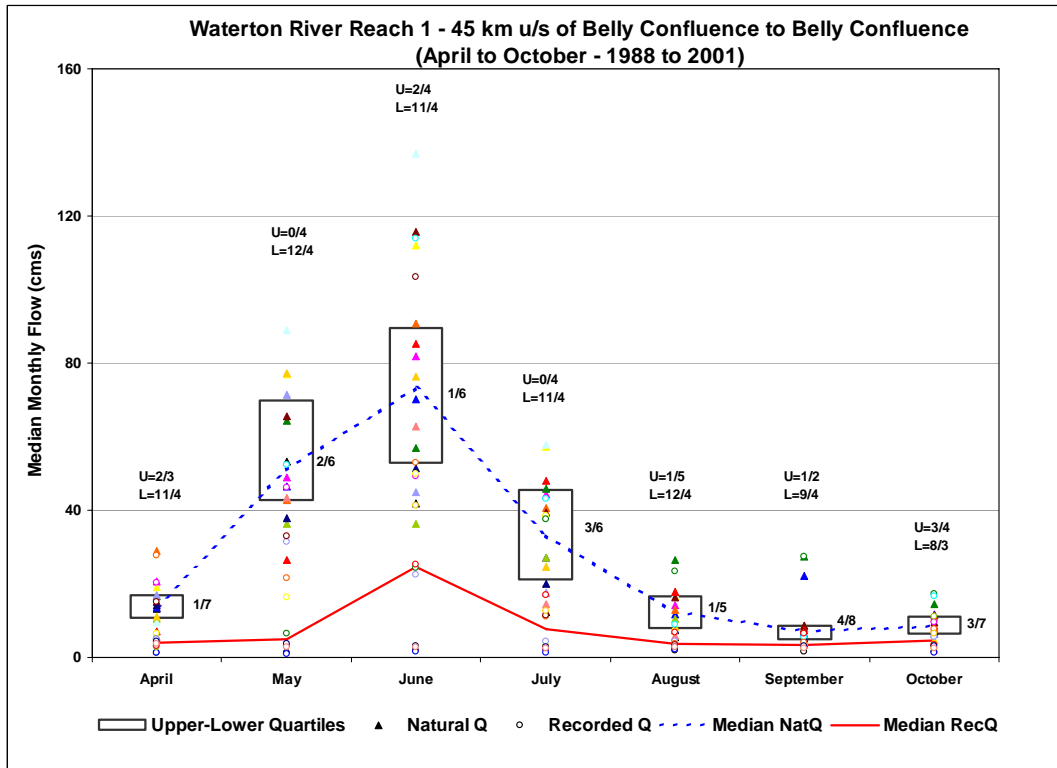
Oldman River – Reach #1



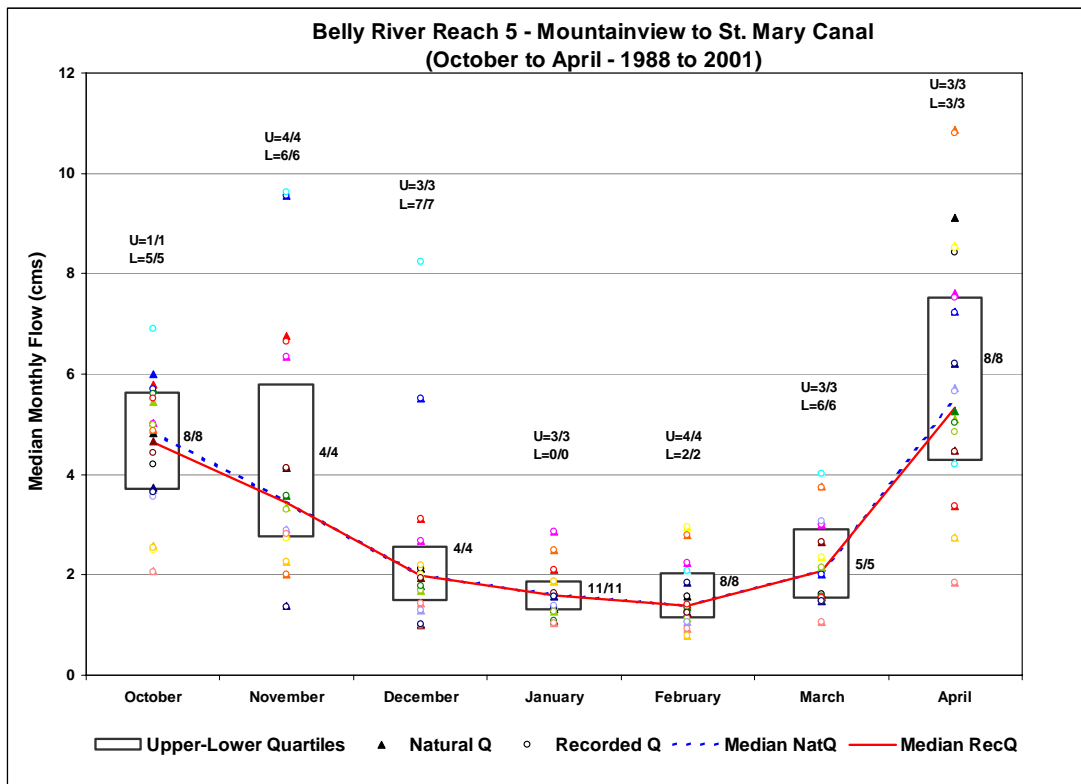
