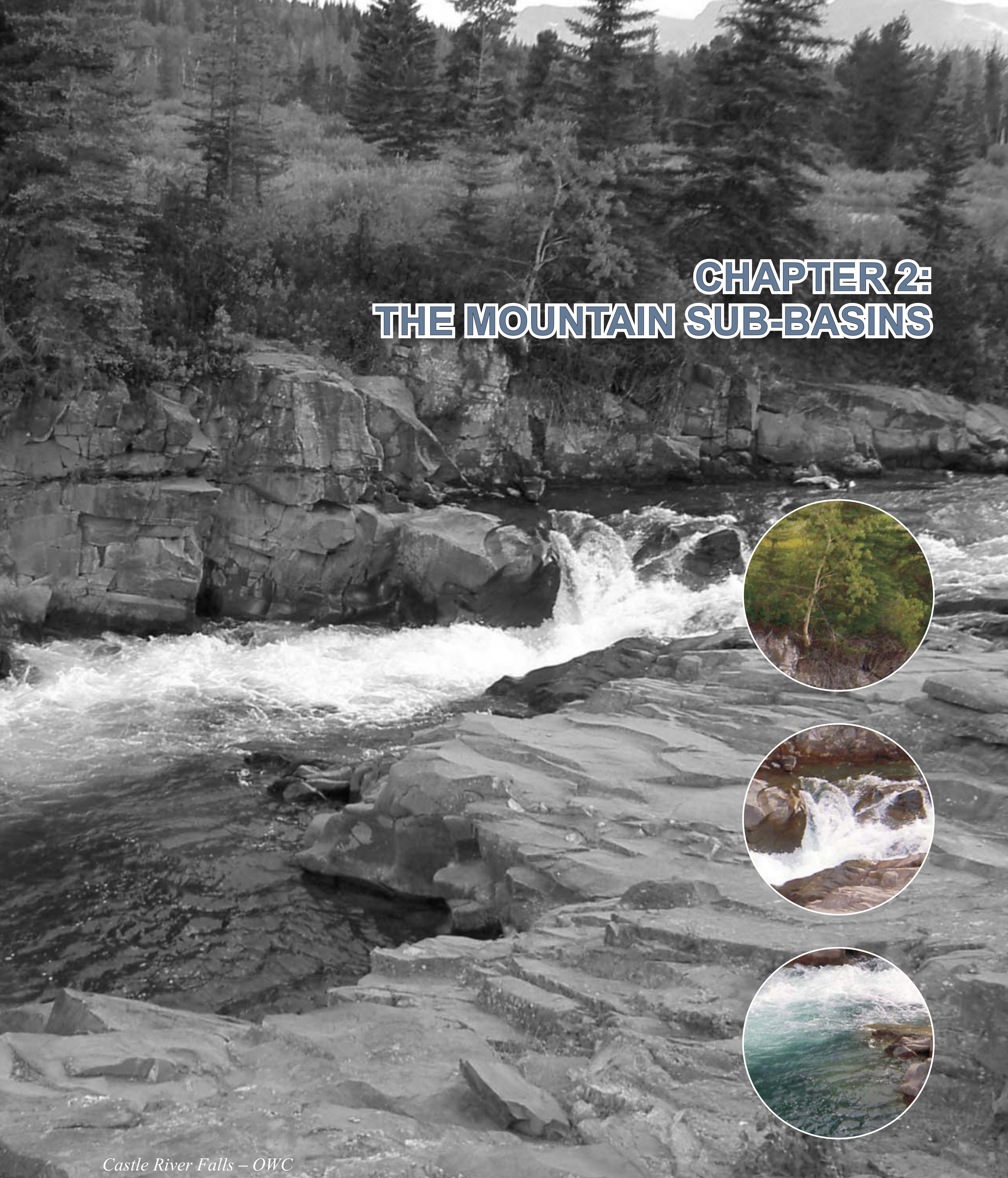
CHAPTER 2: THE MOUNTAIN SUB-BASINS



Castle River Falls – OWC

Chapter 2: The Mountain Sub-basins

The Mountain Sub-basins comprise the westernmost portion of the Oldman watershed (Figure 2.1). Three primary rivers, the Crowsnest, Castle and Oldman, rise in the high elevation areas of the continental divide and separate the Mountain Sub-basins into the Castle River sub-basin, the Crowsnest River sub-basin and an ungauged area that drains into the Oldman River. This latter area will be included in discussion of the Oldman River mainstem in Chapter 6. The Mountain Sub-basins are centered on the Crowsnest Pass and include the towns of Blairmore, Coleman, Cowley, Frank, Hillcrest, and Lundbreck. The landscape is historically rich and has a diversity of landforms and ecological features.

Approaching Cowley on Highway 3 near the eastern edge of the Mountain Sub-basins, the mountains rise quickly from the surrounding plains. The foothills are very narrow in this area, and the mountain peaks of steeply dipping folded and faulted Palaeozoic and Mesozoic rocks dominate the visual landscape. Glaciation played an important role in creating the landscape. Over the Quaternary glacial periods, ice carved out the U-shaped form of the Crowsnest Valley by following the ancestral drainage and eroding the sides of the folded mountains. The same processes occurred throughout the sub-basins creating classic features of glacial erosion – cirques, tarns, hanging valleys, waterfalls, and flat valley bottoms filled with glacial outwash. The process of eroding valley sides from a V-shaped form created by rivers to a U-shaped form created by moving ice is called glacial over-steepening. This process combined with already fractured and faulted rock and subsurface coal mining to create the conditions for the Frank Slide (ESA #2).

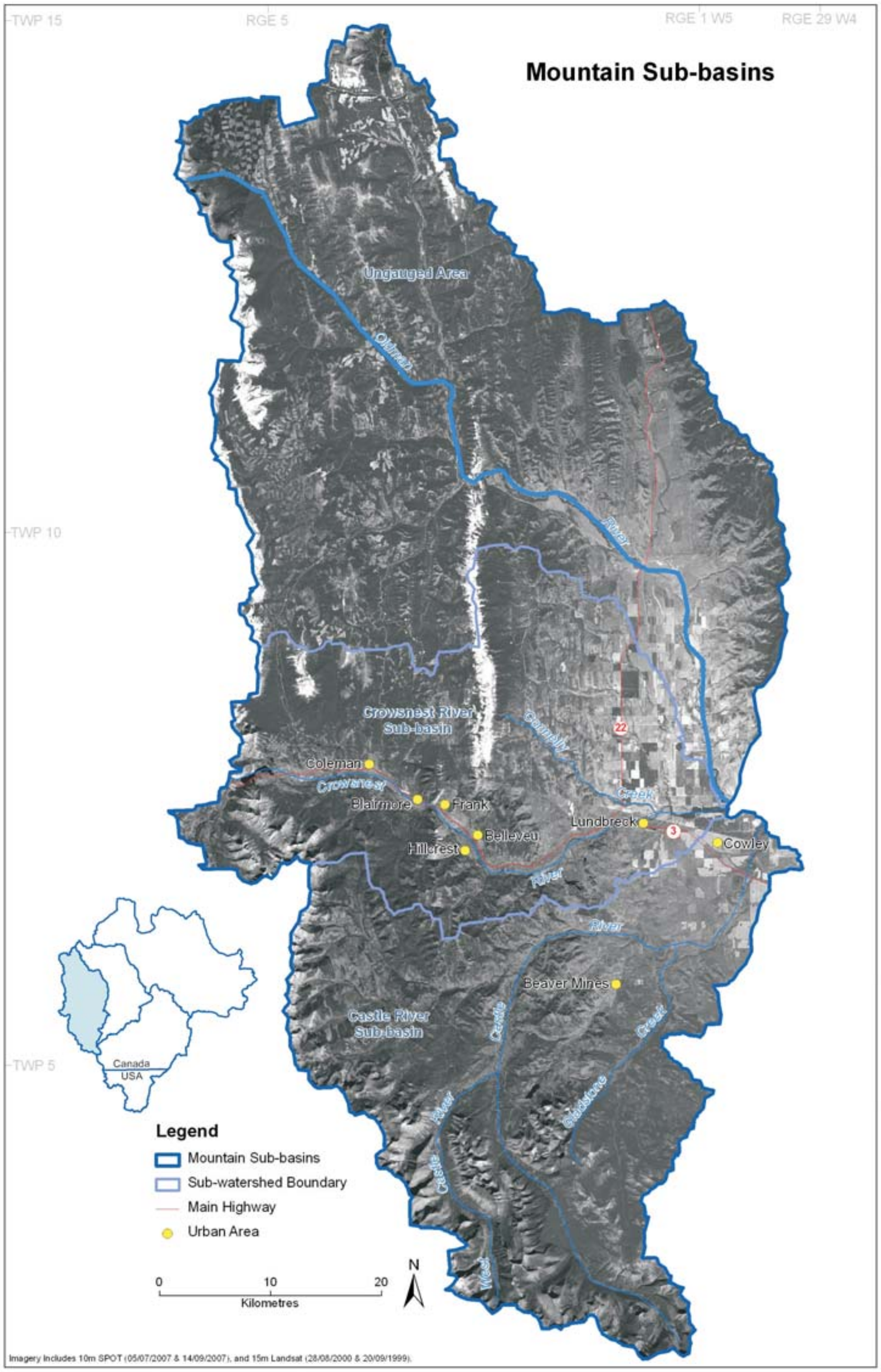


Figure 2.1: Mountain Sub-basins

Frank Slide

On 29 April 1903, at 4:10 a.m., 82 million tonnes (30 million cubic metres) of limestone crashed from the summit of Turtle Mountain and buried a portion of the sleeping town of Frank. The dimensions of the rock mass that fell are 150 m (500 feet) deep, 425 m (1,400 feet) high and one kilometre (3,280 feet) wide.

The bustling town of Frank was home to approximately 600 people in 1903. Of these, roughly 100 individuals lived in the path of the slide. An estimated 70 people were killed.

The primary cause of the Frank Slide was the mountain's unstable structure. Underground coal mining, water action in summit cracks and severe weather conditions may have contributed to the disaster.

Source: 22 April 2009 http://www.frankslide.com/info.html.

The area is unique, as it is here that the mountain glaciers met the continental ice sheets that covered the rest of Canada (Holme et al. 2000). At various times in the last ice age, the cordilleran or mountain ice advanced toward the plains; at other times the continental ice sheets moved into the Crowsnest and Castle valleys. As the ice finally began to melt and retreat, meltwater formed glacial lakes to the east in the Oldman watershed before finding drainage outlets to the south. During this time, an ice-free corridor existed to the east of the mountains.

The Crowsnest Pass area is also home to spectacular limestone caves, created as groundwater eroded soft limestone rocks over millennia. Crowsnest Spring is an environmentally significant area (ESA) immediately north of Crowsnest Lake (ESA #2) where a spring flows from a large cave (Sweetgrass Consultants 1997). Some of these caves are several kilometres in length, and erosion continues today where springs flow through existing caves.

The Mountain Sub-basins can be divided into four natural sub-regions: Foothills Fescue, Montane, Sub-Alpine and Alpine (Figure 2.2).

The Alpine, Sub-Alpine and Montane natural regions comprise most of the area of the Sub-basins. Conditions vary from the highest elevation bare rock fields and permanent snowfields to lush meadows and forested slopes. With increasing elevation, climate becomes increasingly harsh and precipitation rises. Run-off from these mountain areas (including the Oldman River) provides about 35% of the flow of the Oldman River at its mouth. The region includes important habitat for grizzly bear. At lower elevations, the Foothills Fescue natural region is characterized by

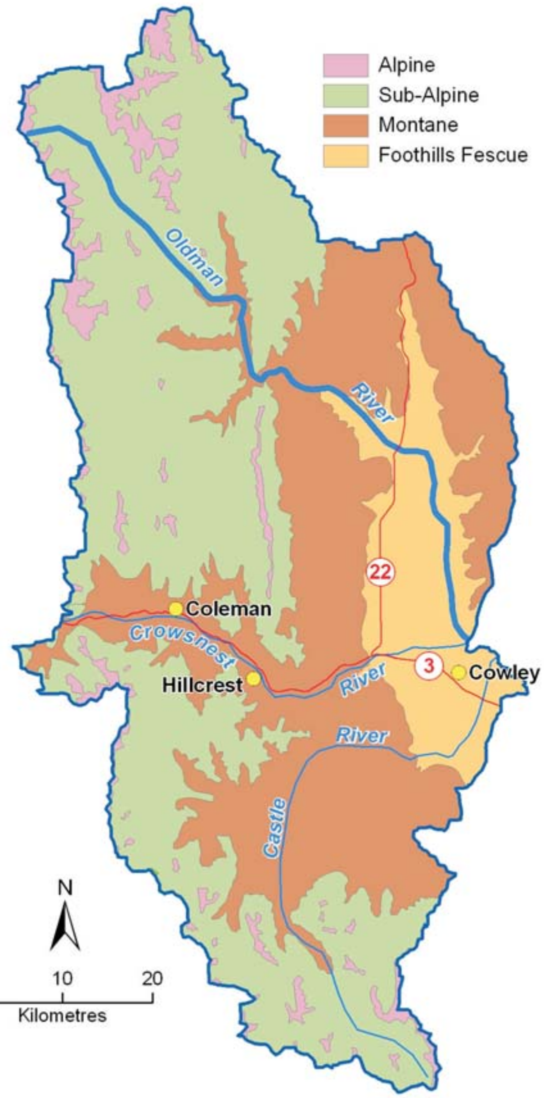


Figure 2.2: Natural Sub-Regions in the Mountain Sub-Basins

rolling cultivated plains and grassy uplands. Soils are Black Chernozemics formed under grassland vegetation.

The mountain tops and highest elevation areas comprise the Alpine natural region. The Palaeozoic and Mesozoic bedrock is exposed and steeply inclined to vertical in some areas. Rock fields are common, and there is little soil development. The growing season is too short for trees, and most plant communities are low-growing and confined to areas sheltered from the strong winds. Permanent snowfields occur in the most exposed areas. The Alpine sub-region has the harshest climate, shortest growing season, and highest precipitation in the Oldman watershed.

The Sub-Alpine is characterized by open meadows at its higher elevations and by open and closed coniferous forest at decreasing elevations. Near the treeline, stunted and misshapen trees occur individually or in small groups, called krummholz islands. Topography is rolling to inclined, exposed bedrock is less common than in the alpine zone, and surface materials are usually of glacial origin. Steeper slopes may be covered by colluvium, loose, broken bedrock that has weathered in place. Soils are thin Luvisols or Brunisols, formed under predominantly coniferous forest cover. Winter snowfall is high, and summers are short and cool, but moderate enough to allow the growth of trees. The boundary with the Montane sub-region occurs at about 1600 m asl. Wetlands are not extensive in the Mountain Sub-basins, but the Rock-Cow Creek Wetlands (ESA #2) in the sub-alpine are a provincially significant, extensive beaver pond and wetland complex that provides key moose habitat and breeding bird habitat (Sweetgrass Consultants 1997).

The Montane sub-region is characterized by cool summers, but warmer winters with frequent chinooks. Vegetation is a mix of coniferous and deciduous forests, but soils and vegetation communities can change over short distances with changes in slope, aspect and exposure to wind. South and west-facing slopes can be warmer and much drier with grassland vegetation than areas with a north or east aspect. The Whaleback/Bob Creek Wildland (ESA #4183) environmentally significant area is the most extensive (340 km^2) and least disturbed area of Montane landscape in the Alberta Rocky Mountains (Sweetgrass Consultants 1997) and provides important elk winter range and habitat for a diverse fauna, including Golden eagle. The Whaleback has been protected from oil and gas development by provincial designation as the Bob Creek Wildland.

The Foothills Fescue sub-region is adjacent to the Montane sub-region in the Mountain Sub-basins. These high elevation grasslands are characterized by warm winters with frequent chinooks, greater summer than winter precipitation, and deep Black Chernozemic soils. The cultivated land in the Mountain Sub-basins lies in this area.

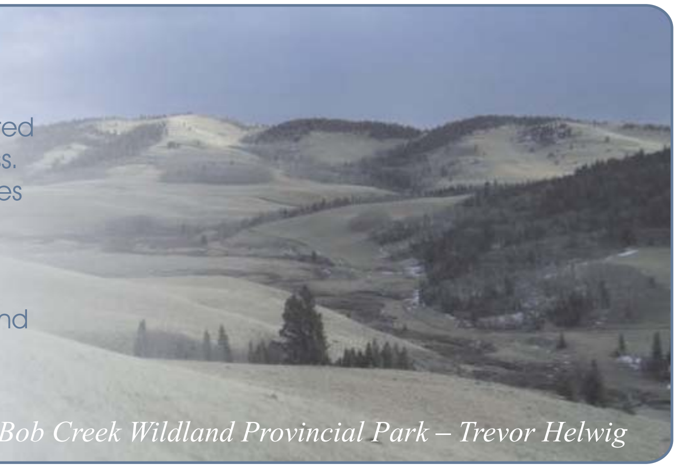
The wind is a constant element in the environment of the Mountain Sub-basins. In recent years, extensive wind turbine installations have been constructed on the ridges in the area east of the Crowsnest Pass. These large slow-turning turbines mark a significant step in the development of renewable energy in southern Alberta.

