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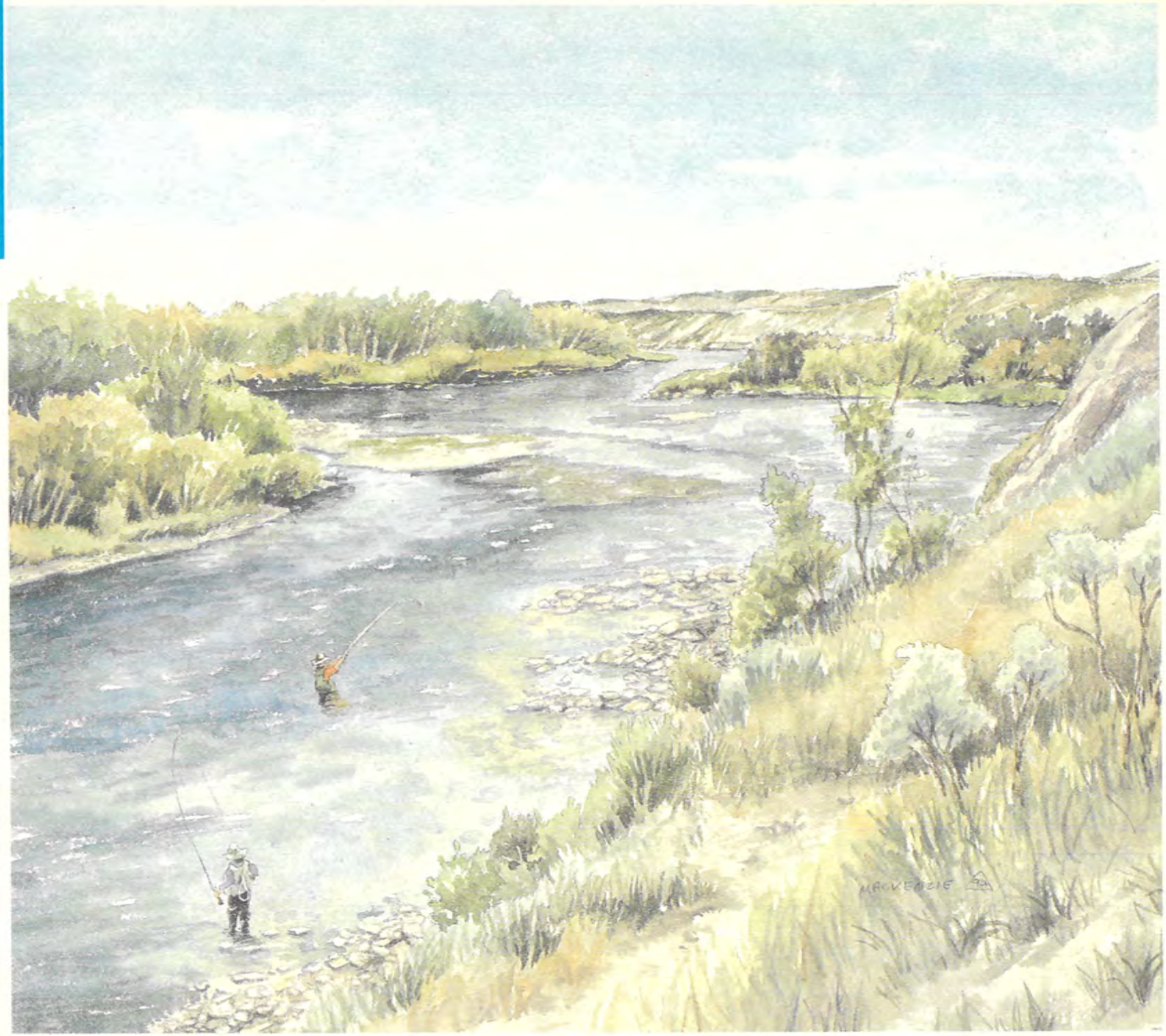
Preserving Our Lifeline:

A Report on the State of the Bow River



Report of the

Bow River WATER QUALITY COUNCIL

October 1994

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Jim Rouse
Chairman, State-of-the-River Committee

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Executive Summary

The Bow River provides lifeline benefits shared by hundreds of thousands of people living in the Bow River Basin. Electrical energy and water to sustain domestic uses, agricultural uses, natural ecosystems, recreation and industry all are provided by the river.

In turn, the human uses of the river influence the river's health. It is important to know the effects of these uses and to manage them to ensure both continued water use and long-term health of river and wildlife ecosystems.

Periodic reporting on the state of the Bow River, such as in this first report Preserving Our Lifeline: A Report on the State of the Bow River, is one of the major responsibilities of the Bow River Water Quality Council. This report provides a benchmark against which water quality and the effectiveness of strategies for river use management can be compared in future reports.

The Council was established in 1992 as an advisory body to the provincial Minister of Environmental Protection. Its broad mandate is to promote awareness, improvement and protection of Bow River water quality, foster cooperation among agencies with water quality responsibilities, and provide communication links among governments, interest groups and the general public. The Council includes representatives from urban and rural municipalities; irrigated and dryland agriculture; recreational, industrial and other interests; and first nations peoples within the Bow River Basin.

This report on the state of the Bow River assesses water quality, and describes water quantity, riparian (river margin) habitats, and aquatic habitats along the river. The assessment of the state of the river is not considered complete without an evaluation of the riparian and aquatic aspects of the ecosystem because of their interdependence with the quality and quantity of water flowing in the river. The report focuses on 1991 and 1992 data, although time-series data from 1985 to 1992 were also used where available.

In 1992, the water quality in the Bow River ranged from being unaffected by local human activity and suitable for all uses in the headwaters, to impacted by pollutants and restrictive for some water uses in the lower reaches. However, lack of appropriate data in some reaches restricts discussion of the reasons and sources for downstream water quality deterioration

In 1992, the natural flow of the Bow River was 3 640 million cubic metres, approximately 91 percent of the long-term average flow of 4 010 million cubic metres. This flow was moderately less than normal.

In 1991 (the latest year for which consumption data had been compiled), 61.6 percent of the river's annual average flow over the long term was licensed for use, 37.8 percent was actually withdrawn and 27.4 percent was consumed. Irrigation and municipal users have the largest total licensed volumes and also withdraw the largest amounts of water. However, with municipalities returning to the river almost all their withdrawals in the form of wastewater effluents, irrigation is the largest consumer with 95.7 percent of the total water consumption.

Consumption of Bow River water varies greatly with the annual precipitation in the basin, as does the water available in the river. From 1981 to 1986, all uses of Bow River water together consumed between 23 and 47 percent of the natural flow.

Relatively undisturbed riparian forest, characterized by native balsam poplar and white spruce, with the occasional plains cottonwood, covers approximately 80 percent of the Bow River valley.

The Bow River supports 15 species of sportfish and is well-known as having one of the best recreational trout fisheries in North America. Rocky Mountain whitefish, brown trout and rainbow trout are the most common fish. The state of the Bow River fishery varies considerably along the river; however, overall a high-quality trout fishery has been maintained.

The Bow River valley supports a variety of wildlife. The state of the wildlife ecosystems are influenced by the degree of human activity and development, the amount and diversity of habitat, and the quality and quantity of river water.

The Bow River is generally in a reasonably good state; however, there are areas where improvement is needed:

- expansion and coordination of regional and local monitoring programs
- new approaches to sewage disposal
- controlling siltation in the river caused by human activities
- integrated river basin planning and management
- control of groundwater contamination from nearshore land sites
- management of water and effluent quantities as they relate to water quality (dilution of contaminants and safe allocation of river assimilative capacity)
- reduction of contamination from agricultural operations
- control of the effects of urban stormwater and rural runoff

Significant strides in identifying and addressing a wide variety of Bow River use issues have been made. Major challenges to improve river use management are still before us.

Use	Reach Number							
	1	2	3	4	5	6	7	8
Contact Recreation	●	●	●	●**	◔	◔	◑	◕
Aesthetic Enjoyment	●	●	●	●	◔	◑	◑	●
Cold-water Ecosystem	●	●	●	●	◑	◑	◕	
-Cool-water Ecosystem							◕	◕
Drinking Water Supply*	◕	◕	◑	◕		◔	◔	◔
Industry			●	●	◑	◕		●
Livestock Watering			●	●		●	●	●
Irrigation	●		●	●	◔**	◔**	◑	◔

Percent of water samples meeting guideline levels:
● 100% ◕ 75-100% ◑ 50-75% ◔ less than 50%

* All drinking water must be treated.
** Localized areas within the reach may have poorer water quality than indicated.
Note: Water quality is evaluated for only the prevalent water uses within each reach.