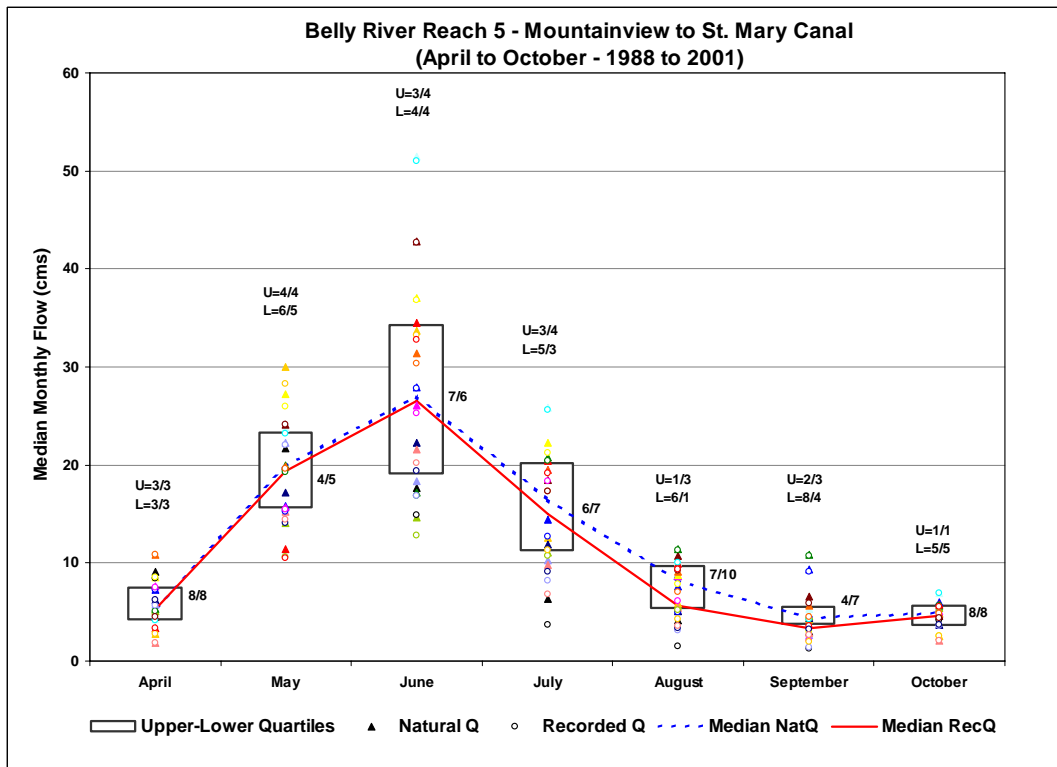
South Saskatchewan River – Reach #2



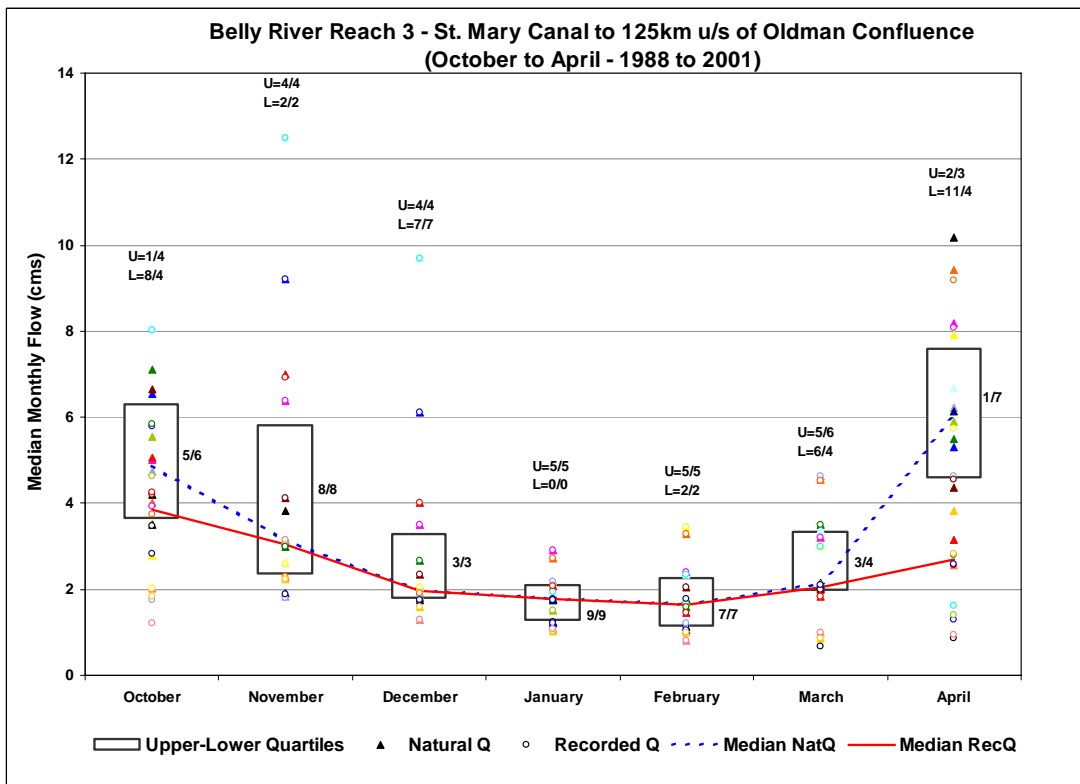