The Crowsnest, Castle and Oldman rivers are deeply incised in their upper reaches. Near their headwaters, the rivers are narrow and swift flowing, and boulders and cobbles form the stream beds. At

Bob Creek Wildland Provincial Park

Bob Creek Wildland includes Whaleback Ridge, considered to be Alberta's last remaining area of montane wilderness. It preserves extensive montane and subalpine landscapes and provides excellent habitat for large ungulates and carnivores such as cougars and bears. The area also contains one of Alberta's most important elk ranges. It is estimated that over 80 bird species breed in the area, and many more use the park during the fall migration.

Source: 22 April 2009
http://gateway.cd.gov.ab.ca/siteinformation.aspx?id=365.



Bob Creek Wildland Provincial Park – Trevor Helwig lower elevations, the well-vegetated valley bottoms provide important habitat for wildlife. These coldwater rivers are world-renowned among avid anglers for their native populations of mountain whitefish and cutthroat and bull trout. Rainbow and brook trout have been introduced and contribute to the recreational and sport fishing experience. The Crowsnest River from Bellevue to Cow Creek is designated an internationally significant trout stream (Sweetgrass Consultants 1997).

2.1 Overview of Indicators

2.1.1 Terrestrial and Riparian Ecology

Land Cover

The dominant land covers in the Sub-basins include forests, grassland, cultivated land and urban areas (Figure 2.3). The area of each land cover type within the Mountain Sub-basins is shown in Table 2.1.

Forest

Coniferous and deciduous forests cover approximately 64% of the Mountain Sub-basins. Most of the coniferous trees are found in the high elevations of the Sub-Alpine natural sub-region (Figure 2.3).

All of the Mountain Sub-basins are included within Forest Management Units (FMUs) C5 (Crowsnest Forest), C01, C02, B10 (Bow Forest) and B11. The majority of the Mountain Sub-basins is located in FMU C5, which extends into the Foothills Sub-basins. Small areas of commercial forest harvesting operations are conducted by Spray Lake Sawmills, which holds a Forest Management Agreement, and a few quota holders.

A draft forest management plan (SRD 2005) has been prepared for the C5 FMU with objectives including:

- manage the timber resources for sustainability while minimizing the impacts of forestry operations on non-timber resource values, land uses and human activities;
- ensure that all forest industry practices are conducted in a manner

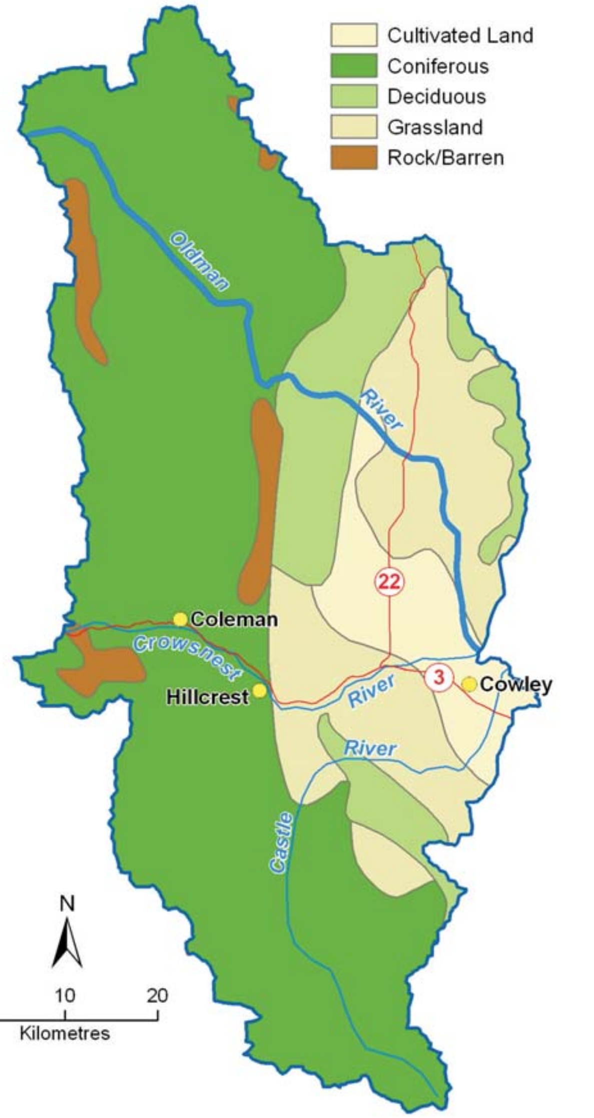


Figure 2.3: Land Cover in the Mountain Sub-basins

Table 2.1: Land Cover in the Mountain Sub-basins

Land Cover	Area of Mountain Sub-basins (%)
Forest (Coniferous & Deciduous)	64
Grassland	23
Cultivated Land (Agriculture)	8
Rock/Barren	3
Water	1
Urban	<1
Total	**100**

that places a priority on the protection of water resources; and

- address the forest health issue associated with the threat of mountain pine beetle.

In the predicted forest management scenario for the next 20 years in the C5 FMU, the average harvest area would vary from 600 to 1100 hectare per year (ha/yr), and the harvest block size (greenup patch) would range from 0.5 to 500 ha. Following forest harvesting, simulations of water yield increases showed small increases ranging from 0.2 to 10% (Watertight Solutions 2006). The time needed for the water yield to return to historical levels is predicted to range from 10 to more than 50 years.

Within the C5 FMU, a snapshot of reforestation status is available as of 13 May 2005 (SRD 2005). At that point in time, reforestation success rate (to full stocking levels) was 93.23% for blocks harvested before 31 March 1991. Where blocks were designated not satisfactorily restocked during the regeneration survey, they may be just under fully stocked; however, in most cases the stem density or height may be limiting. Understanding of the reforestation process, as well as the timing of regeneration surveys, is key to interpreting reforestation status. The regeneration survey must be completed within eight years of the harvest. This growth period must be accounted for but should not misconstrue the interpretation of the actual performance results. There are few absolute reforestation failures (SRD 2005).

The total forest area burned over a four year period (1961 to 2002) is 2430 ha during which 433 fires occurred (SRD 2005). During this period, the largest fire occurred in 2000 and burned 2088 ha which accounts for most of the burned area. Recently, the largest fire was the Lost Creek Fire in 2003 which covered a total area of 18 970 ha. From 1961 to 2002, 70% of fires were caused by humans (i.e., anthropogenic causes) while lightning caused the remaining 30%. The majority of anthropogenic fires are caused by recreational users, who were responsible for over 45% of the fires.

In 2004, the Southern Rockies Watershed Project began with objectives to evaluate both the initial effects of natural disturbance from the Lost Creek Fire on hydrology, water quality, and aquatic ecology; and early recovery of these values in front range headwater streams (Silins 2009). The hydrology of a forested landscape is fundamentally altered by fire, which in turn, produces increased loading of sediments, nutrients, and other contaminants into the fire affected streams. These collective changes resulted in changes to aquatic ecology across a range of trophic levels from primary producers to secondary consumers. Salvage logging produced incremental effects over, and above those of wildfire. The research project will continue to document recovery of the watershed.

This area is part of the “leading edge” zone in Alberta for mountain pine beetle (MPB) where infestations are widely scattered and small, but they

Summary of Immediate Lost Creek Fire Effects

Hydrological response:

- Increased water inputs
- Increases in water yield, change in timing of flows
- Increases in peak flow

Geochemical (water quality) response:

- Increased production of sediments, nutrients, other contaminants
- Incremental effect of salvage logging disturbances
- Strongly differential recovery trajectories
- Contaminant-sediment interactions prolong impacts for some water quality parameters

Ecosystem response:

- Nutrients increase productivity across a large number of tropic levels
- Algae - invertebrates - fish
- Change in community structure

Source: Silins (2009)

Lost Creek – R. Coffey

must receive aggressive single tree treatment by cutting and burning (SRD 2007). In addition, Spray Lake Sawmills follows the management strategy by harvesting susceptible pine in areas with high infestation rates. In the Southern Rockies about 25 000 trees have been treated since 2006, with the highest numbers (around 13 500) occurring in 2008. Within the Oldman watershed, cold weather during the 2009–2010 winter has reduced beetle populations. Annual treatment plans will be finalized after spring mortality surveys. Overall, MPB infestations are expected to either increase or remain static in the Southern Rockies in 2010 – 2012 (B. Jones, pers. comm.).

Within the Green Zone, the Mountain Sub-basins has a carrying capacity of 27 567 animal unit months (AUMs) on publicly managed lands (C. Piccin, pers. comm.). Grazing covers about 315 236 ha of the area and consists of 28 dispositions.

Forest Land Use Zones (FLUZ) were established under the *Forests Act* to protect sensitive resources such as wildlife and their habitats, vegetation, soils or watersheds, and to designate separate areas for motorized and non-motorized recreational activities. The Castle Special Management Area, Cataract Creek, Allison/Chinook and Willow Creek FLUZs cover 21% of the Mountain Sub-basins. In these zones, off-highway vehicles (OHV) are permitted on designated trails from 1 April to 30 November. Other activities are permitted on designated trails as snow conditions permit.

Other protected forested areas include recreation areas, ecological reserves, and provincial parks (Figure 2.4). Combined, these areas cover approximately 5%

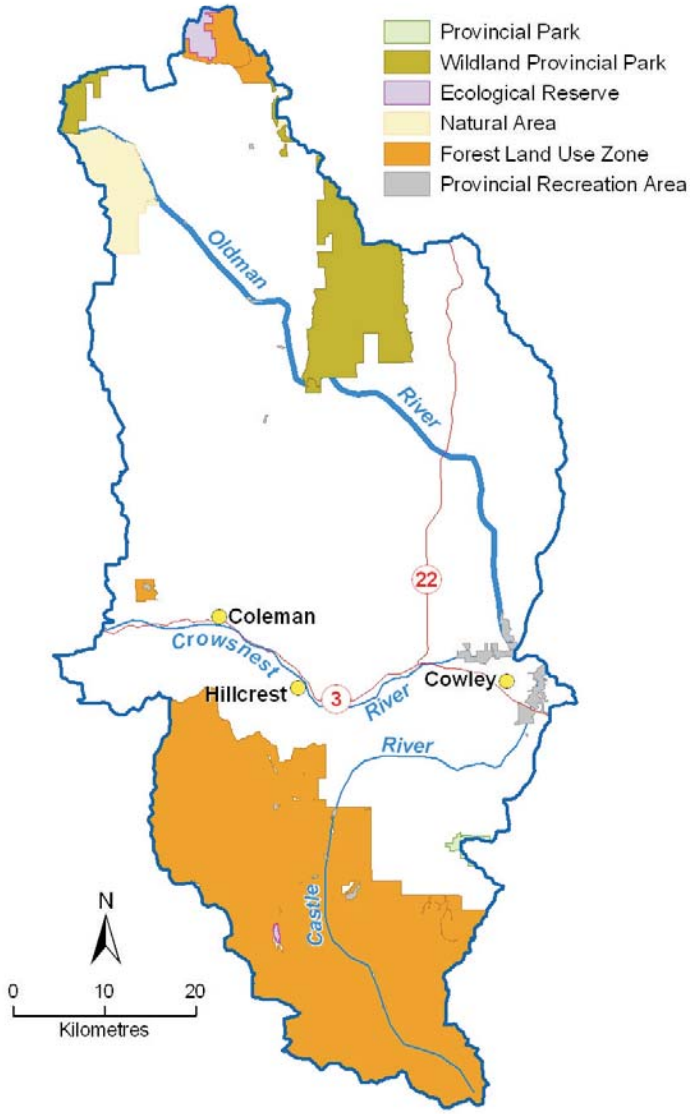


Figure 2.4: Parks, Protected Areas and Forest Land Use Zones in the Mountain Sub-basins

Legislation and Policies for Land Use Management on Crown Land

Forestry:

- *Forest Act*
- Timber Management Regulations
- Forest Management Agreements
- Alberta Timber Harvest Planning and Operating Ground Rules Framework for Renewal
- Alberta Regeneration Survey Manual
- Mountain Pine Beetle Management Strategy
- Mountain Pine Beetle Action Plan

Grazing:

- *Forest Act*
- *Public Lands Act*
- Grazing Lease Stewardship Code of Practice
- Riparian Health Assessment for Lakes, Sloughs and Wetlands

Recreation:

- Recreation on Agricultural Public Land
- Respect the Land
- Forest Recreation Regulation

Source: ASRD website.

of the Mountain Sub-basins (Table 2.2). Human activities in these areas create disturbances such as camp sites, roads, and trails. In addition, random camping and OHV use occur throughout the area.

Table 2.2: Recreational Areas, Ecological Reserves and Parks in Mountain Sub-basins

Protected Area Type	Name	Area (ha)
Provincial Recreation Area	16 different areas	2 300
Ecological Reserve	Plateau Mountain West Castle Wetlands	1 300
Provincial Park	Bob Creek Wildland Don Getty Wildland Beauvais Lake	18 000
	Total	**21 600**

Grasslands

Grasslands consisting of native species cover 23% of the area primarily within the Foothills Fescue and Montane natural sub-regions. The grasslands characterize the lower valleys and slopes of the Crowsnest and Oldman valleys, and are mainly used for grazing.

Cultivated Land

Cultivated lands (8%) lie within the Foothills Fescue natural sub-region and are found along the Crowsnest valley bottom in the vicinity of Cowley. The cultivated land is found mainly within the municipal district (MD) of Pincher Creek No. 9 and the MD of Ranchland No. 66 (Figure 2.5). Table 2.3 shows the distribution between native grassland and cultivated land. Agricultural crops grown within each MD as of the 2006 census (Statistics Canada 2006) are shown in Table 2.4. Livestock commonly raised within the Mountain Sub-basins include cattle, hogs and horses.