Reach No.	Reach Boundaries
1	Headwaters to Lake Louise
2	Lake Louise to Banff National Park
3	Banff National Park to Bearspaw Dam
4	Bearspaw Dam to Western Irrigation District Weir
5	Western Irrigation District Weir to Highway 22X
6	Highway 22X to Bow River Irrigation District Weir
7	Bow River Irrigation District Weir to Bassano Dam
8	Bassano Dam to Oldman River

Message from the Chairman, Bow River Water Quality Council

1.0

The quality of life enjoyed by the residents of the Bow River Basin is substantially dependent on the state of the water flowing in the Bow River. Fortunately or unfortunately, we have, by necessity, linked our sanitary effluents and stormwater discharge to the river. But, there is a water quality balance that must be maintained because the river is a limited renewable resource with a limited capacity to assimilate the impact of many uses. The river provides lifeline benefits such as electrical energy and water to sustain domestic uses, agriculture uses, natural ecosystems, recreation and industry, which contribute to the lifestyle enjoyed by hundreds of thousands of people. In turn, the state of the river is influenced by human activity and an abundance of natural processes and forces.

Knowing and addressing the effects of human activities on the Bow River are major responsibilities of the Bow River Water Quality Council, the publisher of this report. The Council was established in 1992 as an advisory body to the provincial Minister of Environmental Protection and includes representatives from urban and rural municipalities, interest groups, irrigated and dryland agriculture, and first nations peoples (see the Bow River Water Quality Council Profile on page 89 for more information on the Council). The Council has the following broad objectives:

- advising on policies and programs related to Bow River water quality
- promoting awareness, improvement and protection of Bow River water quality
- fostering cooperation and efficiency among agencies with responsibilities for water quality management in the Bow River Basin
- providing communication links among governments, interest groups and the general public

Council's Vision for the River

The Bow River will be conserved and protected as a fragile and unique resource and recognized as our lifeline. Multiple uses will be balanced, ensuring the needs of all stakeholders are met, but recognizing that a healthy ecosystem is paramount.

This report on the state of the Bow River is the first major project of the Bow River Water Quality Council. The report evaluates water quality, and describes water quantity, riparian (river margin) habitats and aquatic habitats. It also discusses human uses of the river (drinking water, agriculture, industry, recreation, waste disposal and hydropower generation) and presents opportunities for improving management of these uses. We believe this report to be an essential first document to assist river users, decision makers and the public in defining river use objectives and determining management strategies both locally and regionally.

In many respects the report can be considered a benchmark against which future reports can compare water quality and strategies for river use management. In this way, we all, private citizens, river users and managers of river uses, will be able to monitor the condition of and affects on our lifeline: the Bow River and its tributaries.

Although the report shows the Bow River is generally in a reasonably good state, future high-quality water provided by this critical lifeline can only be assured by effective cooperation of all river users. Management initiatives are required to minimize contaminated water flows directly into the river and to incorporate river protection mea-

sures into development approvals along all reaches of the Bow River and its tributaries. As a limited resource, the waters of the Bow River basin will require ongoing vigilance and management to ensure a healthy ecosystem is maintained in spite of the ever--increasing demands on the river system.

In preparing this river assessment report, the need to investigate a number of issues was apparent. Some of the water quality issues identified as highest priority for improved river use management processes and technologies are:

- expansion and coordination of the provincial and federal river monitoring programs
- new approaches to sewage disposal and improved sewage treatment
- river basin planning and management
- determination and control of groundwater contamination from current and abandoned land sites
- water quantity as it relates to water quality (dilution of contaminants and assimilative capacity)
- reduction of contamination from agricultural operations
- minimizing the impact of chemicals in our water supplies
- continued timely reporting on the state of the river locally and regionally
- greater awareness of and control of both rural and urban runoff

The high-priority issues related to water quality management are the need for:

- greater interjurisdictional and intergovernmental coordination of water quality and water quantity management, particularly as it relates to development approvals and enforcement
- improved Council profile to encourage cooperative principle-based and performance-based leadership in the basin among river users
- greater accountability from all parties who either have jurisdiction or whose actions may affect water quality and quantity
- methods of funding water quality protection and minimizing the long-term costs of providing clean water and a healthy aquatic ecosystem
- greater awareness of the importance of and methods available for water quality management and protection
- clarification and communication of water quality protection principles, policy and legislation

Jim McLennan

Many of these water quality issues are described in detail in the Bow River Water Quality Task Force Report, published in November, 1991.

Also, when preparing this state-of-the-river report, a number of significant water quality data gaps were encountered. In other words, there are some sections of the Bow River where water quality information is unknown. Some of these data shortcomings are being met by Alberta Environmental Protection, federal agencies and local user organizations. Other shortcomings can be viewed as opportunities for local and regional interest groups, user organizations and water resource decision makers to improve river use management, monitoring and technologies.

Although major challenges to improve river use management are still before us, the Council and responsible agencies have made significant strides in identifying

and addressing a wide variety of river use issues. For example, since the publication of the Bow River Water Quality Task Force Report in November, 1991, Alberta Environmental Protection, in conjunction with the federal government and the Bow River Water Quality Council, has drafted the Bow River Basin Study Design. This study will address many of the recommendations in the task force report and will involve river stakeholders and the public in decision making. The study will improve scientific knowledge, provide analytical tools, and make recommendations to direct integrated river use management in the Bow River Basin. Many other accomplishments by other agencies and the Council are described in a supplemental section to this report Projects by Communities, Governments and Organizations on page 77.

The Council welcomes ideas and suggestions on how to report on and manage the state of the Bow River, manage river use and improve water quality and the health of the ecosystem. Please contact the Chairman, the Executive Director or any member of the Council to discuss water quality issues of importance to you. We welcome your advice and participation.

Introduction

2.0

Purpose of Report

It is important that management of the uses of the Bow River be guided by reliable information. The purpose of this report is to provide information to:

- improve the overall understanding of the Bow River
- aid in informed decision making on issues concerning the quality of the water in the Bow River
- provide a reference point from which to monitor the Bow River ecosystem
- engage stakeholders and water management resource managers in public discussion and provide direction on local and regional water quality improvement measures

This is not a highly technical document intended for the scientific community. Rather, the report has been prepared for a broad cross-section of audiences to answer such basic questions as:

- Can I irrigate with the water?
- Are the river ecosystems healthy?
- Is industry contaminating the river?
- Are the fish safe to eat?
- Is sewage contaminating the river?
- Are pesticides getting into the water?
- Is the water safe to drink?
- Can I safely water livestock with river water?
- Can I safely fish or canoe in the river?
- What is being done to solve water quality concerns of the river?

Scope of Report

The report evaluates the current state of the river ecosystem and considers water quality and quantity, and riparian and aquatic habitats. It also discusses human uses of the river (drinking water, agriculture, industry, recreation, waste disposal and hydropower generation) and presents opportunities for improving our management of these uses.

This report is based largely on 1985 to 1992 data. The lag time between the end of 1992 and the publication date is the result of the time required for the Council to assemble, organize, verify and interpret data, assess interrelationships and design the reporting format.

How the State of the River is Assessed

The river is assessed for the state of its water quality for various uses, water quantity and river ecosystem (including riparian vegetation, fish and fish habitat, waterfowl and wetland habitat and wildlife and wildlife habitat).

Reach No.	Boundaries of Reach	Length (kilometres)
1	Bow Lake to Upstream of Lake Louise	35
2	Lake Louise to Banff National Park Boundary	80
3	Banff National Park Boundary to Bearspaw Dam	115
4	Below Bearspaw Dam to the Western Irrigation District Weir	28
5	Below the Western Irrigation District Weir to Highway 22X	25
6	Highway 22X to the Carseland Weir	53
7	Below the Carseland Weir to the Bassano Dam	136
8	Below the Bassano Dam to the Oldman River	185

Figure 1. Bow River Reaches

Information is presented for each individual river reach or section. The reach-

es used in the report are those defined in the Bow River Water Quality Task Force Report (Figure 1). The reaches are defined by both the human uses along the river and geography of the river basin.