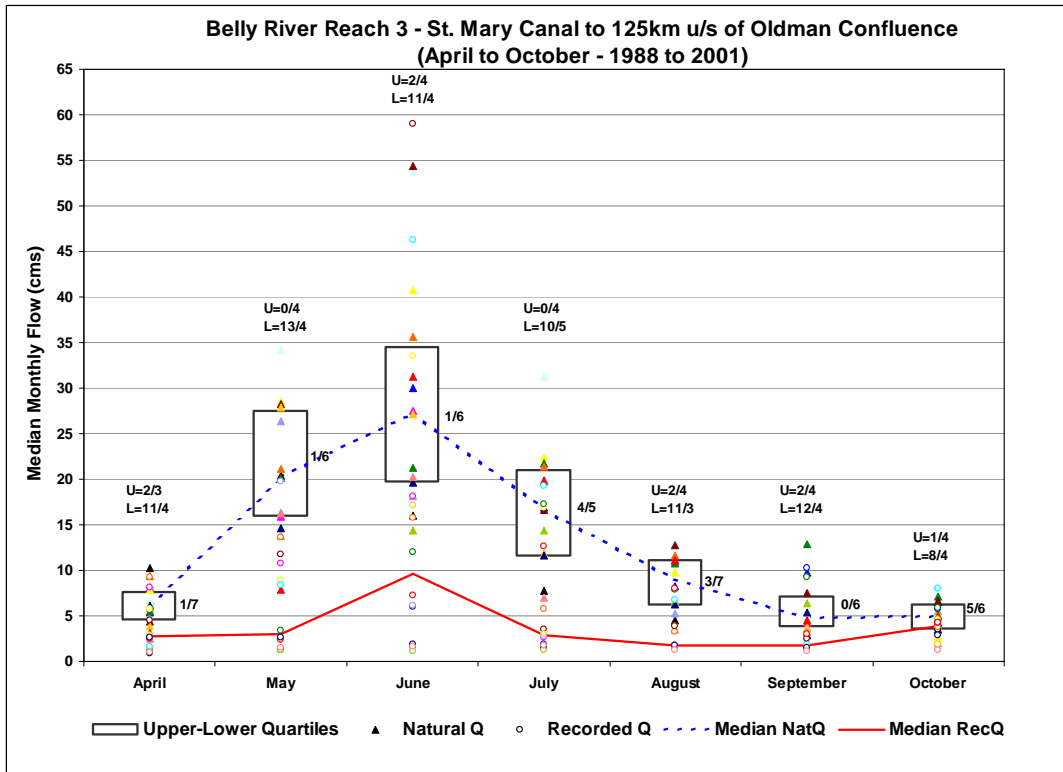
Waterton River – Reach #1