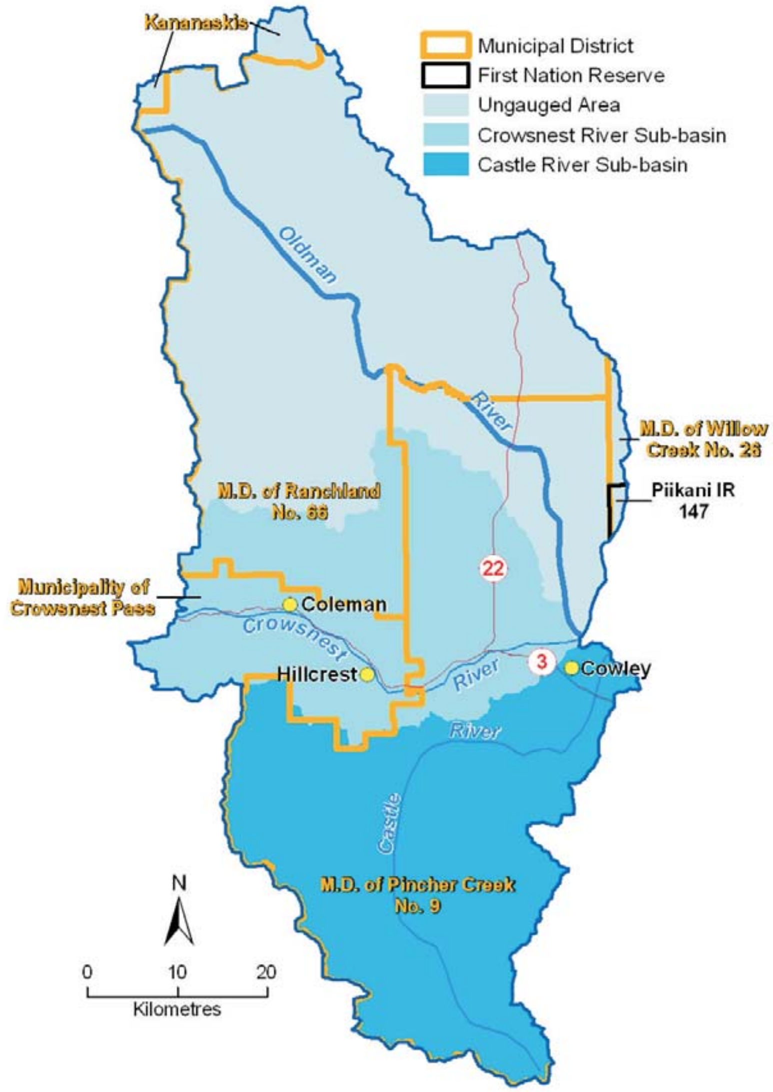
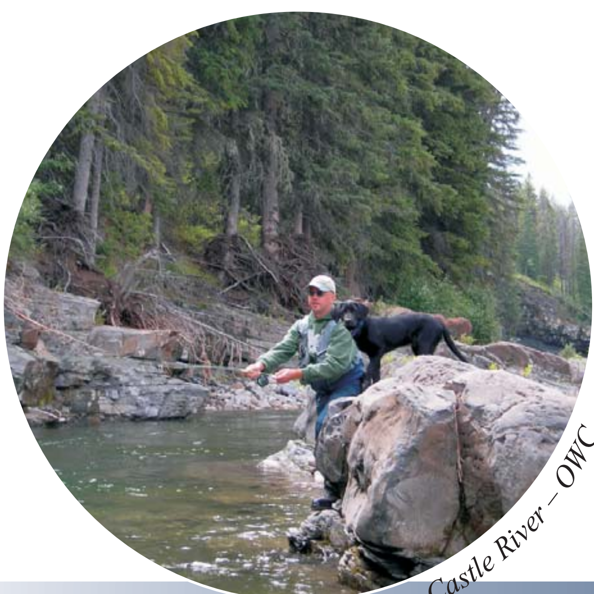


Figure 2.5: Municipal Districts and First Nation Reserves in the Mountain Sub-basins



Fishing Castle River – OWC

Table 2.3: Land Cover by Municipal Districts (%)

Land Cover	MD of Ranchland No. 66 (%)	MD Pincher Creek No. 9 (%)
Grassland (for Grazing)	94	57
Cultivated:		
– Cropped	<1	27
– Summerfallow	0	1
– Seeded pasture	2	8
Subtotal	*2*	*36*
Other (water/treed)	3	7
Irrigation (included in Cultivated lands)	0	1
Total	**100**	**100**

Table 2.4: Types of Crops by Municipal District

Agricultural Land Use	MD of Ranchland No. 66 (% Area)	MD Pincher Creek No. 9 (% Area)
Cereal (wheat, oats, barley, rye)	<1	60
Forage (alfalfa, hay)	<1	38
Canola	0	1
Specialty (mustard, triticale)	0	<1
Total	**<1**	**100**

Rock and Barren Land

Approximately 3% of the Mountain Sub-basins consists of the rock and barren land found on the high mountain elevations.

Urban Centers

The Municipality of Crowsnest Pass was established by the amalgamation of five urban communities – Bellevue, Hillcrest, Frank, Blairmore and Coleman – on 1 January 1979. The five communities cover less than 1% of the Mountain Sub-basins. The other urban area, the village of Cowley, also covers less than 1% of the Mountain Sub-basins.

Soil Erosion

Forested land covers about 64% of the area of the Sub-basins, and no data on soil erosion potential are available for this area. In the remaining areas, the risk is negligible to low (Figures 2.6). The area within each erosion risk category is shown on Table 2.5.

Since 87% of the Mountain Sub-basins is covered by forest and grassland, erosion is not an important concern. In the small number of farms, a number of soil erosion control measures have been implemented for reducing soil erosion losses. In agricultural areas, soil conservation practices have been adopted to minimize soil erosion rates. The three most common

Lost Creek Fire – R. Coffey

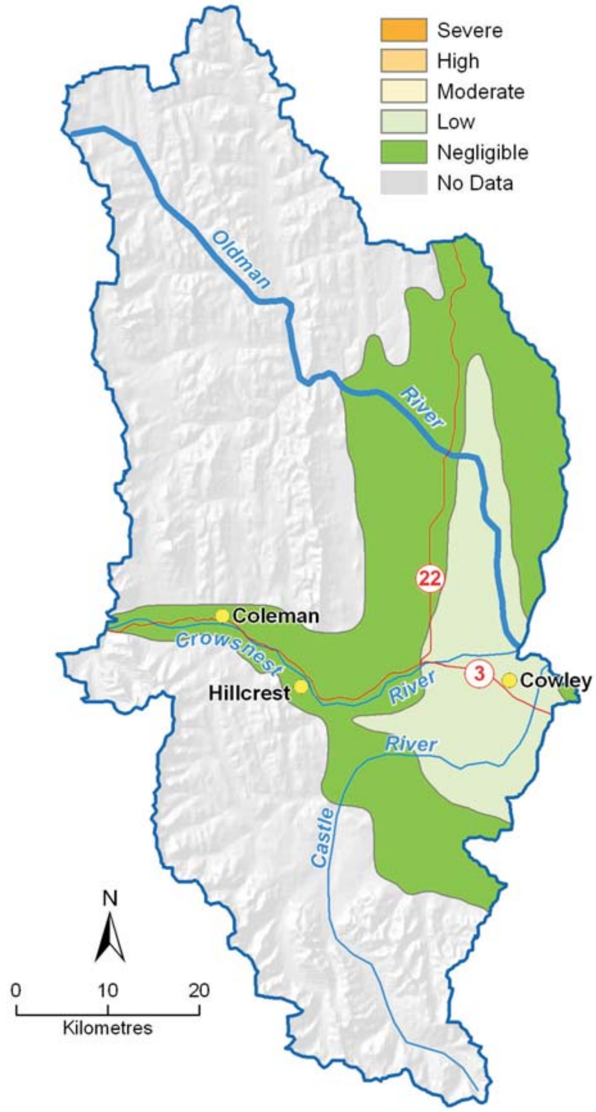


Figure 2.6: Soil Erosion Rating in the Mountain Sub-basins

practices are crop rotation, rotational grazing and shelterbelts (Table 2.6). As well, modified tillage practices, such as zero-till and mini-till methods, are also used.

Riparian Health

In the Mountain Sub-basins, 93 sites were reviewed as part of the Riparian Health Assessment Program. The results indicate that: 26% are healthy, 56% are healthy but with problems, and 18% are unhealthy (Cows and Fish Program 2009). These sub-basins are healthier than the average in the Oldman watershed where 15% are healthy, 55% are healthy but with problems and 30% are unhealthy.

Land Use

Human activities on the land create different land use disturbances throughout the Mountain Sub-basins. Disturbances are grouped into five general categories and the extent of disturbance is shown on Figure 2.7 and in Table 2.7.

Agriculture

Approximately 22% of the area is used for agricultural activities. Most (16%) is annually cropped or summerfallowed, while 5% is seeded pasture land. Within public lands, one farm development lease and one cultivation permit accounts for 67 ha (J. Best, pers. comm.).

On public lands outside the Green Zone, the Mountain Sub-basins has a carrying capacity of 19 474 AUMs. Ninety-five grazing dispositions cover about 25 744 ha or 6% of the total area (J. Best, pers. comm.). Within these publically-managed lands, some

Table 2.5: Soil Erosion Risk Area (ha)

Soil Erosion Risk Rating Class	Area (ha)	% of Total Area
Negligible	102 300	25
Low	44 128	11
Moderate	0	0
High	0	0
Severe	0	0
No Data	269 836	64
Total	**416 264**	**100**

Table 2.6: Erosion Control Techniques by Municipality

Erosion Control Technique	MD of Pincher Creek No. 9 (% of Farms[1])	MD of Ranchland No. 66 (% of Farms[1])
Crop Rotation	43	15
Rotational Grazing	57	46
Windbreaks or Shelterbelts	52	33
Buffer Zones around Water Bodies	25	17
Winter Cover Crops	6	2
Plowing Down Green Fields	2	0
Weed Control: – chemfallow – combined chemicals and tillage – summerfallow, tilled only	 1 3 6	 0 2 2

[1] Based on the number of farms in the MD

remain as undisturbed native prairie. Others, which have been disturbed, are included in Table 2.7 in the category "grazing-seeded".

The locations for six confined feeding operations (CFOs) are shown on Figure 2.8. The CFOs are shown with a square symbol representing a quarter section. On Figure 2.8, there is one discrete location and five others clustered together. While data are available on the locations of CFOs, minimal information is available on the number of animals contained by these operations. The CFOs are located along Highway 22, and along the municipal road network north of the Oldman River.

Infrastructure

Almost 2% of the Mountain Sub-basins supports infrastructure, primarily linear developments. Cutlines (0.7%) produce the most disturbance, followed by roads (0.6%) and pipelines (0.3%). Most of the roads are used to access wellsites and pipeline facilities, while cutlines support oil and gas exploration activities. Road types include paved, gravel, unimproved and truck trails Operating and abandoned oil and gas wellsites occupy <0.1% of the area.

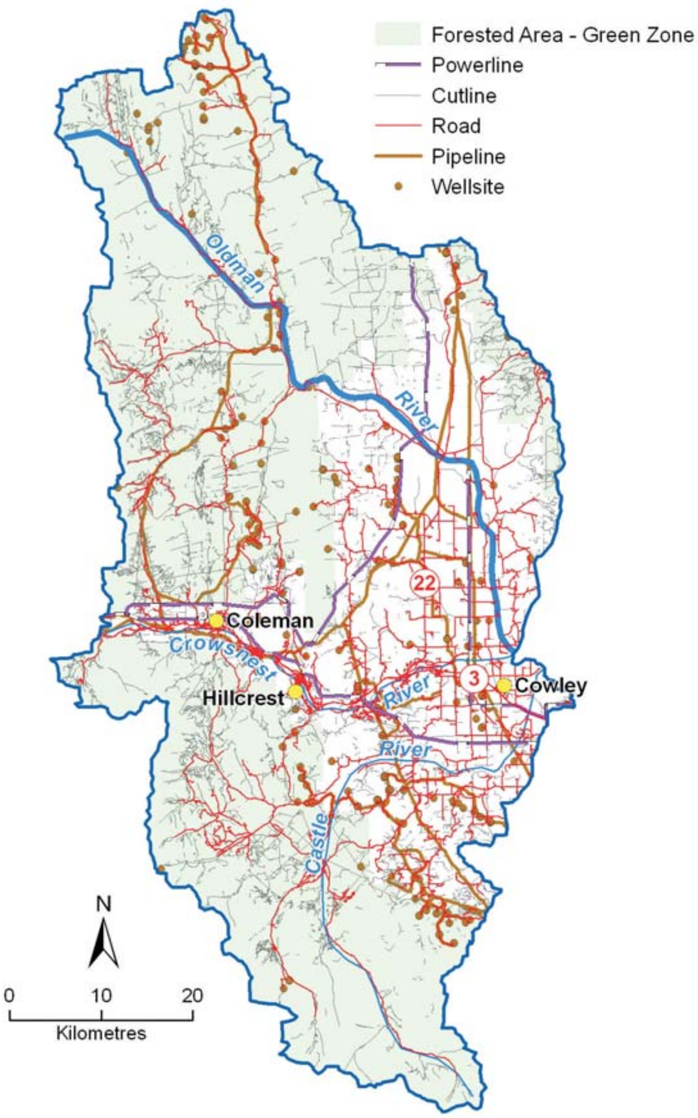


Figure 2.7: Land Use in the Mountain Sub-basins

Table 2.7: Land Use in the Mountain Sub-basins

Disturbance	Length (km)	km/km^2	Total Area Disturbed (ha)	% of Total Area
Agriculture				
Crops			66 789	16
Summerfallow			2 132	1
Grazing – seeded			22 308	5
Irrigation[1]			3 079	1
Subtotal			*91 229*	*22*
Infrastructure				
Roads	2 007	0.48	2 694	0.6
Railways	65	0.02	65	<0.1
Powerlines	164	0.04	329	0.1
Pipelines	479	0.12	3 089	0.3
Cutlines	4 413	1.06	1 436	0.7
Wells – oil and gas			292	<0.1
Airfields and runways			37	<0.1
Sewage lagoons			300	<0.1
Gravel pits			10	<0.1
Subtotal			*8 252*	*1.9*
Urban				
Residential, commercial and light industrial developments			300	0.1
Recreation				
Parks, recreation areas and campgrounds			2 100	0.5
Surface Water Supply Sources				
Reservoirs			0	0
Total Disturbance			**101 881**	**25**

[1] Irrigated land is a combination of grazing and cropped land, and does not include irrigation of native grassland since it is not disturbed. Area is included in “crops” category.

Note: these data are derived from StatsCan agriculture census data for an entire municipality, and for a specific year, i.e., 2006. The disturbances are therefore assumed to occur uniformly over the portion of each municipality that falls within each sub-basin.)

Figure 2.8: Confined Feeding Operations in the Mountain Sub-basins

Recreation

Recreational activities such as camping, fishing and hiking occur within designated areas including Beauvais Lake Provincial Park, located south of the Crowsnest Pass, and within the 16 Provincial Recreations Areas scattered throughout the mountains. Campgrounds and picnic areas in these areas generally consist of picnic tables, fire rings, drinking water, toilet facilities and garbage containers. Additional amenities include electrical hook-ups, boat launches and showers. Less than 1% of the Mountain Sub-basins is designated for recreational use. Extensive random recreational use (hunting, fishing, camping and OHVs) occurs throughout the Sub-basins, but data is not available to quantify the affected area.

Urban

Urban development represents a small portion of land use within the Mountain Sub-basins, affecting approximately 0.1% of the land. Urban development includes residential, commercial and light industrial activities within the urban communities of Cowley, Lundbreck and the Municipality of Crowsnest Pass.

Population within the Mountain Sub-basins has declined by 6% in the period 1996 to 2006 (Table 2.8). The MD of Pincher Creek No. 9 has experienced a 4% increase since 1996. In contrast, the MD of Ranchland No. 66 saw its population decline by 20% during the same period. The Municipality of Crowsnest Pass also experienced a 10% decline in population.

Total Land Use

Approximately 25% of the Mountain Sub-basins is altered by human development. Agricultural activities comprise the largest component (22%), followed by linear developments such as cutlines, roads and pipelines (2%), and recreational sites (1%).

Table 2.8: Population of Municipalities within Mountain Sub-basins

Municipality	1996	2006	% Population Change (1996 to 2006)
Cowley	273	219	-19.8
Municipality of Crowsnest Pass	6 356	5 749	-10
Pincher Creek No. 9	3 172	3 309	4
Ranchland No. 66	108	86	-20
Total	**9 909**	**9 363**	**-6**

2.1.2 Water Quantity

The three primary rivers in the Mountain Sub-basins are the Oldman, Crowsnest, and Castle. There are four long-term natural flow stations within the Castle River and Crowsnest River sub-basins (Figure 2.9):

- Crowsnest River at Frank;
- Crowsnest River near Lundbreck;
- Castle River near Beaver Mines; and
- Castle River near Cowley.

The analysis of stream flow characteristics and water quantity indicators was conducted for the four stations. The standard period (i.e., 1912 to 2001) is used for trend analysis.

Hydrologic Characteristics

Crowsnest River

There is little water use in the upper reaches of the Crowsnest River, and there are no major storage facilities along any section of the river. As a result, the recorded flows at Frank are considered to be approximately equal to natural flows. Flows were recorded at Frank from 1910 to 1920 and from 1949 to 2008. Alberta Environment has extended the period of flows to the period from 1912 to 2001 using statistical methods. Since the recorded flows at Frank are very close to natural flows, the Alberta Environment (AENV) extension simply filled in the gaps in the recorded period.

The hydrologic characteristics of the Crowsnest River at Frank and the Crowsnest River above Lundbreck are shown on Figures 2.10 and 2.11.