Currently, water quality is assessed objectively using the approach devised by the Bow River Water Quality Task Force. Water quantity and the river ecosystem are assessed more subjectively. A brief description of water quality, water quantity and the river ecosystem, as well the methods of assessing their current states are described below.

Water Quality

Water quality is determined by the levels of such variables as oxygen dissolved in the water, suspended solids (e.g., silt), bacteria, toxic chemicals and nutrients such as nitrates and phosphorus. Water quality varies extensively and is affected by natural factors such as the terrain the river is flowing through, time of year and amount of runoff, and human factors such as the type of effluents received from sewage treatment plants and industry. The rating of a water's quality depends on the intended use of the water as different uses require water with different characteristics. For example, in 1992, Reach 6 water was suitable for livestock watering but not recreation as fecal coliforms levels were too high.

In this report, Bow River water in 1992 is assessed for its suitability for the various water uses specified for each reach of the river in the *Bow River Water Quality Task Force Report.* Data available on the water quality in each reach are compared against guideline levels for the variables of importance to the various uses. For example, to assess the suitability of water for contact recreation, the levels of the following variables are measured and compared against guideline levels: coliform bacteria, Secchi depth, turbidity, pH and benthic chlorophyll. All data available for a reach from all sources were used. For some reaches, the data are from one point only; for other reaches, data are from several locations along the river.

Figure 2 shows the water uses along the river and the water quality goals for each use. The appendix, Bow River Water Quality Guidelines, on page 73 shows the variables of importance to each water use and the guideline levels.

As well as the review of 1992 data, available data for some key water quality variables are examined for changes in their levels over the period 1985 to 1992. The key variables reviewed are:

- total dissolved solids
- total phosphorus
- nitrate and nitrite
- fecal coliform bacteria
- benthic algae

These variables are considered key because they affect many water uses or are representative of a broader spectrum of water quality concerns. Figure 3 describes these key variables and their importance. Variables such as dissolved oxygen in the water, suspended solids or levels of aquatic plants are also considered key, but they were not analyzed on a time-series basis in this report

Uses	Goals
Drinking Water Supply	• a minimum of treatment to achieve Canadian Drinking Water Guidelines, which is water without harmful levels of bacteria, viruses, toxic chemicals and trace metals
Contact Recreation	• absence of turbidity resulting from human activity • low risk of bacterial or viral infection • limited weeds and algae • no odour, oily sheen or hazardous chemicals • no litter or garbage
Aesthetic Enjoyment	• weed and algae growth that is not unsightly • no odour or oily sheen
Irrigation	• low salt content • levels of trace metals and herbicides that are non-toxic to plants • no bioaccumulative contaminants or disease-causing organisms • levels of nutrients that do not produce weeds in river intakes or irrigation canals • low levels of suspended solids
Livestock Watering	• no bioaccumulative contaminants or disease-causing organisms • low to moderate salt content • non-toxic levels of nitrate, pesticides and trace metals • levels of nutrients that will not stimulate growth of toxic blue-green algae
Industry	• levels of nutrients that do not produce sufficient weed or algae growth to impair water withdrawal
Hydropower Generation	• no specific water quality requirements
Cold-water Ecosystem	• consistently high oxygen content and cool water temperatures • non-toxic environment for aquatic life • fish with pleasant taste and odour, and levels of potentially toxic chemicals below guidelines for human consumption
Cool-water Ecosystems	• consistently moderate oxygen content and water temperatures • non-toxic environment for aquatic life • fish with pleasant taste and odour, and levels of substances below guidelines for human consumption
Wildlife	• a healthy environment, which would be met by satisfying the cold and cool-water ecosystem requirements

Figure 2. Bow River Uses and Water Quality Goals

because of insufficient data for the period.

Within this report, the most stringent (Level I) of the three Bow River Water Quality Task Force guideline levels for assessing raw drinking water supply is used. The Level I guideline indicates water of high quality for drinking (meets the Canadian Drinking Water Guidelines) with a low risk of pathogenic contamination. The Level II and III guidelines indicate water that must receive more advanced treatment to be of acceptable quality for drinking.

Although Level I water is of high quality, it still must be disinfected before use and should receive chemical treatment to kill protozoan cysts such as *Giardia* (causing what is commonly called beaver fever), which are not killed by disinfection.

In assessing the river's water quality for supporting a healthy ecosystem, the Bow River Water Quality Task Force guidelines for both cold-water and cool-water ecosystems are used. These guidelines refer to water quality necessary to protect cold-water and cool-water fish and differ only in their levels of dissolved oxygen, temperature and ammonia (see the appendix, Bow River Water Quality Guidelines, on page 73). Generally, the upper reaches are home to cold-water fish (e.g., brook trout, rainbow trout, lake trout and burbot) and are assesed against the coldwater ecosystem guideline. Generally, the lower reaches of the river are home to cool-water fish (e.g., northern pike, walleye), but cold- water fish are also found in smaller numbers. Therefore, the lower reaches are assessed against both the cool-water and cold-water ecosystem guidelines.

Water Quantity

Water quantity, or the amount of water flowing in the river, influences water quality, and the amount and health of aquatic and riparian habitat. Flows influence water quality through their dilution of substances in water, move-

Key Water Quality Variable	Description
Total Dissolved Solids	Total dissolved solids (TDS) are the total amount of ions (commonly called salts) dissolved in water and provide a general indicator of a water's physical and chemical characteristics. Sources of ions include natural minerals, surface runoff, municipal and industrial effluents, agricultural runoff and atmospheric fallout. TDS levels are important for water for drinking, irrigation and livestock watering.
Total Phosphorus	Phosphorus is a nutrient essential for growth of plants in water. Elevated concentrations often result in increased growth of algae, which make water green, and large water plants called aquatic macrophytes or "weeds". Sources of phosphorus include surface runoff, dust, rain, municipal effluents and agricultural runoff. Phosphorus levels are also important because of toxicity concerns for water for drinking, irrigation and livestock watering.
Nitrate and Nitrite	Nitrate and nitrite are two dissolved inorganic forms of nitrogen that are nutrients for some plants. Their levels can indicate the growth of algae and macrophytes in water. Sources of nitrate and nitrite include surface runoff, rain, municipal and industrial effluents, and soil leaching. Nitrate and nitrite levels are also important because of toxicity concerns for water for drinking and livestock watering.
Fecal Coliform Bacteria	Fecal coliform bacteria are contributed to the river by the feces of warm-blooded animals. Fecal coliform are measured to indicate the potential level of disease-causing bacteria and viruses in water. Sources of fecal bacteria include wildlife, waterfowl, municipal effluents and livestock runoff. Fecal coliforms levels are important for water for irrigation, drinking and contact recreation (e.g., swimming, kayaking).
Benthic Algae	Benthic algae are microscopic plants attached to the river bed. The amount of growth of benthic algae is measured by the amount of chlorophyll *a* in the water. The level of benthic algae can be used to indicate how well nourished (how rich in nutrients) a water is.

Figure 3. Key Water Quality Variables Used in Report

ment of sediments laden with nutrients and metals, erosion, moderation of water temperature and effects on aquatic plant growth.

The flows in 1992 are compared with long-term average flows. The water uses that affect river flow, such as irrigation and hydropower generation, are also discussed. It is important to note that water use data from 1991 were used as 1992 data were not available.

Ecosystem

The river ecosystem is assessed largely by describing the riparian habitat (nearshore vegetation and wetlands), waterfowl, wildlife and sportfish along the river reaches. The extensive wetland habitats maintained by irrigation canal systems distant from the river are also mentioned.

The number, type and health of waterfowl and wildlife depend mainly on the quality and quantity of riparian habitat. Waterfowl and wildlife are also affected by water quality as they drink water from the river. The number, type and health of fish depend largely on water quality and quanity.

For each of riparian habitat, waterfowl, wildlife and sportsfish, the following information is presented where it is available:

- species
- abundance
- critical features
- factors that limit or enhance survival

For riparian habitat, the focus is on the difference in distribution of riparian forest in 1992 with that 98 years earlier in 1884. For waterfowl, the focus is on use of the river by mallard ducks and Canada geese as these two species are the most common waterfowl on the river. For fish, the emphasis is on the sportfish species: the sportfishery is a key use of the river and current information is largely confined to sportfish species.