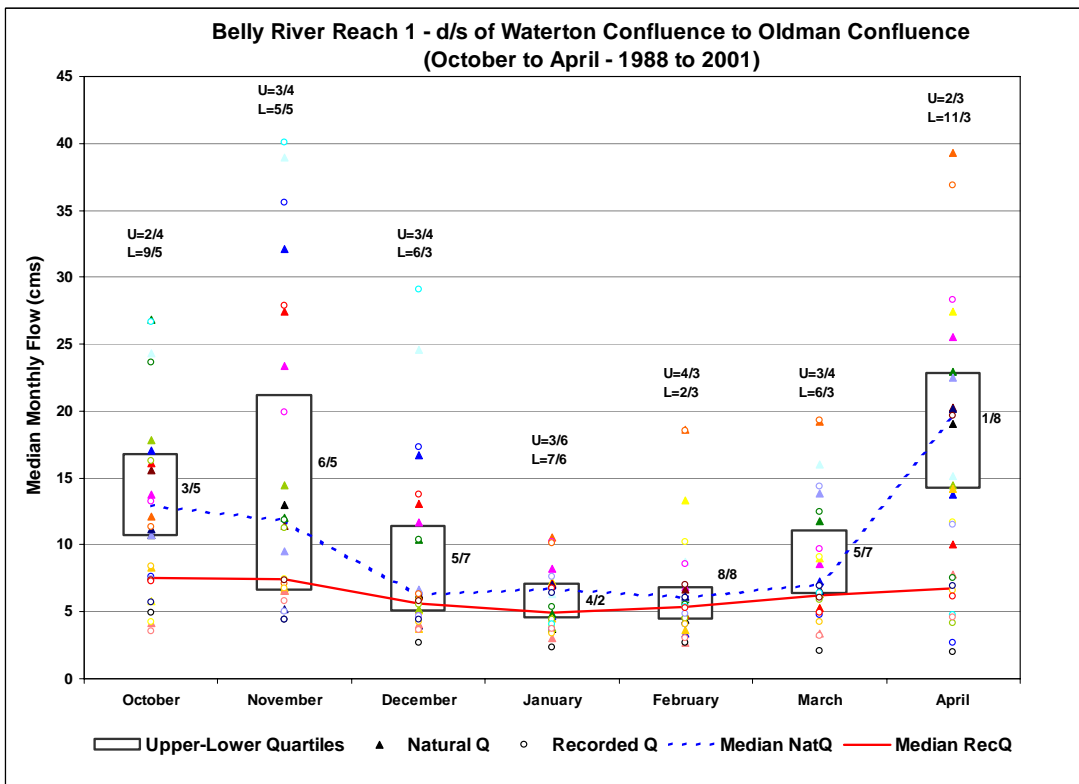
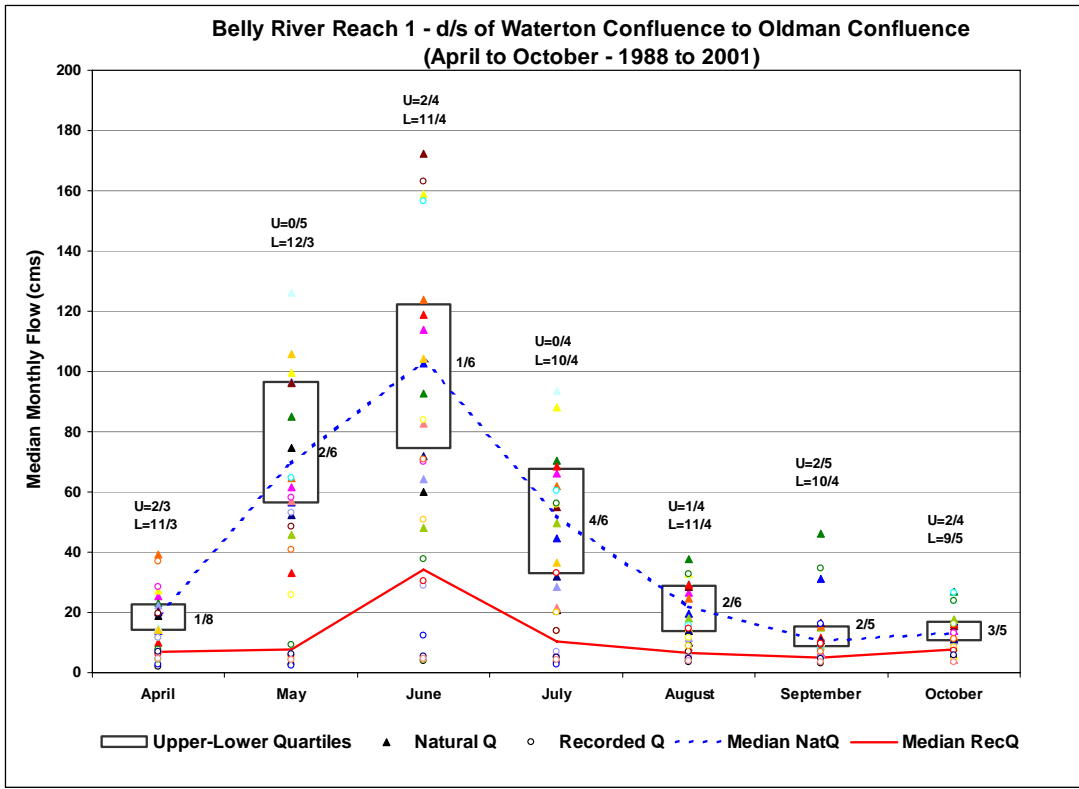
Belly River – Reach #5