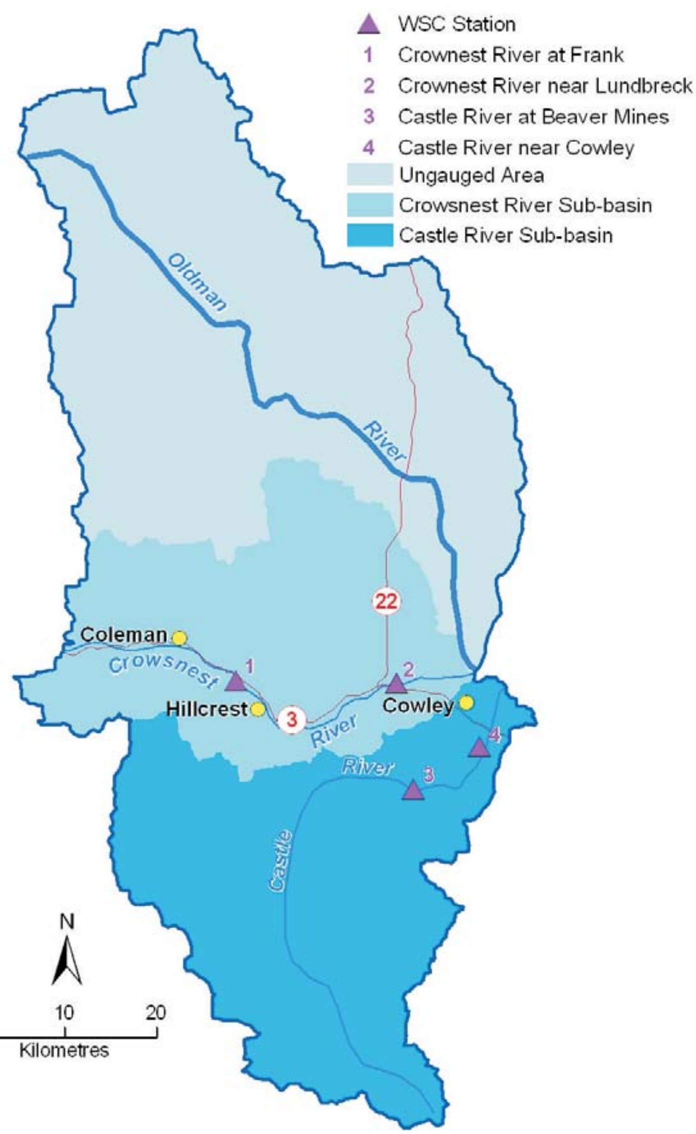


Figure 2.9: WSC Stations in the Mountain Sub-basins

Terms used in this Section are defined in Section 1.3.2.

Westcastle - Castle Confluence – R. Coffey

Crowsnest River at Frank

Gross DA	km^2	403
Effective DA	km^2	403
Natural Discharge 1912-2001		
Mean Annual	dam^3	149,113
Upper Quartile	dam^3	176,408
Median	dam^3	141,976
Lower Quartile	dam^3	116,698
Median Yield		
Gross DA	dam^3/km^2	352
Effective DA	dam^3/km^2	352

DA = Drainage Area

Mean Discharge of Crowsnest River at Frank, 1992-2001

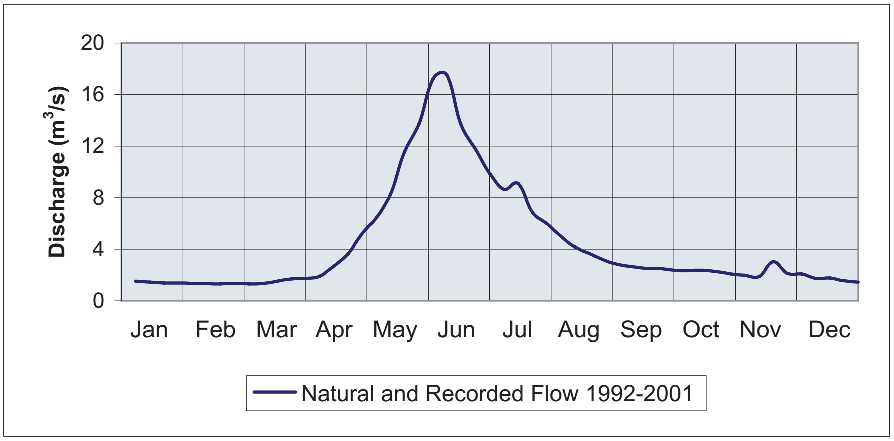


Figure 2.10: Hydrologic Characteristics – Crowsnest River at Frank

Crowsnest River near Lundbreck

Gross DA	km^2	676
Effective DA	km^2	658
Natural Discharge 1912-2001		
Mean Annual	dam^3	210,405
Upper Quartile	dam^3	242,339
Median	dam^3	203,912
Lower Quartile	dam^3	169,817
Median Yield		
Gross DA	dam^3/km^2	302
Effective DA	dam^3/km^2	310

DA = Drainage Area

Mean Discharge of Crowsnest River near Lundbreck, 1992-2001

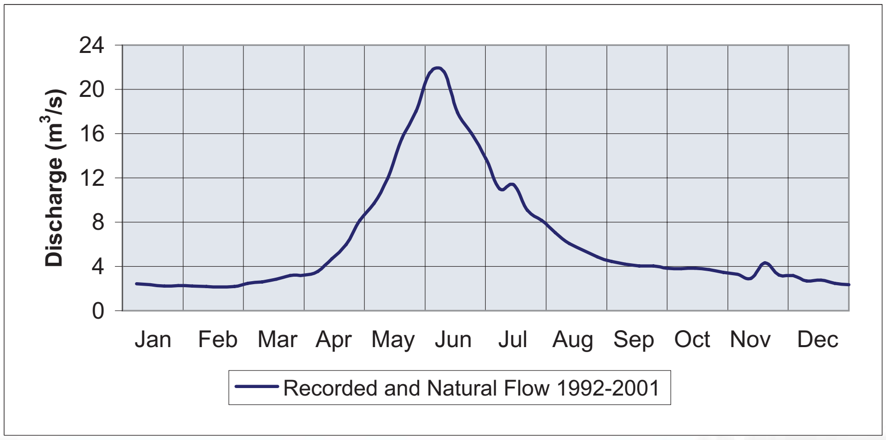
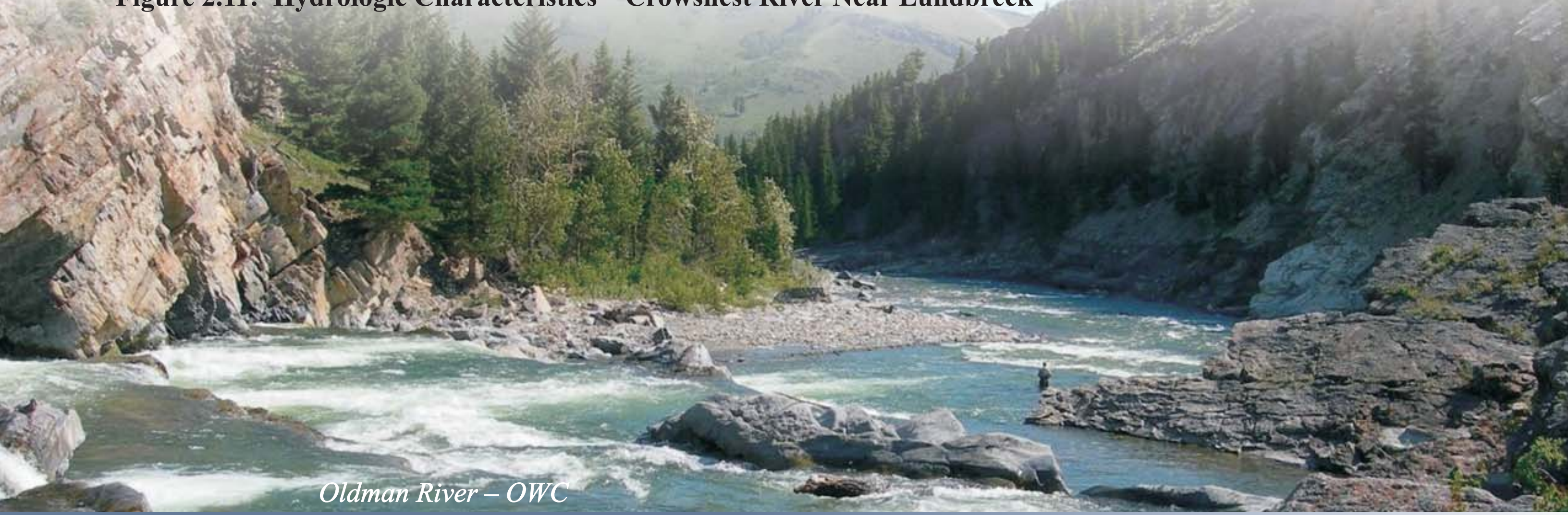


Figure 2.11: Hydrologic Characteristics – Crowsnest River Near Lundbreck



Oldman River – OWC

Both Crowsnest River stations have very high yields and monthly distributions of flows that are typical of mountain streams. Peak flows occur in early June with runoff from the melting snow pack and June rains, a high rainfall month. Low winter flows due to low temperatures are also typical of mountain streams.

While the lower reaches of the Crowsnest River downstream of Frank are unregulated, slightly more water use occurs along this stretch than in the upper reaches. Mean natural and recorded (1911 to 1930) flows near Lundbreck show very little difference for the overlapping period from 1912 to 1930.

Based on the slope of trend lines, annual flows on the Crowsnest River are decreasing by an average 0.3% per year at Frank and by 0.5% per year near Lundbreck (Figures 2.12 and 2.13), for the period from 1912 to 2001. However, these annual decreases do not represent statistically significant trends. On a monthly basis, a significant decrease in flows is observed in April at both Crowsnest River stations.

Crowsnest River at Frank

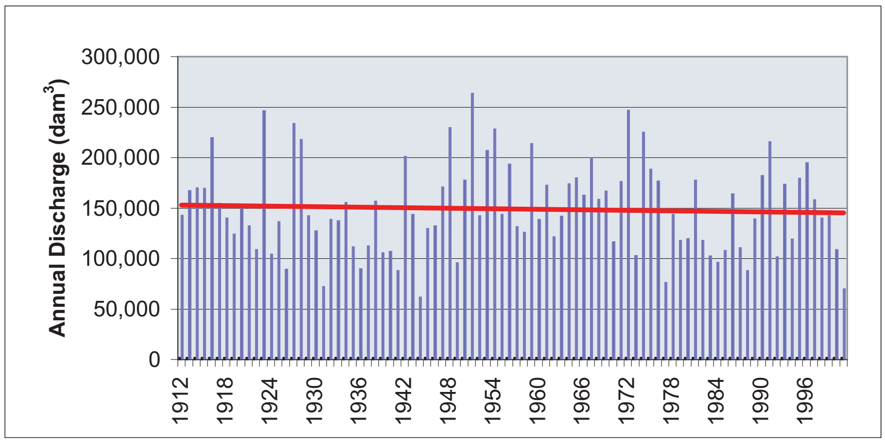
Mann-Kendall Trend Analysis

	MK-Stat	p-value
Annual	-0.40	0.69
Jan	-0.14	0.89
Feb	-0.04	0.97
Mar	0.93	0.35
Apr	-2.20	0.03
May	-0.94	0.35
Jun	-0.33	0.74
Jul	0.56	0.57
Aug	1.46	0.14
Sep	0.85	0.40
Oct	0.16	0.88
Nov	0.14	0.89
Dec	0.48	0.63

Significant Trend

Probable Trend

Annual Natural Flow Volumes and Trend Line.



Average annual decrease in flow = 86 dam^3 based on trend line slope

Figure 2.12: Trends in Natural Flow – Crowsnest River at Frank

Crowsnest River near Lundbreck

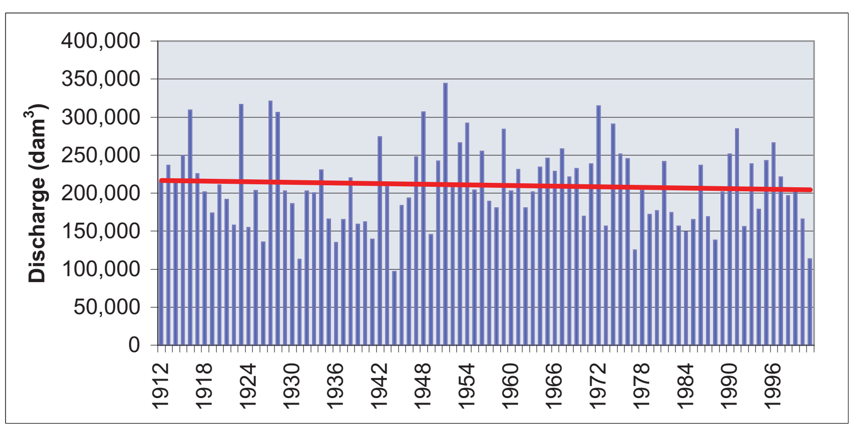
Mann-Kendall Trend Analysis

	MK-Stat	p-value
Annual	-0.53	0.59
Jan	1.09	0.28
Feb	0.78	0.44
Mar	1.10	0.27
Apr	-2.05	0.04
May	-1.43	0.15
Jun	-0.10	0.92
Jul	0.48	0.63
Aug	1.50	0.13
Sep	0.92	0.36
Oct	0.51	0.61
Nov	-0.55	0.58
Dec	0.48	0.63

Significant Trend

Probable Trend

Annual Natural Flow Volumes and Linear Trend Line



Average annual decrease in flow = 135 dam^3 based on trend line slope

Figure 2.13: Trends in Natural Flow – Crowsnest River Near Lundbreck

Castle River

Water uses in the unregulated Castle River sub-basin are low, and natural and recorded flows are essentially the same. Recorded flows were measured on the Castle River near Beaver Mines from 1945 to 2007. Near Cowley, flows were recorded from 1911 to 1931 only. Natural flows, determined by AENV for the period from 1912 to 2001, were used for hydrologic analysis on the Castle River. These values do not reflect the impacts on streamflow of recent projections for climate change.

The yield of the Castle River is very high due to the extensive area within the high precipitation Alpine and Sub-alpine natural regions (Figure 2.2). The Castle River sub-basin also shows a flow profile that is typical of a mountain stream with a single peak hydrograph, typically rising in April, peaking in early June, and receding to winter low flows by September (Figures 2.14 and 2.15).

Castle River flows have been consistent throughout the 1912 to 2001 period with no significant or probable trends in either annual or monthly flows (Figures 2.16 and 2.17). A trend line for annual flows on the Castle River near Beaver Mines indicates a slight decrease in flows (less than 0.2% per year on average). This trend is not observed near Cowley.

Castle River near Beaver Mines

Gross DA	km^2	821
Effective DA	km^2	821
Natural Discharge 1912-2001		
Mean Annual	dam^3	477,534
Upper Quartile	dam^3	543,131
Median	dam^3	466,970
Lower Quartile	dam^3	387,451
Median Yield		
Gross DA	dam^3/km^2	569
Effective DA	dam^3/km^2	569

DA = Drainage Area

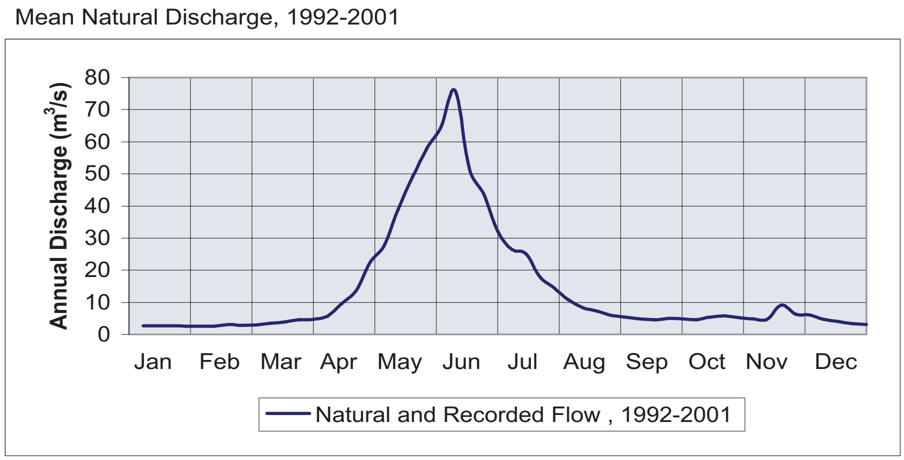


Figure 2.14: Hydrologic Characteristics – Castle River near Beaver Mines

Castle River near Cowley

Gross DA	km^2	1120
Effective DA	km^2	1120
Natural Discharge 1912-2001		
Mean Annual	dam^3	575,643
Upper Quartile	dam^3	662,341
Median	dam^3	563,934
Lower Quartile	dam^3	471,531
Median Yield		
Gross DA	dam^3/km^2	504
Effective DA	dam^3/km^2	504