Bow River Basin Overview

3.0

As background to understanding the current state of the Bow River, this section provides brief overviews of the geography, natural environment and human population in the Bow River Basin. It also provides an overview of the uses of the river, and the challenges in managing these uses while preserving river ecosystems.

Geography

In Alberta, the South Saskatchewan River drainage basin is located in the southern part of the province and drains about 20 percent of Alberta as well as a small portion of Montana. The Bow River is part of the South Saskatchewan River system, as are the Red Deer and Oldman rivers (Figure 4).

Figure 4. South Saskatchewan River Basin

The Bow River, with a drainage area of approximately 25 000 square kilometres, accounts for about 23 percent of the drainage area that forms the South Saskatchewan River (Figure 5). Of the 9 500 million cubic metres of average annual combined flows that form the South Saskatchewan River, the Bow River contributes nearly 43 percent, thus making it the largest tributary. In 1992, the natural flow of the Bow River was 3 640 million cubic metres, approximately 91 percent of the long-term average of 4 010 million cubic metres. Thus flow in 1992 was moderately less than normal.

Major tributaries of the Bow River (Figure 5), all of which have their headwaters in the Rocky Mountains of Alberta, include the Pipestone, Spray and Cascade rivers in Banff National Park; the Kananaskis and Ghost rivers entering the Bow in the foothills; and the Elbow and Highwood rivers that join the Bow River on the prairies.

Landscape

The western or upper third of the Bow River flows through the heart of the Rocky Mountains in Banff National Park. In this upper part of the basin, the river landscape is dominated by steep-sided valleys covered with coniferous forests and surrounded by glacier-clad mountains with elevations up to 3 400 metres. The river begins at Bow Lake at an elevation of 2 000 metres.

The eastern slopes of the Rockies and the foothills are covered with mixed deciduous and coniferous forests, opening into grasslands. The topography becomes increasingly gentler as the river flows eastward. In the remaining two-thirds of the Basin east of the mountains and foothills, the river flows mostly in a wide, deep valley through the prairie. West of Medicine Hat, at an elevation of 740 metres, the Bow River joins the Oldman River to form the South Saskatchewan River.

Climate

Most of the water in the Bow River actually originates above the Pacific Ocean. From there, masses of air flow to the mountains and eastern slopes of the Rockies, depositing rain and snow. This rain and snow and some meltwater from glaciers provide the source waters for the Bow River.

Normal precipitation along the course of the Bow River ranges from over 600 millimetres in the mountain valleys to about 300 millimetres on the eastern prairies. In the upper end of the river above Lake Louise, over 50 percent of the annual precipitation falls as snow, but on the prairies east of Calgary, snowfall normally accounts for only 25 percent of the annual precipitation, much of which normally evaporates in the chinook winds.

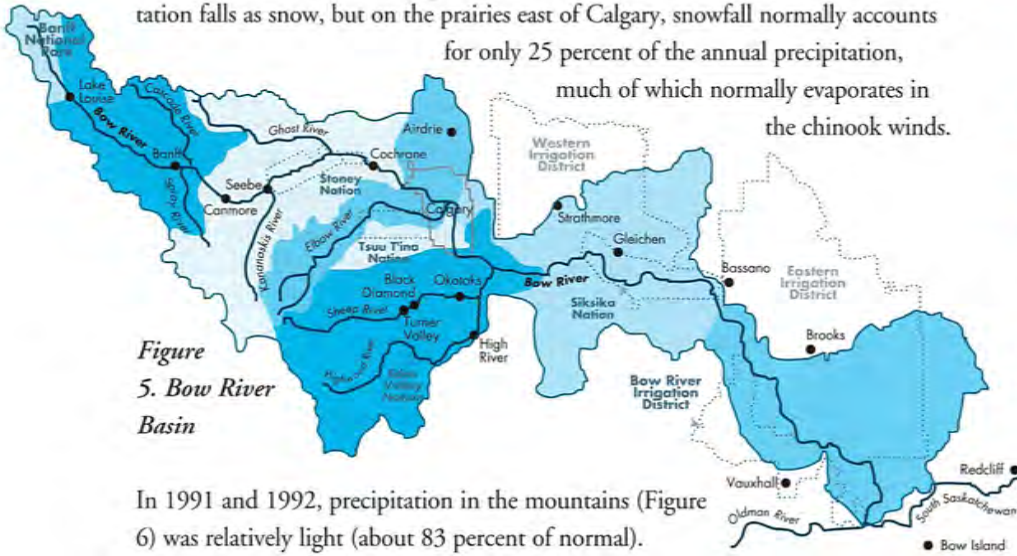


Figure 5. Bow River Basin

In 1991 and 1992, precipitation in the mountains (Figure 6) was relatively light (about 83 percent of normal). Heavier than normal rainfall in the Calgary area in 1992 and the Brooks area in 1991 produced above-average soil moisture conditions.

Annual and daily temperatures vary widely across the basin. There are approximately 100 frost-free days in the Bow Lake area and up to 200 frost-free days in the eastern areas of the Bow River basin.

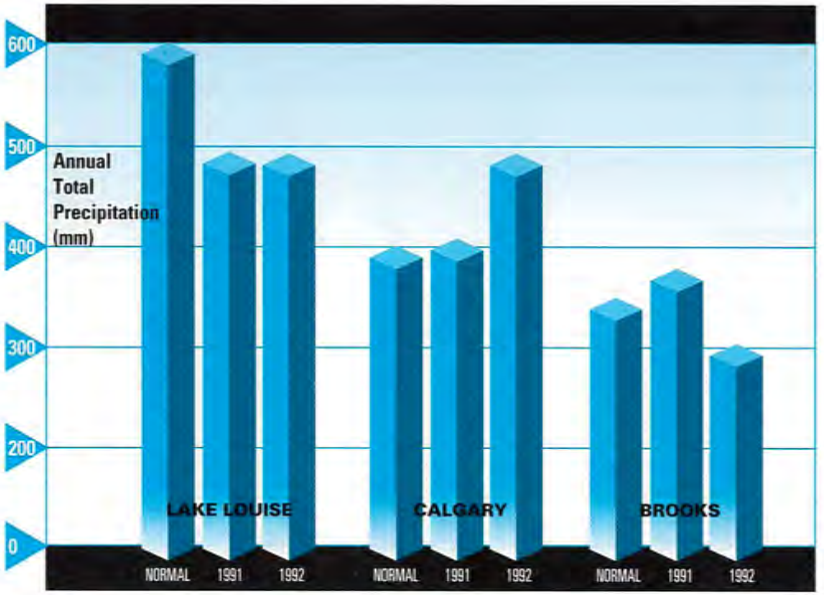


Figure 6. Precipitation in the Bow River Basin

Human Population

In 1991, approximately 836 000 people lived in the Bow River basin. An additional 12 000 people lived outside the basin, but depended on waters exported from the Bow drainage by canal systems.

The current population of the Bow River basin is expected to increase to approximately one million by the turn of the century and reach approximately

Region (See figure 8)	1991		2011		% Change over Forecast Period
	Population	Percent of Basin Population	Population	Percent of Basin Population	
Upper Bow	17 173	2.0	24 709	2.2	+44
Foothills	63 403	7.6	98 420	8.6	+55
Calgary	727 719	87.0	989 500	86.5	+36
Carseland-Bassano Dam	12 198	1.5	16 151	1.4	+32
Lower Bow	15 786	1.9	15 733	1.4	0
Total	836 279		1 144 513		+37

Figure 7. Population in the Bow River Basin

Note: Areas are defined for purposes of the population study and are not representative of geographical boundaries.

1.14 million by the year 2011 (Figures 7 and 8). All areas, except the Lower Bow region, are expected to increase in population over this period. Population is expected to grow fastest in the upper regions of the basin. In the Upper Bow region, the population is forecast to increase 44 percent, and in the Foothills region, 55 percent.

This population growth will greatly increase demands on the river. There will be a need for greater monitoring and vigilance to maintain and improve water quality for downstream users.

River Uses

The Bow River is used for many activities. Most of these activities require water of certain quality and most can also impact river water quality.