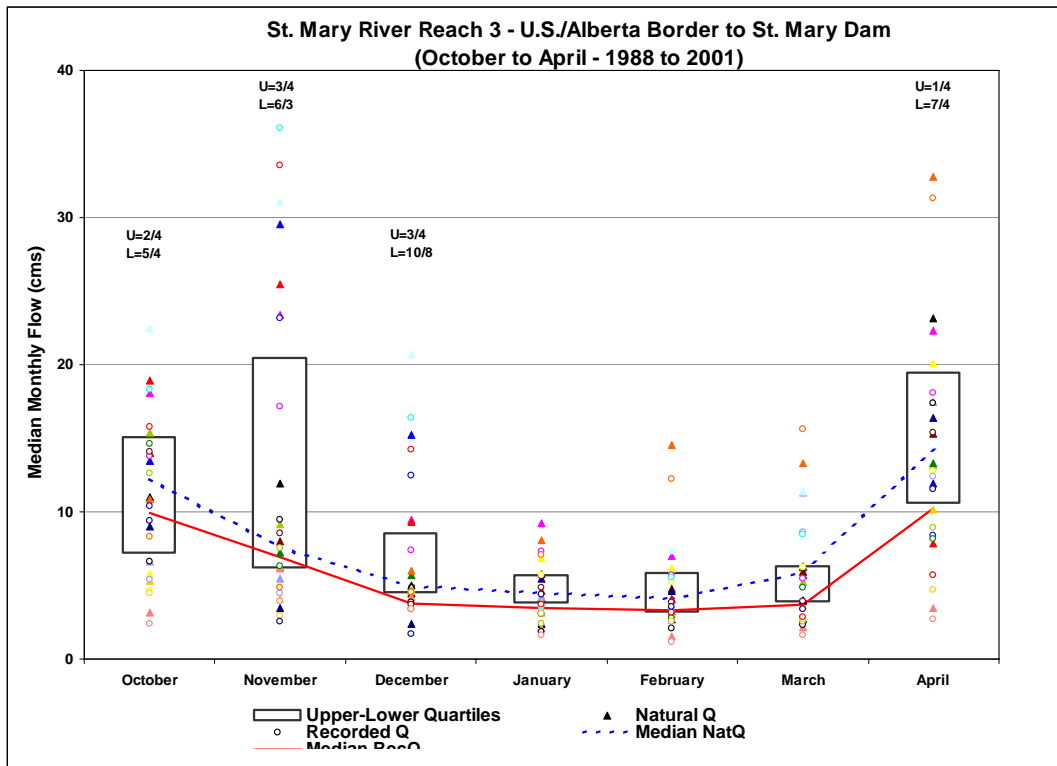
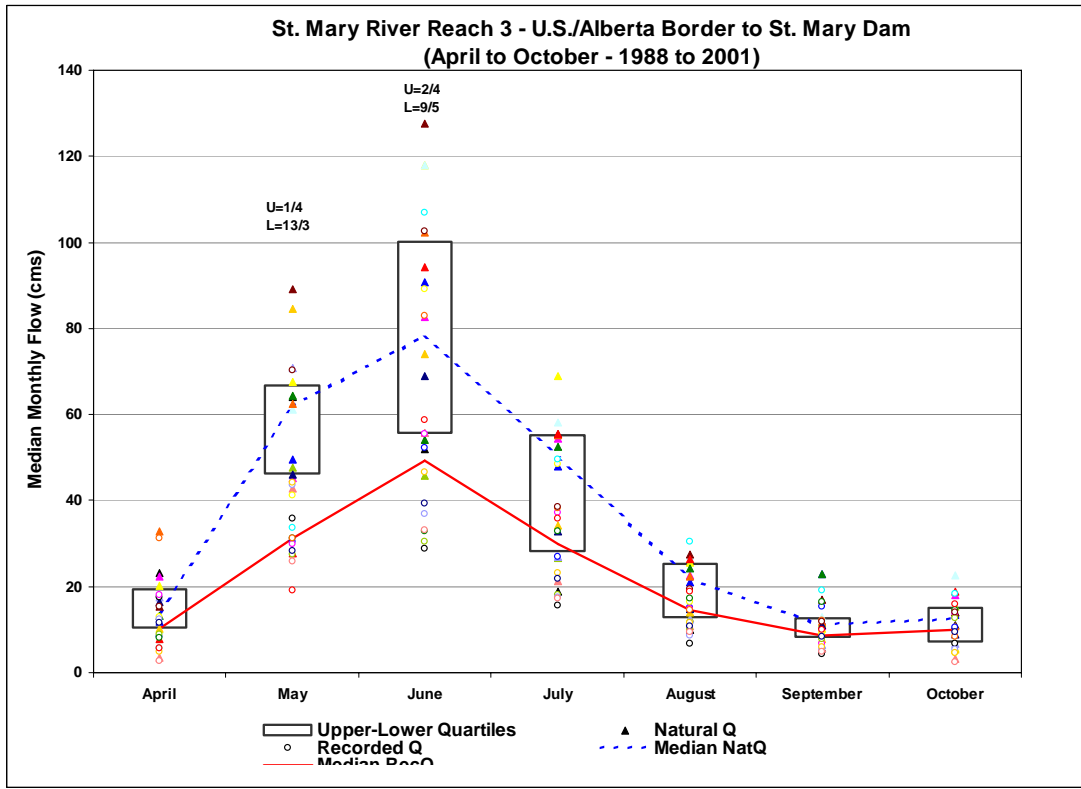
Belly River – Reach #3