DA = Drainage Area

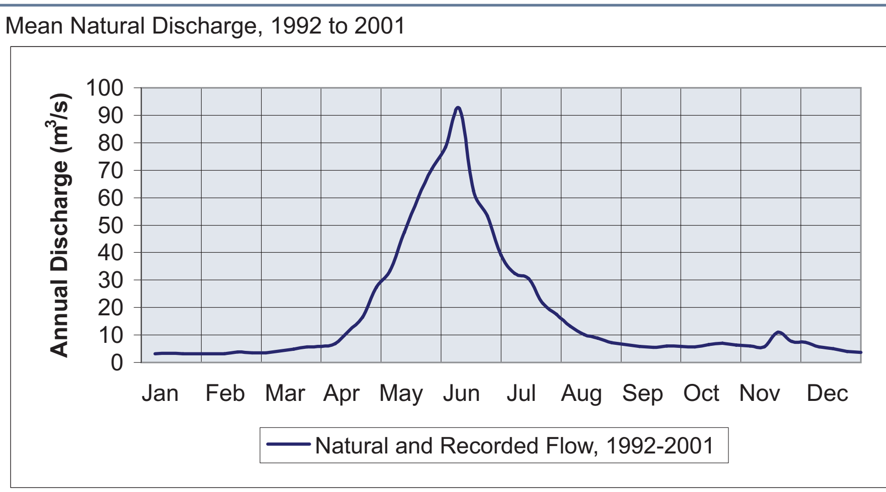


Figure 2.15: Hydrologic Characteristics – Castle River near Cowley

Castle River near Beaver Mines

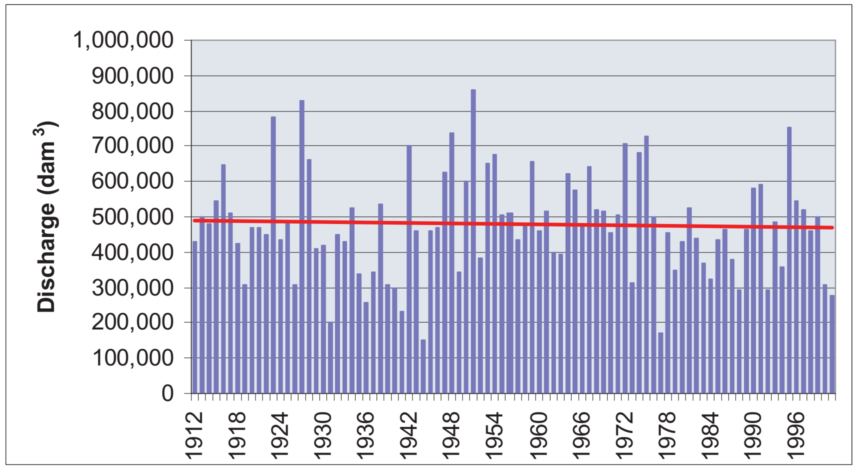
Mann-Kendall Trend Analysis

	MK-Stat	p-value
Annual	-0.32	0.75
Jan	-0.91	0.36
Feb	0.18	0.86
Mar	0.34	0.74
Apr	0.28	0.78
May	-0.23	0.82
Jun	-1.13	0.26
Jul	0.69	0.49
Aug	0.42	0.67
Sep	0.51	0.61
Oct	0.25	0.80
Nov	-0.93	0.35
Dec	-0.93	0.35

Significant Trend

Probable Trend

Annual Natural Flow Volumes and Trend Line.



Average annual decrease in flow = 224 dam^3 based on trend line slope.

Figure 2.16: Trends in Natural Flow – Castle River Near Beaver Mines

Castle River near Cowley

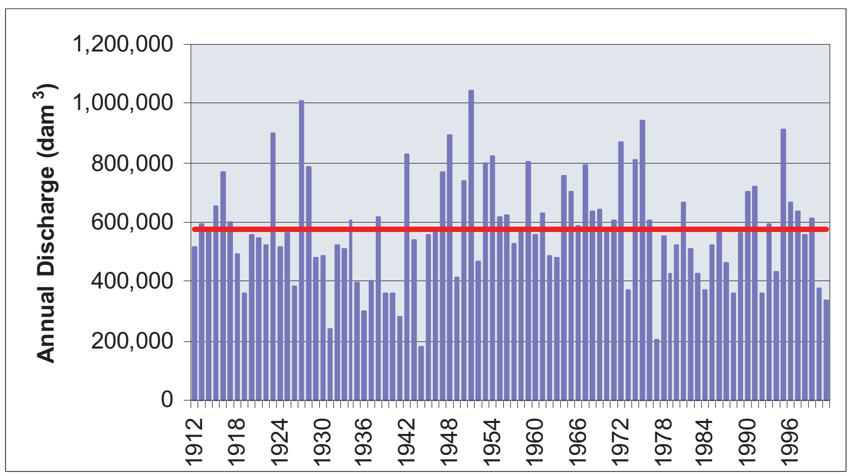
Mann-Kendall Trend Analysis

	MK-Stat	p-value
Annual	0.09	0.93
Jan	-0.96	0.34
Feb	0.14	0.89
Mar	0.65	0.51
Apr	0.73	0.47
May	0.68	0.50
Jun	-0.56	0.57
Jul	0.09	0.93
Aug	-0.02	0.98
Sep	-0.88	0.38
Oct	-1.18	0.24
Nov	-0.95	0.34
Dec	-0.69	0.49

Significant Trend

Probable Trend

Annual Natural Flow Volumes and Trend Line.



Average annual decrease in flow = 19 dam^3 based on trend line slope.

Figure 2.17: Trends in Natural Flow – Castle River Near Cowley

Licensed Allocation and Actual Use

Terms "at Frank" and "near Lundbreck" refer to locations of hydrometric stations. Allocations and estimated water use quantities are upstream of these locations.

Crowsnest River Sub-basin

Water is used for agricultural, municipal, commercial, industrial, and other uses within the Crowsnest River sub-basin. At Frank, upstream allocations are about 4% of median natural flows. This percentage decreases in the lower reaches. Near Lundbreck only about 3% of the median natural flow is allocated to upstream users. Less than 1.0% of the median natural flows are estimated to actually be used at both locations.

The largest user of water is the commercial sector, representing almost the entire allocation upstream of Frank and about 94% of estimated actual water use (Figure 2.18). Commercial use in the Mountain Sub-basins is primarily for the Allison Creek Fish Brood Station and Hatchery west of Coleman. The hatchery has high return flows. Upstream of Frank, municipal use is the only other allocated water use. Upstream of Lundbreck, the commercial sector (the fish hatchery) holds approximately 85% of the total allocations (Figure 2.19); however its estimated actual use is only about 33% of the total actual use. Municipal use

Crowsnest River at Frank

Purpose Sector	Allocation dam^3	Est. Actual Use dam^3
Irrigation		0
Other Agric		0
Municipal	20	16
Commercial	5562	240
Industrial		0
Other		0
Totals	5582	256
% of median flow	3.9%	0.2%

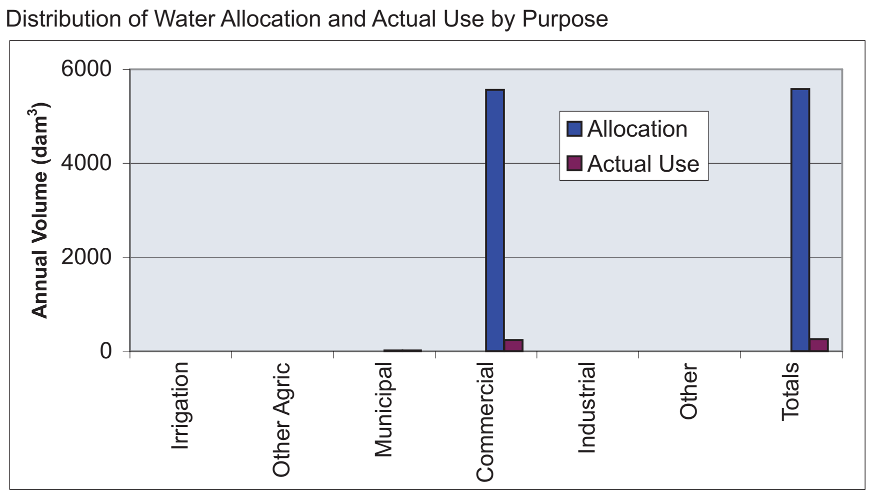


Figure 2.18: Water Allocation and Actual Use – Crowsnest River at Frank

Crowsnest River near Lundbreck

Purpose Sector	Allocation dam^3	Est. Actual Use dam^3
Irrigation	115	94
Other Agric	10	8
Municipal	866	546
Commercial	5635	313
Industrial		0
Other		0
Totals	6626	961
% of median flow	3.2%	0.5%

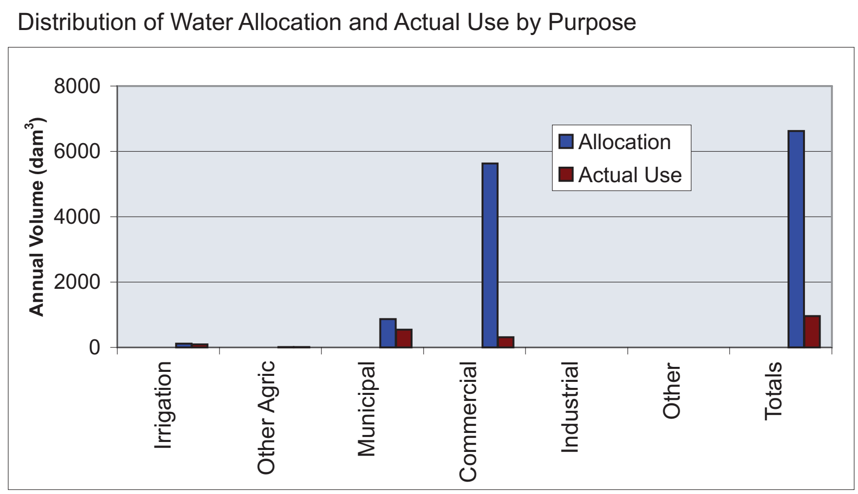


Figure 2.19: Water Allocation and Actual Use – Crowsnest River Near Lundbreck

accounts for about 13% of the allocated water near Lundbreck but approximately 57% of the total estimated actual use. Irrigation is less than 2% of allocated use, but comprises about 10% of the estimated actual water use upstream of Lundbreck. Actual water use in the Crowsnest River sub-basin is estimated to be between about 15% of total allocations, and about 0.5% of median natural flow.

Within the Crowsnest River sub-basin, the recent performance in meeting the Instream Objectives (IO) and the Water Conservation Objectives (WCO) were assessed at Frank and near Lundbreck[2] using the 10-year period of recorded flow from 1992 to 2001 (Figures 2.20 and 2.21). At Frank, flows fell short of the IO flow in about 28% of the months assessed. Near Lundbreck the flow was less than the IO flow only 2.5% of the time. During periods when flow is less than the IO, licensees that are subject to the IOs are not entitled to divert.

At both stations, flows that are less than the WCOs also occurred. Occurrences were much more frequent at Frank (about 44% of the months) than near Lundbreck (2.5%). At Frank, deficits to the WCOs and IOs occurred in the spring, fall and winter, while deficits near Lundbreck occurred primarily in early winter.

Crowsnest River at Frank

WCO and IO

WCO = MAX(0.45Qnat or 1.1(IO)) m^3/s

IO = Variable by week (Average = 2.465 m^3/s)

Comments:

1. Recorded flow approximately equals natural flow.
2. IO deficits occur in 28.4% of the months assessed.
3. WCO deficits occur in 43.6% of the months assessed.
4. Deficits are most numerous in spring, fall and winter.

Performance in Meeting the WCO and IO, 1992-2001

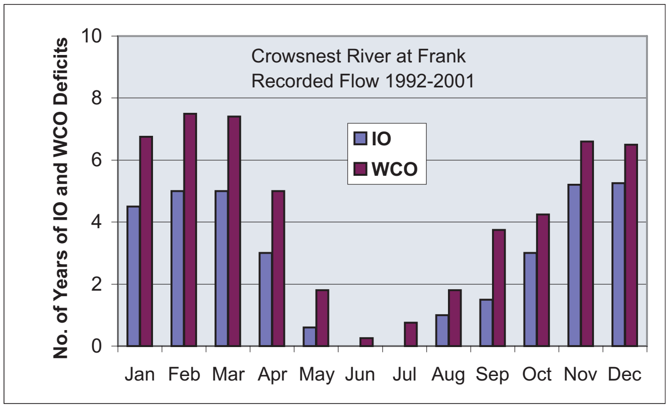


Figure 2.20: Performance in Meeting IOs and WCOs – Crowsnest River at Frank

Crowsnest River near Lundbreck

WCO and IO

WCO = MAX(0.45Qnat or 1.1(IO)) m^3/s

IO = Variable by week (Average = 2.465 m^3/s)

Comments:

1. Recorded flow unavailable at this station. Estimated natural flow approximately equal to recorded flow.
2. IO and WCO deficits in 2.5% of the months assessed.
3. Deficits were in early winter.

Performance in Meeting the IO and WCO 1992-2001

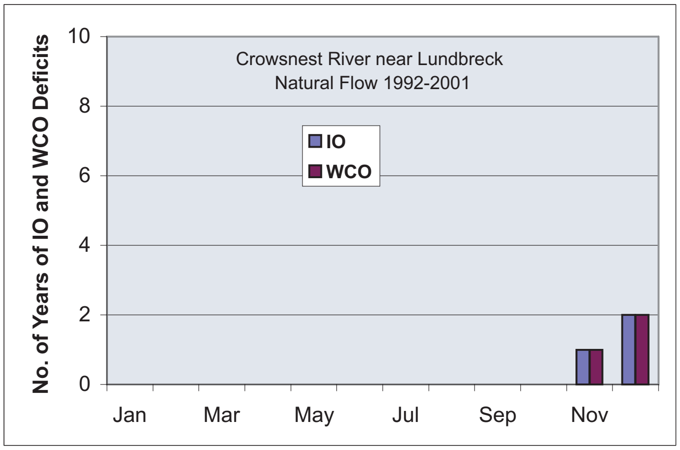


Figure 2.21: Performance in Meeting IOs and WCOs – Crowsnest River Near Lundbreck

[2] IOs, WCOs, and IFNs are described in section 1.2.7. Generally, the recommended WCO is 45% of the natural flow or the existing IO plus 10%, whichever is greatest at any point in time. These values vary for different reaches of each stream, and may also vary seasonally. the actual IO or WCO used to assess performance is shown on the appropriate figure. The months where data were available to assess performance is also shown on the appropriate figure.

Castle River Sub-basin

Water is used for agricultural, municipal and commercial uses within the Castle River sub-basin. Surface water allocations are less than 1% of median natural flows. Estimated water use upstream of the Beaver Mines hydrometric station is nearly 100% of the allocations and about 75% of the allocated use upstream of Cowley.

In the upper reaches, the largest user of water is the commercial sector, representing about 96% of the allocation near Beaver Mines (Figure 2.22). Commercial use includes recreation, parks, and aggregate washing. Irrigation, agricultural and municipal water uses are less than 4% of the allocated and actual water uses near Beaver Mines. Near Cowley, commercial use drops to about 43% of the allocations and 58% of estimated actual use (Figure 2.23). Municipal use accounts for about 37% of the allocated water near Cowley but only about 21% of the actual water use. Irrigation is not quite 18% of the actual use near Cowley and other agricultural uses comprise about 4% of the actual water use.