Water uses are broadly classified as consumptive or nonconsumptive.

Consumptive water uses are those that withdraw water from the river (portions of which may be returned), resulting in a net decrease in downstream river flow. Water used for municipal purposes, industry and irrigation are examples of consumptive uses. Recreational activities such as fishing and boating are examples of nonconsumptive uses. TransAlta Utilities' hydropower system, which stores water in reservoirs and then releases it for power generation, is another nonconsumptive use although the large surface areas of the reservoirs result in some evaporation losses.

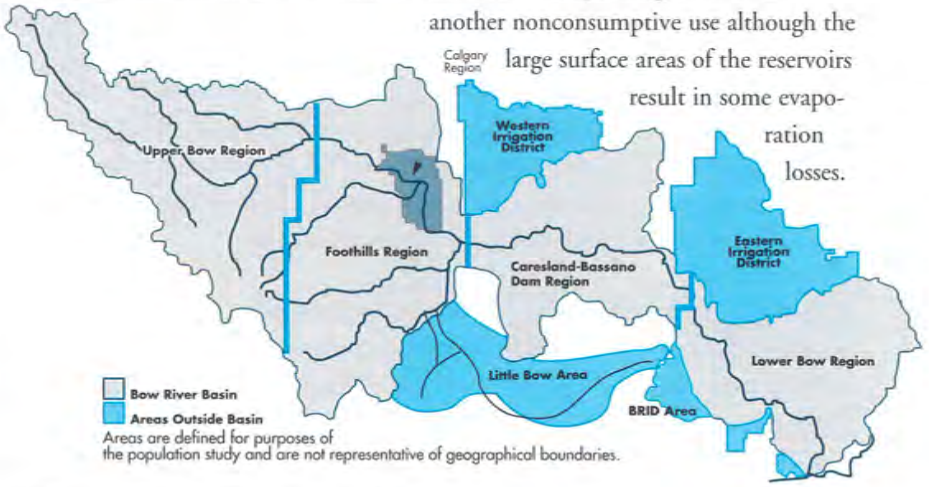


Figure 8. Population Zones in the Bow River Basin

The various uses of the river and the challenges in managing these uses are briefly described below.

Consumptive Water Use

Domestic/Municipal Water Supplies

At the end of 1991 (the last calendar year that information has been compiled), there were 74 licences for direct withdrawals from the Bow River for

domestic or municipal purposes and an additional 25 for indirect withdrawals from irrigation systems. Of these, Calgary draws the most water from the Bow River. On the Elbow River, a major tributary of the Bow that flows through Calgary, the city also owns and operates its own onstream storage, the Glenmore Reservoir.

Municipal and domestic withdrawals accounted for 19.4 percent of the water licensed by the government for withdrawal from the river. Actual domestic/ municipal withdrawals in 1991 were 11.0 percent of total withdrawals and consumption was 0.9 percent of the total amount of water used. While municipalities make significant withdrawals from the river, they are minor consumers because collectively, they return about 94 percent of their withdrawals to the river through wastewater treatment systems.

In the upper reaches of the river, the pristine waters require little treatment to be suitable for drinking. Moving downstream, natural and manmade contaminants increase, requiring more advanced treatment of water for drinking. There are some taste and odour problems in the lower reaches associated with high nutrient levels.

Irrigation

Irrigation is a major use of water in Southern Alberta where temperatures are hot and precipitation is low. In 1991, there were 200 licences for irrigation withdrawals in the Bow River basin. These licences, which also sometimes include secondary uses such as agriculture, municipal supplies and support of wetland habitat, accounted for about 75 percent of all possible licensed diversions from the Bow River.

In 1991, 96 percent of all water actually consumed (withdrawals less the amounts returned to the river) from the Bow River was for irrigation. About 98 percent of the diversions for irrigation are by three irrigation districts: Bow River Irrigation District, Western Irrigation District and Eastern Irrigation District. Together these districts encompass about 1900 square kilometres.

Ideally water for irrigation is low in salts, nutrients and suspended solids. Weed growth and siltation in canals and intake structures have been problems for irrigators.

Agriculture

Agricultural activities other than irrigation also require water from the Bow River. In 1991 there were 572 licences to divert water for agricultural purposes—typically to water livestock. These licences accounted for 0.4 percent of the volumes licensed for diversion from the river. In 1991, 0.8 percent of the water actually consumed from the river was for agricultural purposes.

Ideal water for livestock watering is free of disease-causing contaminants and low in nutrients to minimize algae growth in storage facilities. With 95 percent of the agricultural licenses below Calgary, most withdrawals are subject to the nutrient loadings from Calgary.

Industrial Processes

In 1991 there were 68 licences for withdrawals from the river for industrial purposes. Typical of the industries licensed to make direct withdrawals are cement manufacturers, fertilizer manufacturers, and oil companies for oilfield injections. In 1991, industries consumed 1.2 percent of the total consumption of Bow River water.

Ghost Hydropower Plant

For industries that withdraw water directly from the Bow River, the quality of the river water is normally satisfactory. Their major concern has been periodic clogging of water intakes with weeds.

Most industrial uses of water in the Bow River basin occur in urban areas using water drawn from municipal water systems and are included in municipal consumption figures.

Other Uses

Miscellaneous activities ranging from golf courses to waterfowl enhancement projects held 67 licenses for water from the Bow River in 1991. These licences accounted for 0.6 percent of all permitted diversions and 1.4 percent of all consumption. Water quality requirements for these activities depend on the water use.

Nonconsumptive Water Use

Recreation and Aesthetic Enjoyment

The river itself and the reservoirs along the river provide many attractive settings for recreational and tourist activities. The river is used extensively for rafting, fishing, canoeing, kayaking, power boating and general enjoyment of nature. Many waterside parks, cottage developments and campgrounds reflect the recreational interest in the river.

Water for recreation should be free from disease-causing organisms and have little weed growth. Both these have been a problem in some areas of the Bow River.

Hydropower Generation

TransAlta Utilities operates a network of hydropower facilities in the upper Bow River basin, extending from Banff to Calgary. There are 11 generating stations with one storage reservoir on the Bow and five on the tributaries (Figure 9). There is also a regulating reservoir at Bearspaw, which is used to smooth flow variations through Calgary (there is very little storage at this site).

The combined storage capacity of the six reservoirs is around 700 000 000 cubic metres of water. In general, the reservoirs are filled during spring and summer, and then drawn down during the fall and winter to generate power. Operating these reservoirs decreases flows in the Bow River during summer and increases flows during fall and winter. The timing and quantities of releases from the reservoirs can affect downstream water uses and the aquatic and riparian ecosystem.

The hydropower facilities in the Bow River Basin generate 3.5 percent of TransAlta Utilities' total generating capacity. While this is a small amount, it is very significant to TransAlta's operations because, compared to coal-fired thermal power, hydropower can provide quick response to varying demands for power.

Plant	Capacity (megawatts)	Reservoir	Storage ('000 cubic metres)
Cascade	36	Lake Minnewanka	221,950
Three Sisters	4	Spray Lakes	177,560
Spray	100	Upper Kananaskis Lake	63,100
Rundle	50	Lower Kananaskis Lake	24,800
Pocaterra	15	Barrier Lake	92,500
Interlakes	6	Ghost Lake	
Barrier	13		
Kananaskis	19		
Horseshoe	16		
Ghost	51		
Bearspaw	17		

Figure 9. Hydropower Facilities in the Bow River Basin

Wastewater Disposal

The river is used to dispose of liquid wastes from wastewater treatment plants, urban stormwater and industrial effluents. These effluents must not exceed the river's capacity to assimilate them because of downstream users.

Wherever there is a wastewater discharge to the river, there is a zone downstream of the discharge point where the effluents become mixed with the river water. Downstream of the zone, the water is of a consistent quality because the discharge is evenly mixed. The mixing zone varies in length and shape with the concentration and amount of discharge and the flow in the river. Downstream of Calgary's wastewater treatment plants, the mixing zone is considered to extend to a location known as Policeman's Flats, about 7.5 kilometres downstream of the Highway 22X bridge over the river. The quality of effluent entering the river at a point source may require certain water uses in the mixing zone to be modified, restricted or avoided.