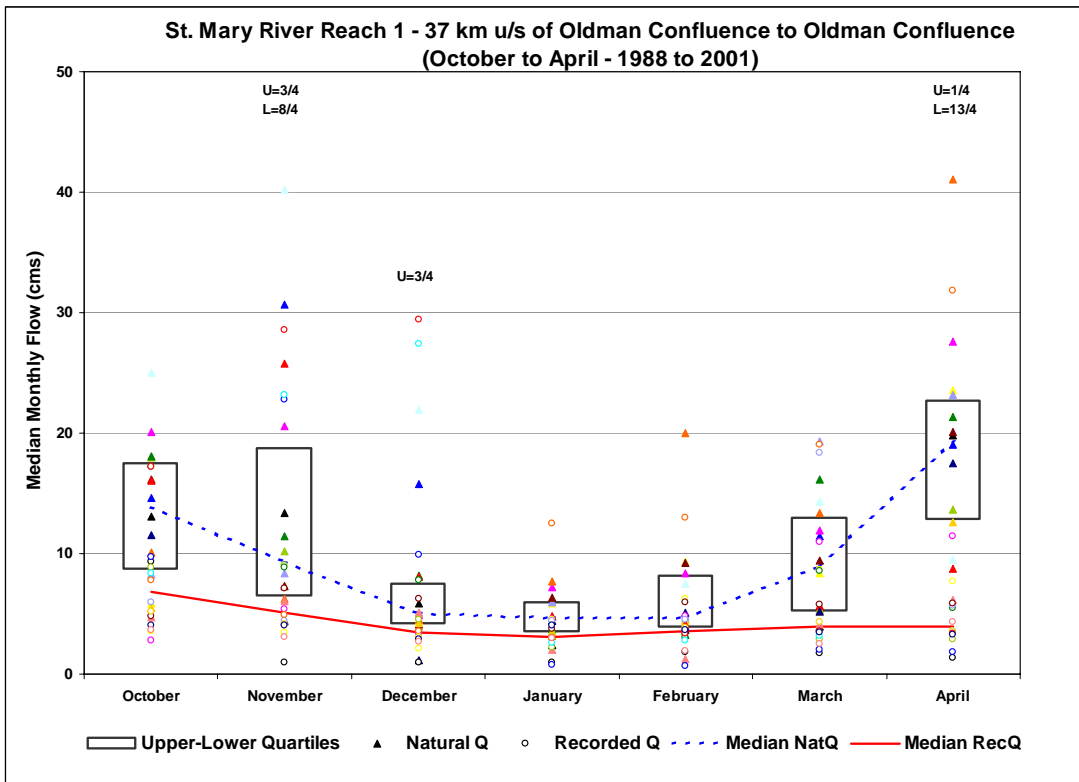
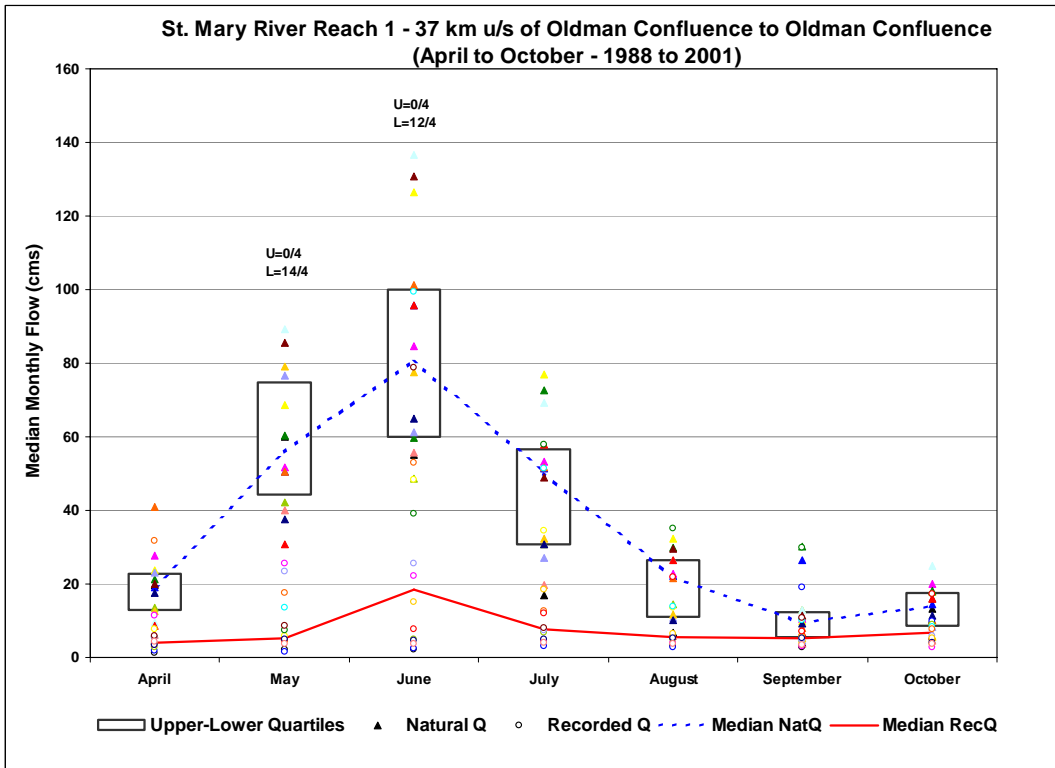
Belly River – Reach #1



St. Mary River – Reach #3



St. Mary River – Reach #1



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