Castle River near Beaver Mines

Purpose Sector	Allocation dam^3	Estimated Actual Use dam^3
Irrigation	74	61
Other Agric	2	2
Municipal	1	1
Commercial	1742	1742
Industrial		0
Other		0
Totals	1819	1805
% of median flow	0.4%	0.4%

Distribution of Water Allocation and Actual Use by Purpose

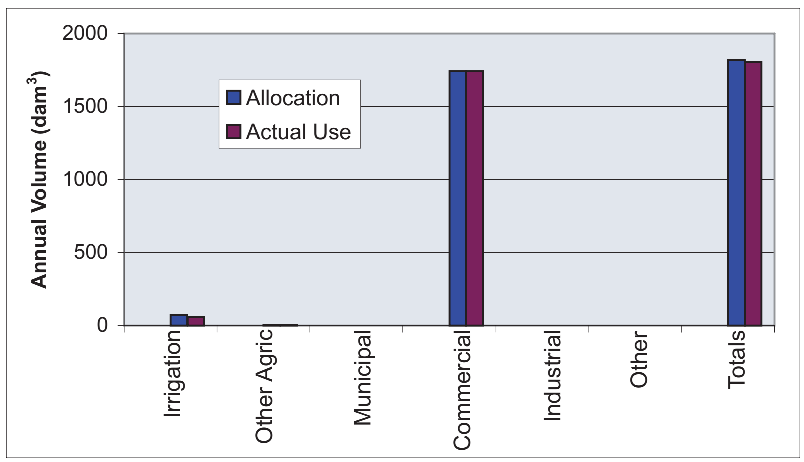


Figure 2.22: Water Allocation and Demand – Castle River Near Beaver Mines

Castle River near Cowley

Purpose Sector	Allocation dam^3	Est. Actual Use dam^3
Irrigation	653	535
Other Agric	151	113
Municipal	1479	638
Commercial	1742	1742
Industrial		0
Other		0
Totals	4025	3029
% of median flow	0.9%	0.6%

Distribution of Water Allocation and Actual Use by Purpose

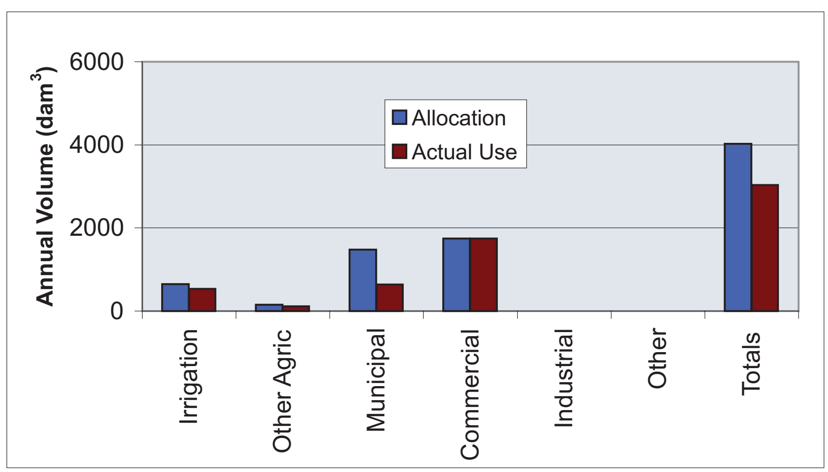


Figure 2.23: Water Allocation and Demand – Castle River Near Cowley

For the Castle River near Beaver Mines, flows are less than the IO about 49% of the months assessed, considerably more frequently than occurrences downstream near Cowley (about 39%). Similarly, WCO deficits were observed in 55% of the months that were assessed near Beaver Mines, while only 44% of the months assessed near Cowley had WCO deficits. Deficits in the Castle River sub-basin were most frequent in spring, fall and winter (Figures 2.24 and 2.25). Flows less the WCO and IO occurred much more often in the Castle River than in the Crowsnest River, especially when comparing the downstream reaches near Cowley (Figure 2.25) and near Lundbreck (Figure 2.21).

Irrigation and Municipal Water Use

All irrigation projects within the Mountain Sub-basins are individual licensed private developments. There are no irrigation districts licensed to draw water from streams in the Mountain Sub-basins.

Communities using surface water in the Mountain Sub-basins are:

- Cowley;
- Lundbreck; and
- the Municipality of Crowsnest Pass.

Castle River near Beaver Mines

WCO and IO

WCO = MAX(0.45Qnat or 1.1(IO)) m^3/s

IO = Variable by week (Average = 7.95 m^3/s)

Comments:

1. Recorded flow approximately equal to natural flow.
2. IO deficits in 49.3% of the months assessed.
3. WCO deficits in 54.5% of the months assessed.
4. Deficits are numerous in spring, fall and winter.

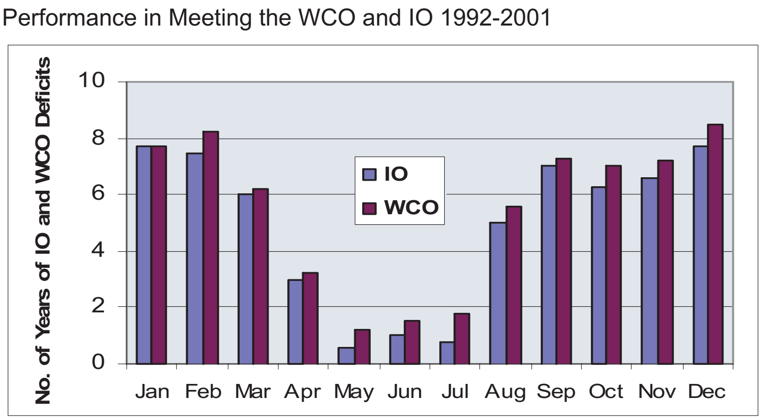


Figure 2.24: Performance in Meeting IOs and WCOs – Castle River Near Beaver Mines

Castle River near Cowley

WCO and IO

WCO = MAX(0.45Qnat or 1.1(IO)) m^3/s

IO = Variable by week (Average = 7.95 m^3/s)

Comments:

1. Recorded flow approximately equal to natural flow.
2. IO deficits occurred in 39.2% of the months assessed.
3. WCO deficits occurred in 44.2% of the months
4. Deficits are most numerous in spring, fall and winter.

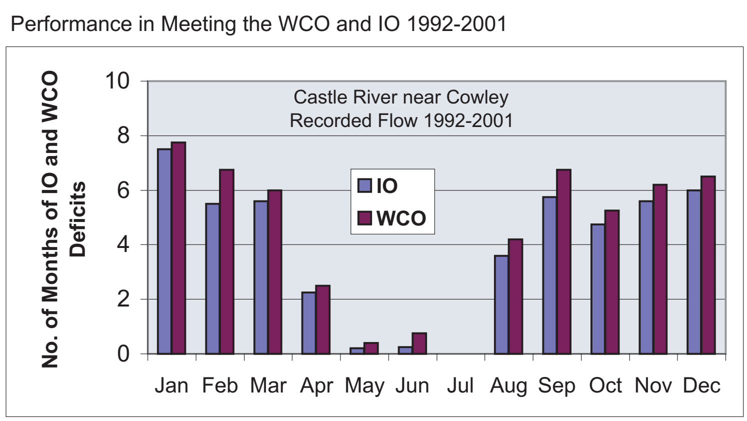


Figure 2.25: Performance in Meeting IOs and WCOs – Castle River Near Cowley

2.1.3 Water Quality

Water quality monitoring has occurred along both the Crowsnest and Castle rivers as well as along the West Castle River. Water quality monitoring stations, identified by station numbers, are located along the tributaries as indicated in Figure 2.26.

Alberta Environment Surface Water Quality Guidelines for Protection of Aquatic Life threshold:

Total Nitrogen = 1.0 mg/L
Total Phosphorus = 0.05 mg/L

Total Nitrogen

Water quality data have been collected sporadically over the years at several stations in the Mountain Sub-basins (Appendix D). Intensive data collection occurred in 1979 to 1980 with another period in both the Crowsnest and Castle river sub-basins around 1991 until 2005. Interestingly, recent intensive data collection has occurred on the West Castle River in 2007 until spring 2009. This was initiated in response to stakeholder concerns and provides data to monitor the effects of runoff from the Westcastle ski hill on the river.

Total nitrogen in the Mountain Sub-basins was typically less than the guideline (Table 2.9) for the period from 1974 to 2009, with the exception of two sites in 2005.

Table 2.9 indicates the occurrence of guideline exceedances in 2005 on both the Crowsnest River upstream of Connelly and the Castle River at the Castle River Recreation Area. This increase in total nitrogen concentrations was likely caused by the large rainfall and flood events which occurred throughout the Sub-basins in late-spring and early-summer of 2005.

The stations on the Crowsnest River above Coleman and upstream of Connelly Creek, as well as the Castle River station at the Castle River Recreation Area, were assessed for trends in nitrogen concentrations over the collection period from 1991 to 2000. Total loadings were determined for the Crowsnest River

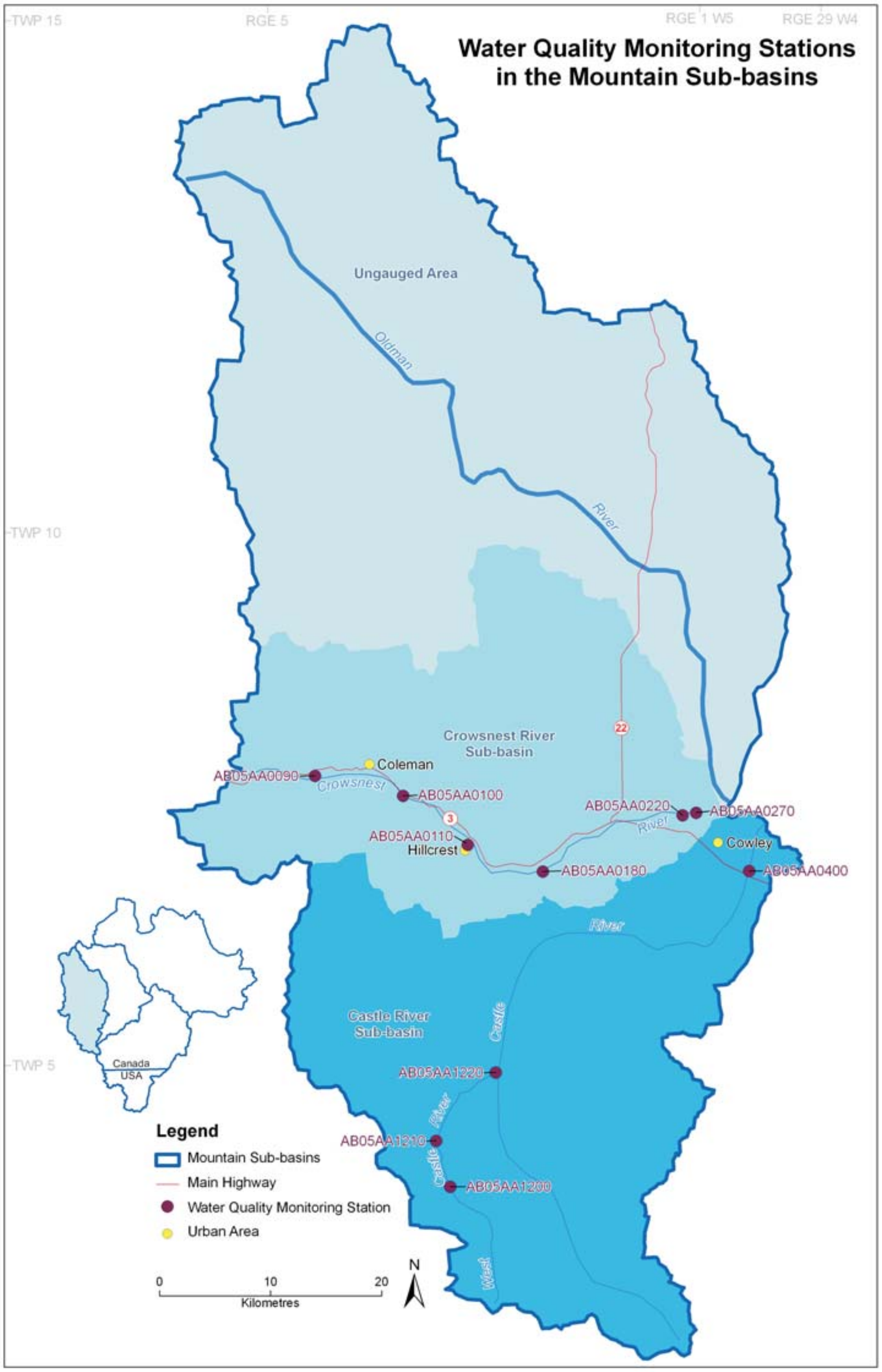


Figure 2.26: Water Quality Monitoring Stations in the Mountain Sub-basins

Table 2.9: Annual Median Total Nitrogen (mg/L) Guideline Adherence by Site

Monitoring Sites / Years	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CROWSNEST RIVER ABOVE COLEMAN			< 1.0		< 1.0	< 1.0																			< 1.0	< 1.0	< 1.0		< 1.0	< 1.0		< 1.0 *				
CROWSNEST RIVER ABOVE BLAIRMORE					< 1.0	< 1.0																														
CROWSNEST RIVER ABOVE BELLEVUE					< 1.0	< 1.0																														
CROWSNEST RIVER NEAR BURMIS					< 1.0	< 1.0																														
CROWSNEST RIVER U/S OF CONNELLY CREEK																		< 1.0	< 1.0	< 1.0 *	< 1.0	< 1.0	< 1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		1.0 - 5.0 *				
CROWSNEST RIVER NEAR THE MOUTH						< 1.0					< 1.0	< 1.0	< 1.0																							
WEST CASTLE RIVER ABOVE SKI HILL																											< 1.0							< 1.0	< 1.0	< 1.0 *
WEST CASTLE RIVER BELOW SKI HILL																											< 1.0							< 1.0	< 1.0	< 1.0 *
WEST CASTLE RIVER ABOVE CONFLUENCE WITH SOUTH CASTLE RIVER																											< 1.0							< 1.0	< 1.0	< 1.0 *
CASTLE RIVER AT CASTLE RIVER RECREATION AREA																		< 1.0	< 1.0	< 1.0 *	< 1.0	< 1.0	< 1.0		< 1.0	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0		1.0 - 5.0 *				

* median not calculated, results shown are based on less than 3 samples

- No Data
- < 1.0 mg/L (below guideline)
- 1.0 - 5.0 mg/L
- > 5.0 mg/L

above Bellevue and upstream of Connelly Creek and for the Castle River at the Castle River Recreation Area.

Total nitrogen loadings for 1991, 1995, 1998 and 2001 are shown on Figure 2.27 for the Crowsnest River upstream of Connelly Creek and the Castle River at the Castle River Recreation Area. Generally, loadings are higher in the Castle River sub-basin than the Crowsnest River sub-basin at these sites.

Phosphorus

Collection of total phosphorus data in the Mountain Sub-basins occurred over similar time periods and frequencies as the total nitrogen concentrations (Appendix D). Total phosphorus in the Mountain Sub-basins was typically less than the guideline (Table 2.10) for the period from 19150 to 2009.

Exceedances were observed at all sites sampled for total phosphorus in 2005 due to the large storm event which caused excessive runoff and carried phosphorus into the rivers. One other exceedance was observed in 1979 in the Crowsnest River upstream of Bellevue.

The stations on the Crowsnest River above Coleman and upstream of Connelly Creek and the Castle River station at the Castle River Recreation Area were assessed for trends in total phosphorus concentrations from 1991 to 2000. Total loadings were determined for the same sites when discharge data were available.

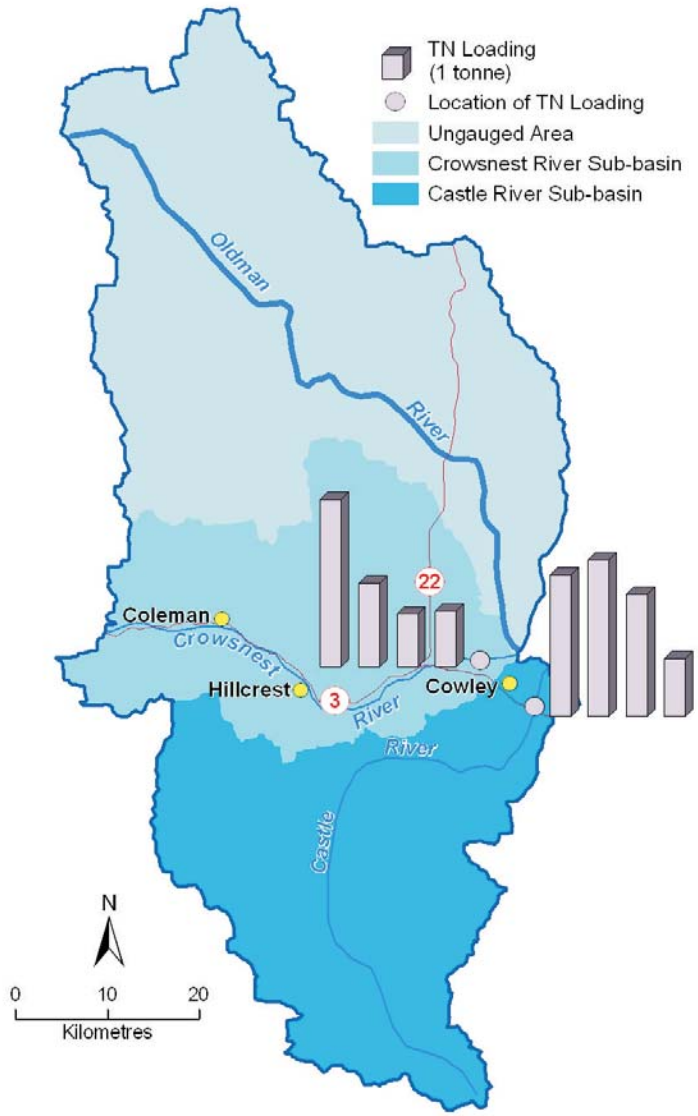


Figure 2.27: Total Nitrogen Loadings in the Mountain Sub-basins (1991, 1995, 1998, 2001)

Table 2.10: Annual Median Total Phosphorus (mg/L) Guideline Adherence by Site

Monitoring Sites / Years	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CROWSNEST RIVER ABOVE COLEMAN			< 0.05		< 0.05	< 0.05																			< 0.05	< 0.05	< 0.05		< 0.05	< 0.05		0.05 - 0.5 *				
CROWSNEST RIVER ABOVE BLAIRMORE					< 0.05	< 0.05																														
CROWSNEST RIVER ABOVE BELLEVUE					< 0.05	0.05 - 0.5																														
CROWSNEST RIVER NEAR BURMIS					< 0.05	< 0.05																														
CROWSNEST RIVER U/S OF CONNELLY CREEK																		< 0.05	< 0.05	< 0.05 *	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		> 0.5 *				
CROWSNEST RIVER NEAR THE MOUTH						< 0.05					< 0.05	< 0.05	< 0.05																							
WEST CASTLE RIVER ABOVE SKI HILL																											< 0.05							< 0.05	< 0.05	< 0.05 *
WEST CASTLE RIVER BELOW SKI HILL																											< 0.05							< 0.05	< 0.05	< 0.05 *
WEST CASTLE RIVER ABOVE CONFLUENCE WITH SOUTH CASTLE RIVER																											< 0.05							< 0.05	< 0.05	< 0.05 *
CASTLE RIVER AT CASTLE RIVER RECREATION AREA																		< 0.05	< 0.05	< 0.05 *	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		> 0.5 *				

* median not calculated, results shown are based on less than 3 samples

No Data
< 0.05 mg/L (below guideline)
0.05 - 0.5 mg/L
> 0.5 mg/L

Total phosphorus loadings for 1991, 1995, 1998 and 2001 are shown on Figure 2.28 for the Crowsnest River upstream of Connelly Creek and the Castle River at the Castle River Recreation Area. Unlike nitrogen loadings, phosphorus loadings were typically slightly higher in the Crowsnest River sub-basin than in the Castle River sub-basin at these sites with the exception of 1995.