River Use Management

Management of the river and its water quality is a complex task because of the many consumptive and nonconsumptive uses of the river, and the variety of land uses throughout the basin. This complexity of management responsibilities is partly because management of specific aspects is assigned to specific agencies and partly because the Bow River traverses various land jurisdictions.

A key factor in managing the state of the river is the land jurisdiction and land use controls on riparian lands. Approximately one-half of the riparian lands along the Bow River fall under the jurisdiction of seven rural municipalities (Figure 10). The other half of the riparian lands are within Indian reserves, federal parkland and urban municipalities.

Another key factor in managing the Bow River is the interprovincial agreement called the Master Agreement on Apportionment. Alberta must maintain as a cross-border flow, the lesser of 50 percent of the natural flow or 1500 cubic feet per second (42.5 cubic metres per second).

The agreement is monitored by the Prairie Provinces Water Board, a federal-provincial agency. The provincial government manages the flow in the South Saskatchewan River through ownership and operation of key water management structures such as irrigation system headworks and the Oldman Dam.

In 1992, Alberta delivered 54.7 percent of the natural flow to Saskatchewan and in the past decade has delivered amounts ranging from 54.7 to 83.7 percent.

Jurisdiction Category	Specific Jurisdiction	Percent of Shoreline
Federal	Banff National Park	17
Provincial	Various Provincial Parks	1
Reserves	Siksika Nation, Stoney Nation	24
Urban Municipalities	Banff, Canmore, Exshaw, Cochrane, Calgary	10
Rural Municipalities	Big Horn, Rocky View, Foothills, Vulcan, Taber, Newall, Wheatland	48

Figure 10. Bow River Riparian Lands by Jurisdiction

Assessment of the Bow River

4.0

Water Quality - Overview

In 1992, the water quality in the Bow River ranged from being unaffected by local human activity and suitable for all uses in the headwaters to impacted by pollutants and restrictive for some water uses in the lower reaches. Along the length of the river, generally the number and frequency of water quality variables meeting guideline levels decreased. However, lack of appropriate data in some reaches has restricted discussion of the reasons and sources of downstream water quality.

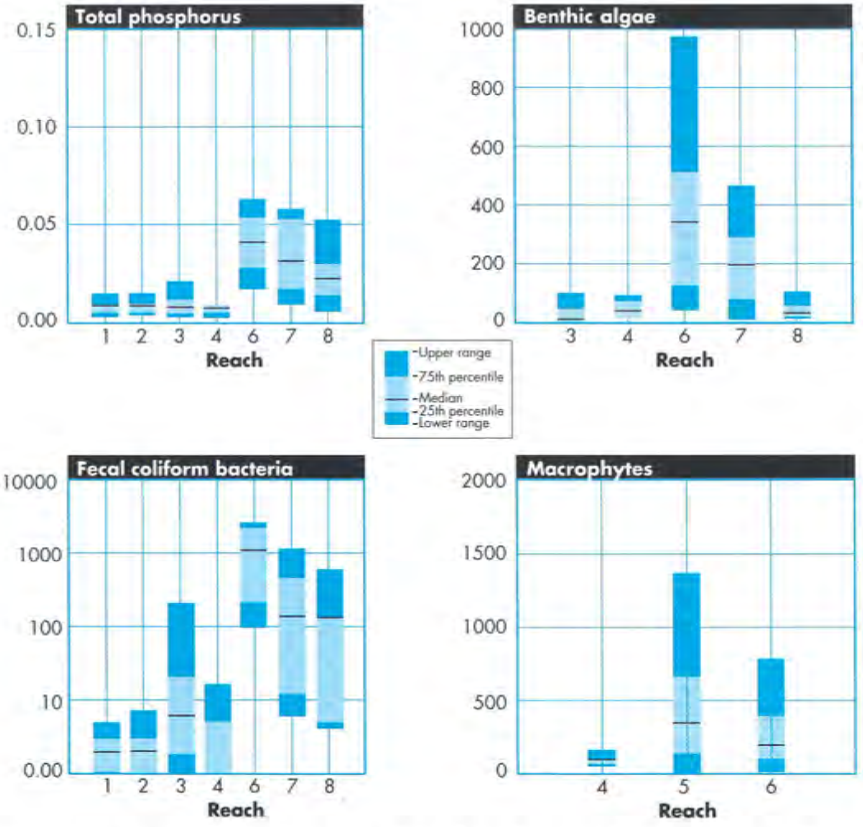


Figure 11. Levels of Phosphorus, Fecal Coliform Bacteria, Benthic Algae and Macrophytes in Reaches 1 to 8, 1992

Figure 11 shows the changes in levels of total phosphorus, benthic algae, fecal coliform bacteria and macrophytes over Reaches 1 to 8. Figure 12 shows a general rating of the water quality within each river reach for each water use in the reach. Background information used in making these general ratings is provided in Appendix B.

In the Bow River, benthic algae and macrophytes (weed-like aquatic plants) cause daily fluctuations in the amount of oxygen dissolved in the water. Aquatic plants are useful to fish and other aquatic organisms because they provide food and cover, but they may also reduce levels of dissolved oxygen. Dissolved oxygen must be at adequate levels for fish and other aquatic organisms to survive, and therefore is a good indicator of river health.

Although plants affect dissolved oxygen levels, many other factors do too: temperature, salinity, turbulence, atmospheric pressure, decomposition of organic waste and oxidation of inorganic wastes. As a result, dissolved oxygen levels are variable, fluctuating daily and seasonally with changes in these factors.

Dissolved oxygen levels in the river water are lower at night because while plants use oxygen in respiration day and night, they produce oxygen through photosynthesis only during the day. The effects of photosynthesis and respiration are most severe when water temperatures are high (because oxygen is then less soluble in water), river flows are low, and there is much plant growth.

These conditions are common in the Bow River in the latter part of the summer downstream of Calgary and stress fish to the point that there is little trout incubation in the river below Calgary.

To illustrate the dissolved oxygen fluctuations in the Bow River, five days of data from mid-August are shown in Figure 13 at sites upstream and downstream of Calgary.

The more algae and plants, the greater their effect on the river water's dissolved oxygen levels. The plants grow when nutrients are available, river flow is suitable (high flows limit plant growth)

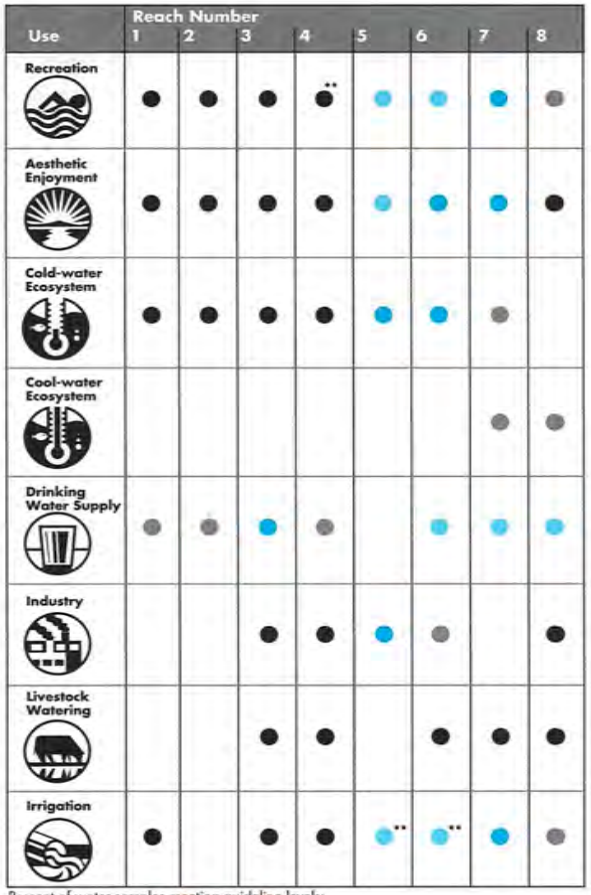


Figure 12. Overall Rating of Water Quality for Water Uses by Reach, 1992

and for larger plants, suitable substrate sediments are available for rooting. Benthic algae can survive under a wide range of nutrient and flow conditions, whereas aquatic plants require a narrower range of conditions for growth.