Total Suspended Solids

Collection of total suspended solids (TSS) samples in the Mountain Sub-basins has been sporadic over the years (Appendix D). From 1991 to 1997 samples were collected regularly at two sites: Crowsnest River upstream of Connelly Creek and Castle River at the Castle River Recreation Area. Collection of TSS data on the West Castle River was initiated in 2007 and continues at the present.

The median TSS concentration of the available data set for stations and reaches was compared to the annual medians for the same locations in Table 2.11. In 2005, extreme levels of TSS were observed at all sampled stations. This extreme concentration is likely a result of the major rainfall event which occurred that year and caused large amounts of sediment and minerals to enter the surface water through overland runoff.

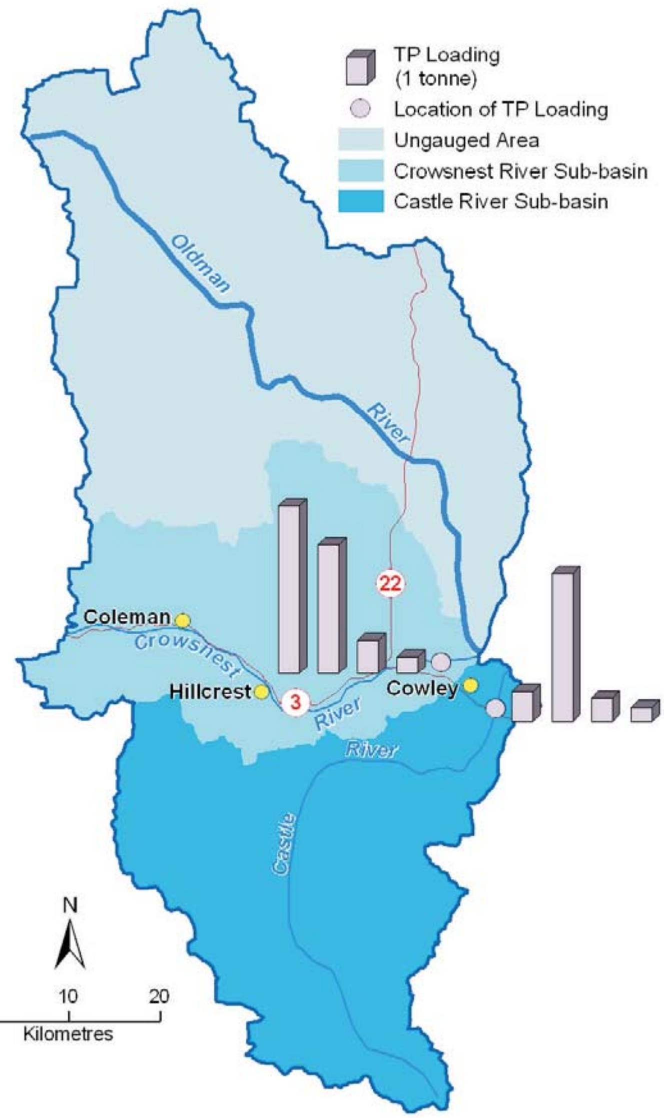


Figure 2.28: Total Phosphorous Loadings in the Mountain Sub-basins (1991, 1995, 1998, 2001)

Table 2.11: Annual Median TSS (mg/L) Compared to Data Set Median

Monitoring Sites / Years	MEDIAN	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CROWSNEST RIVER ABOVE COLEMAN	5	*																								*							*				
CROWSNEST RIVER ABOVE BLAIRMORE	8																																				
CROWSNEST RIVER ABOVE BELLEVUE	7																																				
CROWSNEST RIVER NEAR BURMIS	7																																				
CROWSNEST RIVER U/S OF CONNELLY CREEK	3																				*					*							*				
CROWSNEST RIVER NEAR THE MOUTH	8																																				
WEST CASTLE RIVER ABOVE SKI HILL	0.5																																				*
WEST CASTLE RIVER BELOW SKI HILL	1																																				*
WEST CASTLE RIVER ABOVE CONFLUENCE WITH SOUTH CASTLE RIVER	0.5																																				*
CASTLE RIVER AT CASTLE RIVER RECREATION AREA	2																				*					*		*					*				

Total suspended solids loadings were assessed for the period from 1991 to 2000, at the Crowsnest River upstream of Connelly Creek and the Castle River at the Castle River Recreation Area. Total suspended solids loadings were consistently lower in the Crowsnest River sub-basin than the Castle River sub-basin (Figure 2.29). Decreases in TSS loadings were observed in the Crowsnest River sub-basin between 1991 and 1998.

Fecal Coliforms

Fecal coliform sampling was conducted regularly from 1991 to 2001 at two sites: Crowsnest River upstream of Connelly Creek and Castle River at the Castle River Recreation Area (Appendix D). Additionally, fecal coliforms were collected in the Crowsnest River sub-basin at the Crowsnest River above Coleman from 1998 to 2000 and in 2002. In the Castle River sub-basin, collection of fecal coliforms on the West Castle River was initiated in 2007 and continues to the present.

Total fecal coliform loadings were assessed for the period from 1991 to 2000, at the Crowsnest River upstream of Connelly Creek and the Castle River at the Castle River Recreation Area.

Several instances of guideline exceedances were observed in the late 1970s, however, during the 1980s and 1990s the number of fecal coliforms was below the guidelines (Table 2.12). During the storm event in

> Alberta Environment Surface Water Quality Guidelines for Irrigation threshold:
>
> Fecal Coliforms = 100 coliforms/100 mL

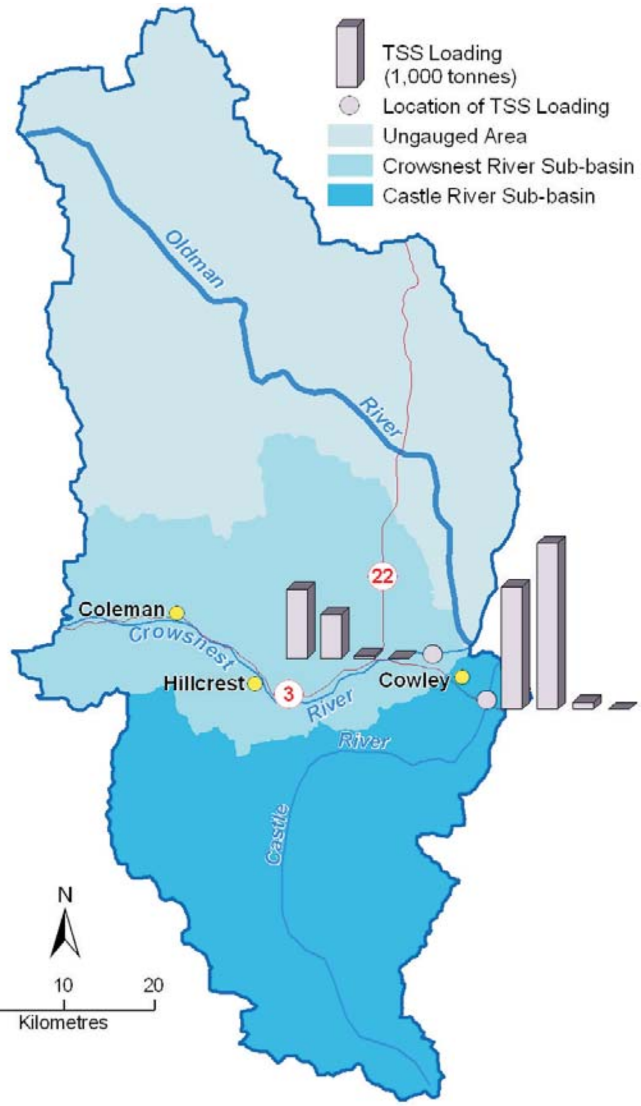


Figure 2.29: Total Suspended Solids Loadings in the Mountain Sub-basins (1991, 1995, 1998, 2001)

Table 2.12: Annual Median Fecal Coliform Count Guideline Adherence by Site

Monitoring Sites / Years	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CROWSNEST RIVER ABOVE COLEMAN	< 100 *	< 100	< 100		< 100	< 100																			< 100	< 100	< 100		< 100	< 100		100 - 1000 *				
CROWSNEST RIVER ABOVE BLAIRMORE					< 100	> 1000																														
CROWSNEST RIVER ABOVE BELLEVUE					100 - 1000	100 - 1000																														
CROWSNEST RIVER NEAR BURMIS					< 100	100 - 1000																														
CROWSNEST RIVER U/S OF CONNELLY CREEK																		< 100	< 100	< 100 *	< 100	< 100	< 100		< 100	< 100	< 100	< 100	< 100	< 100		100 - 1000 *				
CROWSNEST RIVER NEAR THE MOUTH						100 - 1000					< 100	< 100	< 100																							
WEST CASTLE RIVER ABOVE SKI HILL																											< 100							< 100	< 100	< 100 *
WEST CASTLE RIVER BELOW SKI HILL																											< 100							< 100	< 100	< 100 *
WEST CASTLE RIVER ABOVE CONFLUENCE WITH SOUTH CASTLE RIVER																											< 100							< 100	< 100	< 100 *
CASTLE RIVER AT CASTLE RIVER RECREATION AREA																		< 100	< 100	< 100 *	< 100	< 100	< 100		< 100	< 100	< 100	< 100	< 100	< 100		> 1000 *				

* median not calculated, results shown are based on less than 3 samples

No Data
< 100 per 100 mL (below guideline)
100 - 1000 per 100 mL
> 1000 per 100 mL

2005, high levels of fecal coliforms were observed at all sites sampled in the Mountain Sub-basins. Observations in 2005 were similar or higher than those measured in the late 1970s.

Loadings of fecal coliforms in the Crowsnest River at the site upstream of Connelly Creek were determined for 1991, 1995, 1998 and 2001. Typically loadings in the Crowsnest River sub-basin have been lower than the fecal coliform loadings observed in the Castle River sub-basin (Castle River at the Castle River Recreation Area) (Figure 2.30). A steady decrease in loadings has occurred in the Crowsnest River sub-basin between 1991 and 2001.

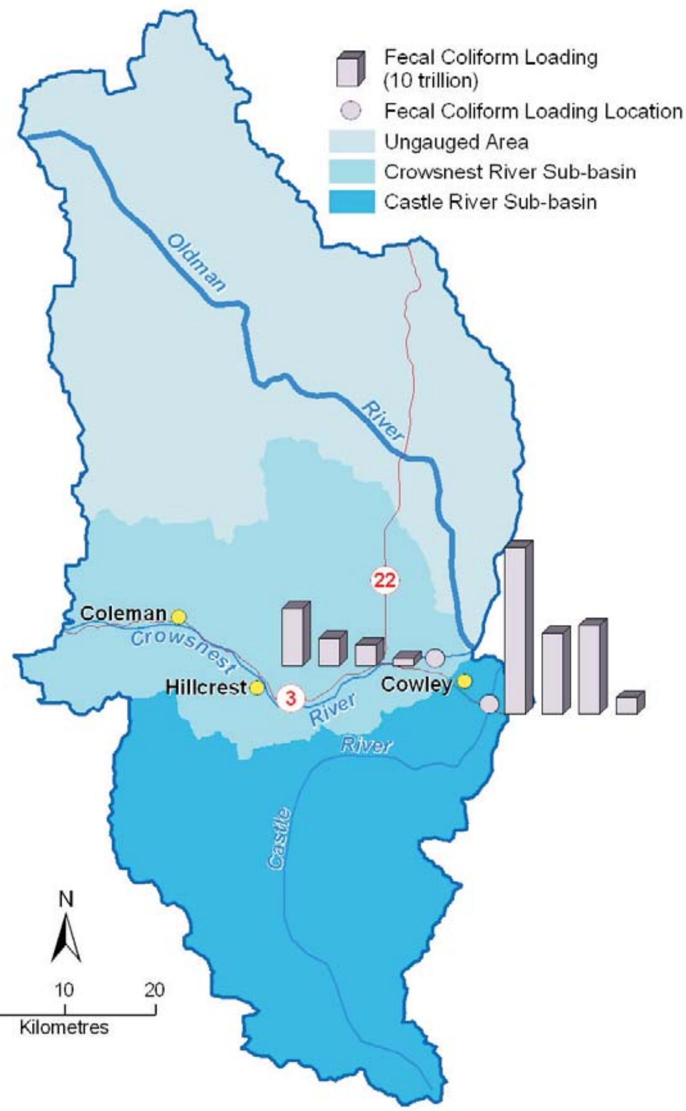
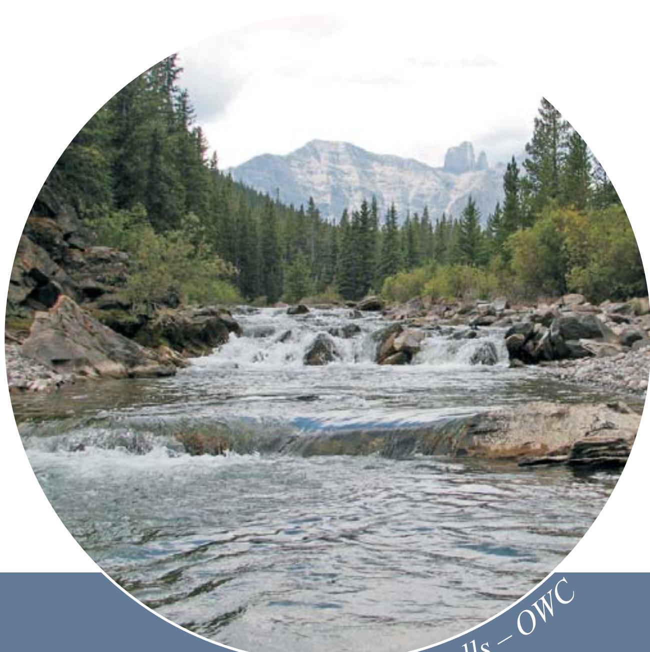


Figure 2.30: Fecal Coliform Loadings in the Mountain Sub-basins (1991, 1995, 1998, 2001)



Oldman Falls – OWC

Mountain Sub-basins Water Quality Overview for Non-indicator Parameters

Temperature[1]

Water temperature in rivers and streams is important to observe when assessing water quality. Temperature fluctuations can affect fish populations by altering the preferred habitat for certain species. The median water temperature in the Crowsnest River, from 1998 to 2003, was 5.8°C. In the Castle River, during the same time period, the median water temperature was 4.9°C. The Oldman River, upstream of the Oldman Reservoir had a median water temperature of 3.6°C. The median and maximum temperatures of the three rivers in the Mountain Sub-basins are very similar and the tributaries do not likely have adverse thermal effects on the mainstem.

pH[1]

In the Crowsnest and Castle rivers, the median pH values measured from 1998 to 2003 were both 8.1. These values are the same as the median pH of 8.1 observed for the Oldman River upstream of the Reservoir during the same time period.

Dissolved Oxygen[1]

Median dissolved oxygen levels are only moderately indicative of the health of the surface water body. The true indicator in terms of available oxygen dissolved in the water column is the magnitude of the daily fluctuations, observed over a 24 hour period. This series of measurements can indicate if dissolved oxygen levels fall below the Guidelines for the Protection of Aquatic Life during the nightly respiration cycle. Median dissolved oxygen concentrations were very similar in the Crowsnest and Castle rivers, as well as in the Oldman River upstream of the reservoir. These median values were 11.93 mg/L, 11.59 mg/L and 11.6 mg/L, respectively.

Hardness[1]

Water hardness is an aesthetic water quality objective since hard water often has a taste and will cause deposits on pipes and in kettles. One characteristic of hard water is a decrease in the ability to lather soap. The Crowsnest and Castle rivers, during the period 1998 to 2003, had median hardness levels of 205 mg $CaCO_3$/L and 140 mg $CaCO_3$/L, respectively. The Oldman River through the Mountain Sub-basins had a median hardness level of 170 mg $CaCO_3$/L. The hardness levels are quite consistent throughout the Mountain Sub-basins.

Metals and Ions[1]

Metals were very low in both major tributaries in the Mountain Sub-basins with median values of dissolved iron and manganese well below guideline levels. Ions measured between 1998 and 2003 included fluoride, chloride, and sulphate. Dissolved fluoride median concentrations were naturally above the Guidelines for the Protection of Aquatic Life in the Crowsnest River, however, concentrations in the Castle River were not observed to exceed the guidelines at any time. Median chloride and sulphate concentrations in both the Crowsnest and Castle rivers were well below all guideline levels.

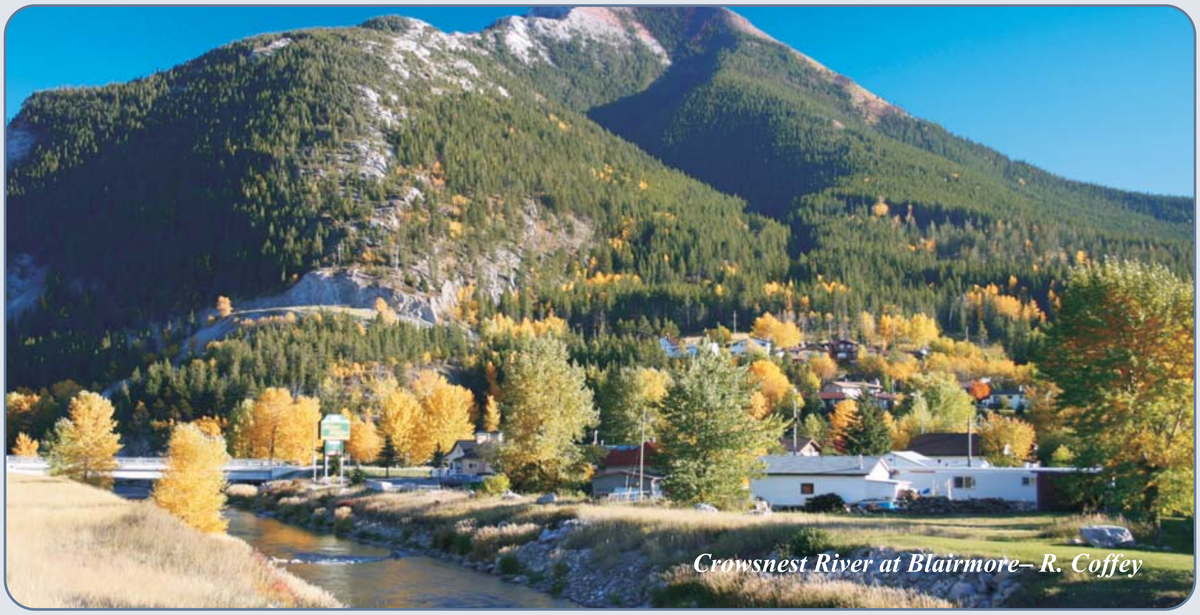
Pesticides[1]

Pesticide concentrations in the Castle River were either undetected or well below guideline levels during the sampling period between 1998 and 2003. In the Crowsnest River, pesticide concentrations were generally well below guideline levels for the protection of aquatic life, however, two exceedances of the guidelines were observed for Dicamba during the period from 1998 to 2003.

Water Quality Indices[2]

Often water quality studies use a Water Quality Index. This approach takes several different indicators and, using thresholds for best to worst quality, combines the indicators into one index to give a general overview of the water quality in a tributary or at a specific site. According to the Water Quality Index, the water upstream of the Oldman Reservoir, including the tributaries, was excellent during the period from 1998 to 2002. There were two exceptions at sites sampled along the Crowsnest River where the worst level of water quality was observed in 1998 and had improved by one level by 2002.

Sources:
[1] Saffran, K. 2005. Oldman River Basin Water Quality Initiative Surface Water Quality Summary Report April 1998 - March 2003, Oldman River Basin Water Quality Initiative.
[2] Oldman Watershed Council (OWC). 2005. Oldman River Basin Water Quality Initiative – Five Year Summary Report.
Guidelines: AENV 1999; CCME 2005



Crowsnest River at Blairmore– R. Coffey

2.2 Current Issues and Trends

2.2.1 Terrestrial and Riparian Indicators

Most human land use is restricted to the valley bottoms of the major rivers and streams because of the mountainous terrain and extensive forest cover in the Mountain Sub-basins. Grazing occurs on the grasslands and seeded pastures throughout.

Although less than 1% of the land base is set aside for recreational activities, protected areas (e.g., Bob Creek Wildland) are an important feature of the Sub-basins. Random recreational activity occurs throughout the Green Zone.

Agricultural uses predominate in the lower reaches, nearer the inlet to the Oldman Reservoir. Eight percent of the land base is cultivated land, and this is concentrated in the Crowsnest River valley bottom. Most of the urban development is along the Crowsnest River.

Linear developments, particularly cutlines and haul roads through the forested areas, result in temporary removal of mature forest and fragmentation of wildlife habitat. Wildlife corridors can be altered by roads. Watersheds can have their drainage patterns and water quality altered by increases in compacted surfaces. There is an increased potential for erosion when cutlines or roads are developed on the steep slopes of the Mountain Sub-basins. Continued disturbance and loss of wildlife habitat may add to the cumulative impact of these linear developments.

2.2.2 Water Quantity

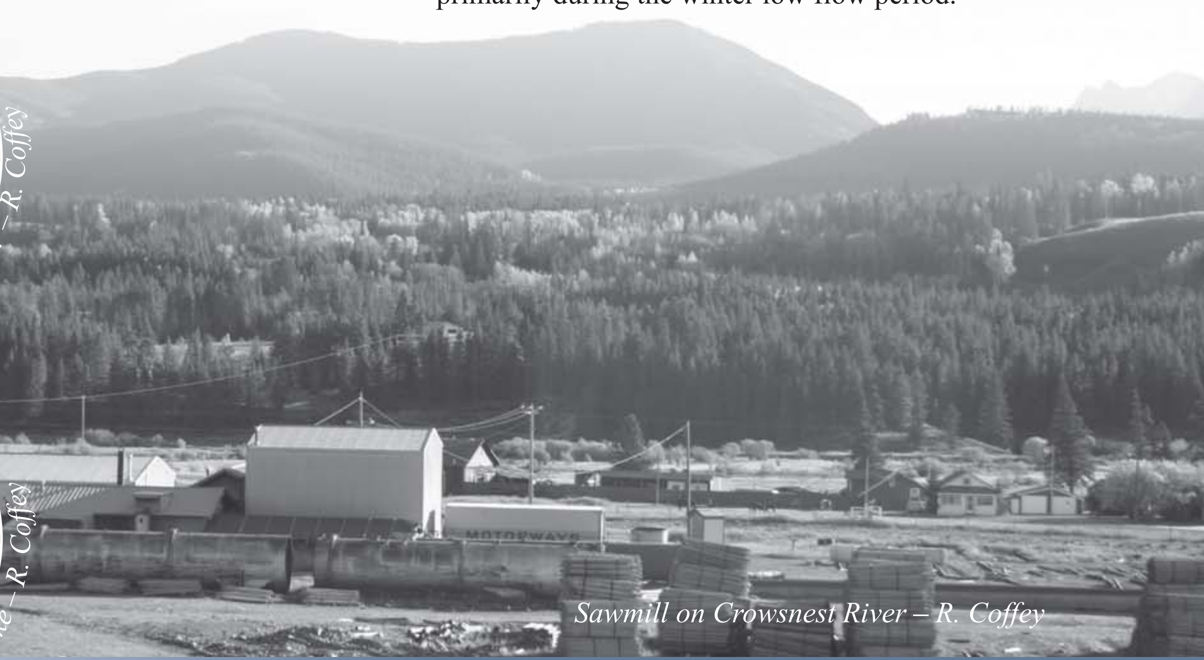
The Crowsnest and Castle rivers are the primary sub-basins of the Mountain Sub-basins. The headwaters of these rivers begin in the mountain regions and flow down toward the foothills, before discharging into the Oldman Reservoir on the Oldman River. The snowpack in the Mountain Sub-basins is much higher than in other areas of the Oldman watershed. Additionally, the Alpine and Sub-Alpine natural regions receive higher precipitation throughout the year than other natural regions in the Mountain Sub-basins. The Crowsnest and Castle river sub-basins are characterized by high basin yields resulting from the considerable snowpack and high amounts of precipitation.

In both the Crowsnest and Castle rivers, recorded flows are equivalent to natural flows because the rivers are unregulated and have low water demands. Water uses in the Mountain Sub-basins are small consisting primarily of commercial (e.g., fish hatchery) with some municipal and agricultural uses. There are periods when flows are less than IOs and WCOs in both streams, particularly during the spring, fall and winter.

No significant change to annual trends in streamflow exist in the Crowsnest and Castle rivers, however the Crowsnest River exhibits a significant decreasing trend in April. The rivers perform better at meeting water conservation and instream objectives at downstream sites compared with upstream locations, however deficits occurred at all monitored sites, primarily during the winter low flow period.

Mountain Wildflower – R. Coffey

Fishing Beaver Mines Lake – R. Coffey



Sawmill on Crowsnest River – R. Coffey

2.2.3 Water Quality

Water quality within Mountain Sub-basins is largely within guidelines under current land use and hydrologic conditions; the only exceedances observed in the past are related to an extreme rainfall event in June 2005 with subsequent flooding which is reflected in high loadings for phosphorus, nitrogen, TSS, and fecal coliforms.

Based on a comparison of annual loadings, nitrogen, fecal coliforms and TSS are higher in the Castle River than in the Crowsnest River. Annual phosphorus loadings are higher in the Crowsnest River.

Water quality has tended to decrease at the mouth of the Crowsnest River; decreases in water quality are apparent in the Castle River for nitrogen, phosphorus, and fecal coliform (Figure 2.31).

All indicators tended to decrease in the Crowsnest River sub-basins from 1991 to 2000.

No trends were observed in TSS concentrations over the period from 1991 to 2000 in the Castle River sub-basin.

The numbers of fecal coliforms in both the Castle and Crowsnest River sub-basins show a decreasing trend for the period from 1991 to 2000.

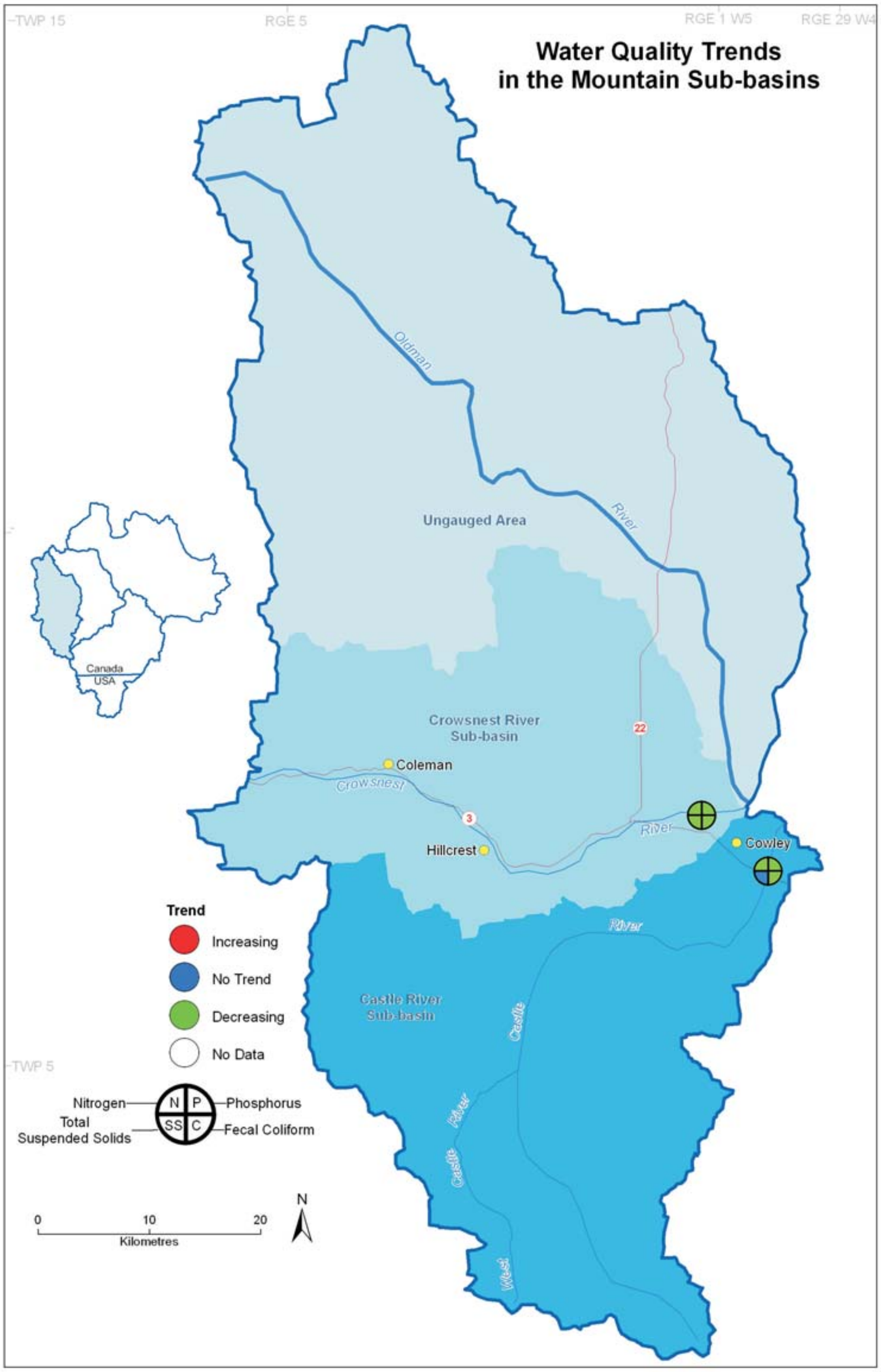


Figure 2.31: Water Quality Trends in the Mountain Sub-basins

2.3 Summary

Overall, the Mountain Sub-basins is rated as **Good**. A summary of the observations and analyses of indicators in the Mountain Sub-Basins is provided below.

Terrestrial (Good)

- Land cover of natural forest and grassland is 87%, rated good.
- Soil erosion risk is low, rated good.
- Riparian health is healthy but with problems, rated fair.
- Linear developments cover 1.9% of area, rated good.
- Total land use at 25%, rated good.

Water Quantity (Good)

- Streams have relatively high unit yields (dam^3/km^2), but not as high as the upper reaches of the Southern Tributary Sub-basins (see Chapter 4)
- No significant trends in annual flow volumes.
- Low level of water allocation and use
- Flows are frequently less than the IO and WCO flows on the Castle River and upper reach of the Crowsnest River (near Frank) during fall, winter and spring months.

Water Quality (Good)

- All water quality indicators are within guidelines under current conditions.
- Exceedances observed in the past are related to an extreme rainfall event in 2005 which is reflected in high loadings for phosphorus, nitrogen, TSS, and fecal coliforms.
- Annual loadings (nitrogen, fecal coliforms and TSS) are higher in the Castle River than in the Crowsnest River.
- Annual phosphorus loadings are higher in the Crowsnest River.
- Water quality at the Crowsnest River mouth tended to have overall decreasing trend.
- No trend observed in the Castle River sub-basin for TSS with decreasing trends in all other indicators.

Management recommendations are provided in Chapter 10.

Bales and turbines at Cowley – R. Coffey