Each spring, the deeply rooted aquatic plants regrow from the river bed, drawing nutrients from the sediments as well as the water. The plants slow the movement of the water which results in both a rise in temperature and more suspended sediments to get deposited. In the fall, the aquatic plants die, break off and decay moving downstream and releasing nutrients to the water.

The provincial government has studied aquatic plant growth in and below Calgary since 1981. The studies indicate that biomass has been reduced by about two-thirds at sites most impacted by the Calgary wastewater treatment plants since phosphorus began to be removed from the wastewater efflu-

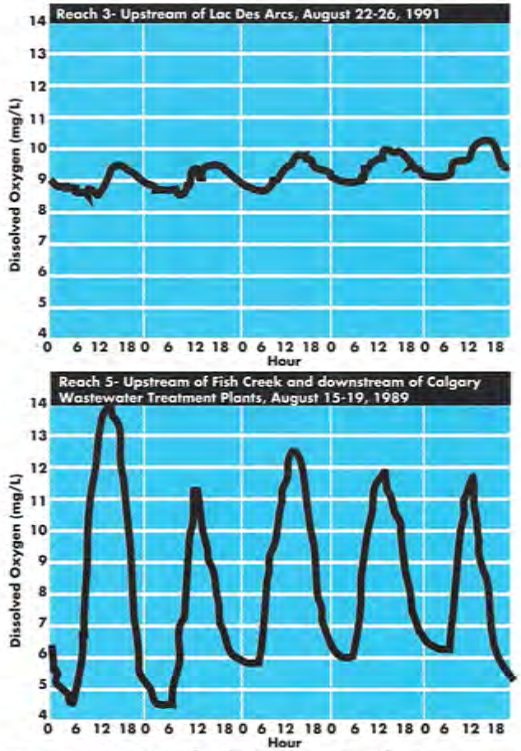


Figure 13. Dissolved Oxygen Levels Upstream and Downstream of Calgary

ents in 1983. The high nuisance levels experienced in the early 1980s have been reduced and the zone of aquatic plant growth downstream of the wastewater treatment plants may be decreasing in length.

Water Quantity - Overview

In 1991 (the latest year for which data have been compiled), 61.6 percent of the river's annual average flow over the long term was licensed for use, 37.8 percent was actually withdrawn and 27.4 percent was consumed (Figure 14). Irrigation and municipal users have the largest total licensed volumes and also withdraw the largest amounts of water. However, with municipalities returning to the river almost all their withdrawals in the form of wastewater effluents, irrigation is the largest user with 95.7 percent of the total water consumption. The major irrigation users include the Western Irrigation District withdrawing from Reach 4, the Bow River Irrigation District from Reach 6, and the Eastern Irrigation District from Reach 7.

Consumption of Bow River water varies greatly with the annual precipitation in the basin, as does the water available in the river. The more precipitation, the less water is required for irrigation. From 1981 to 1986, all water uses in the Bow River consumed between 23 to 47 percent of the natural flow. Of this consumed water, irrigation systems returned 19 per cent to the Oldman and Red Deer rivers. The water was removed from the Bow River but was kept within the South Saskatchewan River Basin.

In 1992, the natural flow of the Bow River was 3 640 million cubic metres, approximately 91 percent of the long-term average flow of 4 010 million cubic metres. Flow in 1992 was moderately less than normal as this amount of flow was exceeded 63 percent of the years for which records have been kept.

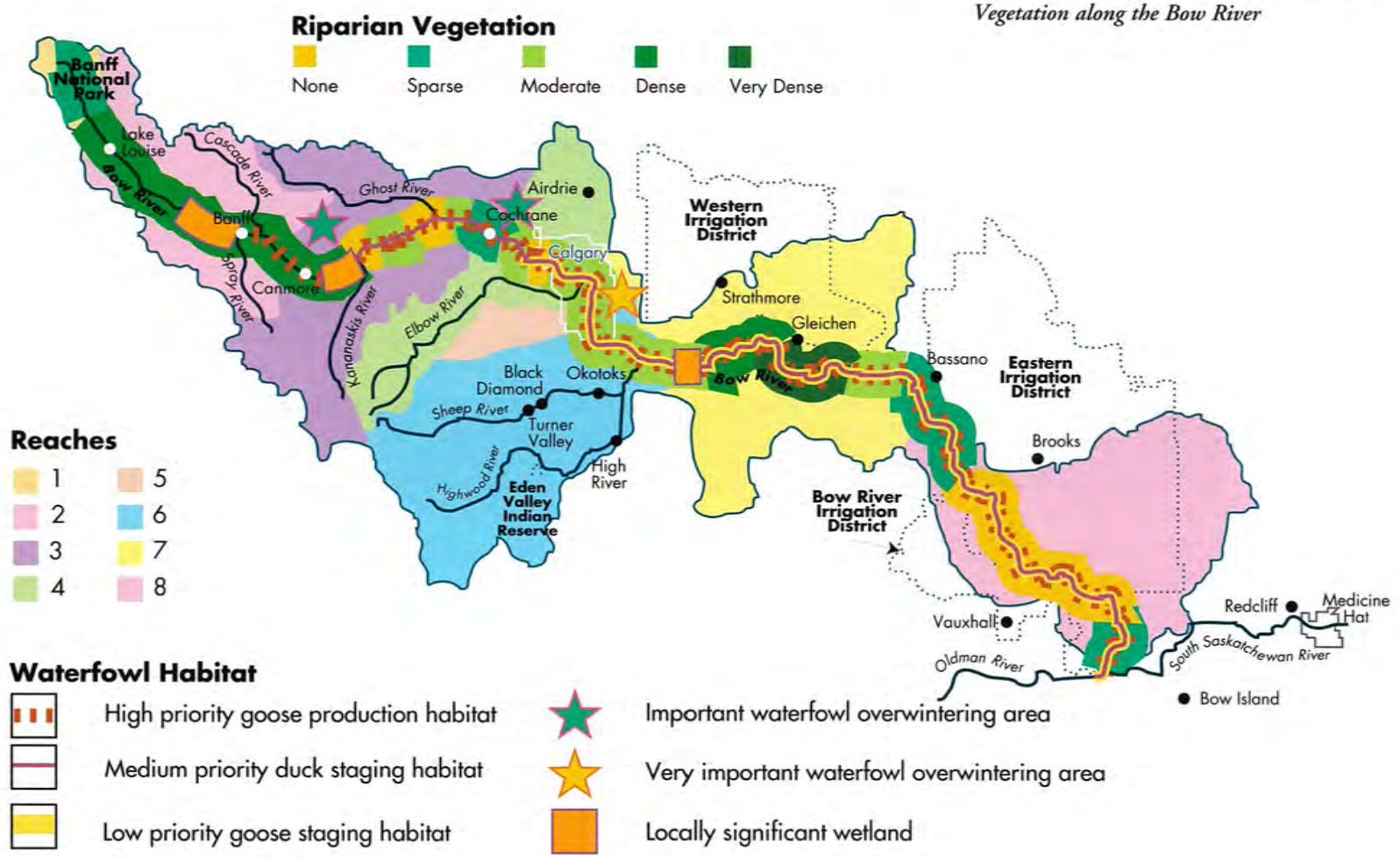
Hydropower generation is a nonconsumptive water use that affects the state of the river. Although it returns to the river virtually all the water it retains in

Figure 14. Bow River Basin Water Use by Sector, 1991

Water Use	Licensed by Government		Withdrawn		Consumed	
	Amount (cubic metres)	% Total	Amount (cubic metres)	% Total	Amount (cubic metres)	% Total
Domestic/Municipal Water Supply	490 005 000	19.8	166 577 000	11.0	10 194 000	0.9
Irrigation*	1 894 019 000	76.7	1 296 617 000	85.4	1 050 888 000	95.7
Agriculture	8 867 000	0.4	8 496 000	0.6	8 496 000	0.8
Industrial	60 797 000	2.5	30 633 000	2.0	13 621 000	1.2
Others	16 005 000	0.5	15 341 000	1.0	15 341 000	1.4
Totals	2 469 693 000	100.0	1 517 664 000	100.0	1, 098, 540 000	100.0
Percent of long term average annual flow of 4 010 000 million cubic metres		61.6		37.8		27.4

*Includes interbasin transfers of 26 262 000 cubic metres to Oldman River Basin through the Bow River Irrigation District, 139 543 000 cubic metres to the Red Deer River Basin through the Eastern Irrigation District and 35 201 000 cubic metres to the Red Deer Basin through the Western Irrigation District.

Figure 15. Waterfowl, Wetland Habitat and Riparian Vegetation along the Bow River



storage reservoirs, the timing and location of water diversions and releases impact riparian vegetation, fish and wildlife habitat and recreation. In January, river flows are greater than they would be naturally because of water releases during the operation of the dams in Reaches 2 and 3. In July, flows are less than they would be naturally because of storage of spring and summer flows in reservoirs for use the following winter.

Ecosystem - Overview

Riparian forest, characterized by balsam poplar and white spruce, with the occasional plains cottonwood, covers approximately 80 percent of the Bow River valley (Figure 15). Since the forest depends largely on the river flow regime for its distribution and survival, identifying changes in forest distribution provides an indication of the state of the river.

The remaining 20 percent of the valley's area is covered by shrubs and grasses. There are some willow shrublands within Reach 1 around Bow Lake, which is almost at the tree line, and small areas of wet shrublands between Mosquito Creek and the TransCanada Highway. The largest non-forested area is within Reach 8 downstream of Bow City, where the vegetation is largely shrubs and grasses. The distribution of riparian forest within the river valley has changed little over the past 100 years (Figure 16) aside from:

- relatively minor amounts of clearing for townsites (Lake Louise, Banff, Canmore, Exshaw, Calgary), and highway and utility corridors
- clearing and flooding of approximately 45 square kilometres for hydropower reservoirs

The riparian forest within the valley is generally healthy; however, there is a lack of balsam poplar regeneration east of Banff National Park. This is caused by:

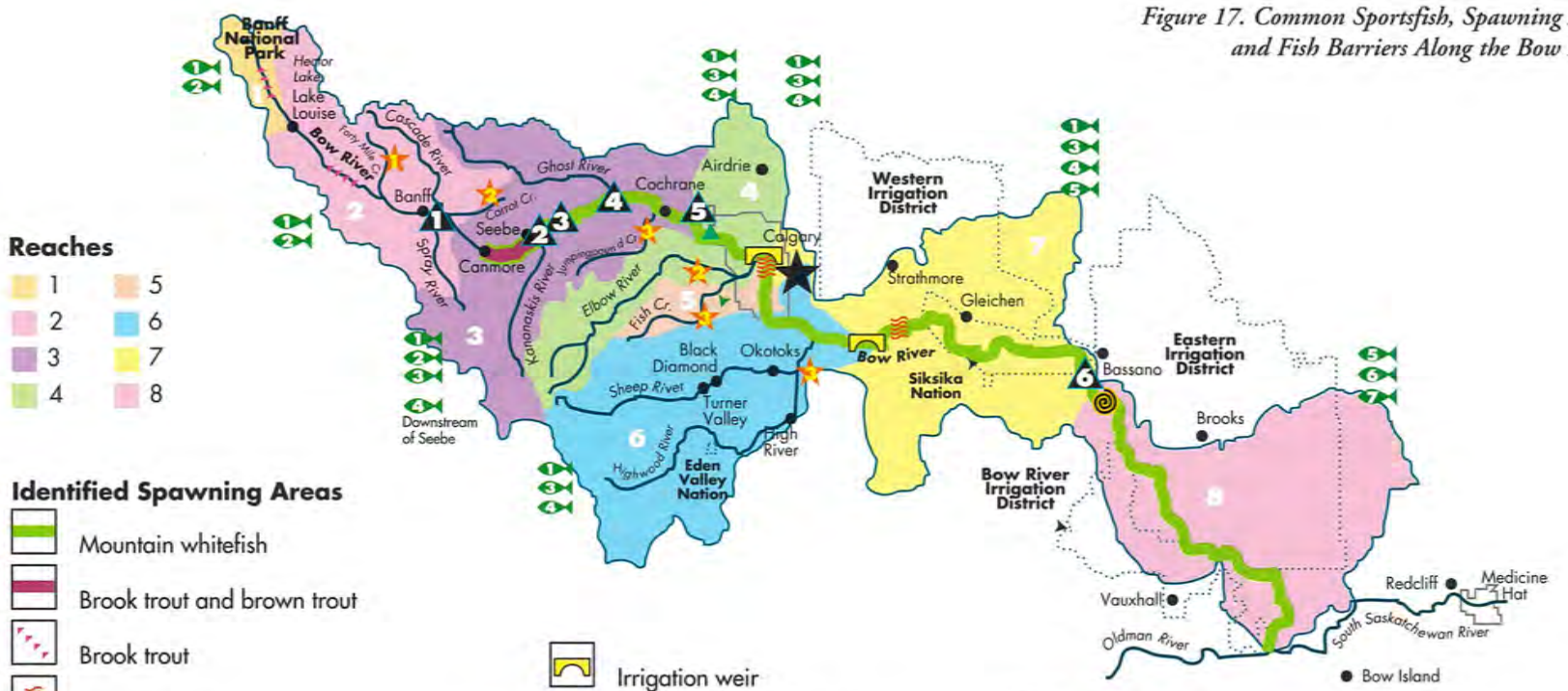
- lack of large periodic floods
- urban development
- beaver activity
- river flow stabilization
- cattle grazing

Figure 16. Changes in Riparian Forest Distribution from 1884 to 1992

Reach	Forest Type	1884	1992	Change
❶ Headwaters to Lake Louise	white spruce and shrub	-	moderate	probably no change
❷ Lake Louise to Banff Park Boundary	white spruce and balsam poplar	-	moderate to dense	probably no change
❸ Banff Park to Bearspaw Dam	balsam poplar and white spruce	moderate	none to moderate	decrease
❹ Bearspaw Dam to Western Irrigation District Weir	balsam poplar	moderate	moderate	no significant change
❺ Western Irrigation District Weir to Highway 22X	balsam poplar	moderate	moderate	no significant change
❻ Highway 22X to Carseland Weir	balsam poplar	moderate	moderate	no significant change
❼ Carseland Weir to Bassano Dam	balsam poplar	moderate	moderate to very dense	no significant change
❽ Bassano Dam to Oldman River	balsam poplar	negligible to sparse	negligible to sparse	no significant change

* In the original 1884 data, the terms used for the forest type classifications were: none/negligible = treeless; sparse = small isolated groves; moderate = no category; dense = wooded river valleys; and very dense - no category.

Figure 17. Common Sportsfish, Spawning Areas and Fish Barriers Along the Bow River



Reaches

1 5
2 6
3 7
4 8

Identified Spawning Areas

- Mountain whitefish
- Brook trout and brown trout
- Brook trout
- Brown trout
- Brown trout and rainbow trout
- Rainbow trout and walleye

Important Spawning Tributaries

- Brook trout
- Brown trout
- Rainbow trout

Irrigation weir

Common Sportfish Species

1. Mountain whitefish
2. Brook trout
3. Brown trout
4. Rainbow trout
5. Northern pike
6. Walleye
7. Lake whitefish

Effective Barrier to Upstream Migration

1. Bow Falls
2. Kananaskis Dam
3. Horseshoe Dam
4. Ghost Dam
5. Bearspaw Dam
6. Bassano Dam

Of the above, one of the most important deterrents to poplar regeneration and survival is lack of large periodic flooding. Large floods shift river channels and deposit sediments, including large amounts of nutrient-rich silt, on point bars, river banks and floodplains. The water then recedes for prolonged periods, providing seedbeds for balsam poplar. Overbank flooding has decreased since the 1930s and if precipitation patterns remain similar and a large flood does not occur, then it is likely that cottonwood forests will progressively decline.

The Bow River is home to many kinds of fish. The Bow's rainbow and brown trout fishery attracts anglers from around the world. Fifteen species of sportfish live in the river:

bull trout
brown trout
brook trout
mountain whitefish
northern pike
burbot
sauger
westslope cutthroat trout
Yellowstone cutthroat trout
rainbow trout
lake trout
walleye
goldeye
lake whitefish
lake sturgeon

Many of these fish species are native to the Bow River basin but the Yellowstone cutthroat, brook, brown and rainbow trout are all introduced species. Lake trout and lake whitefish are thought to be introduced species.

The Yellowstone cutthroat, brook, brown and rainbow trout have interbred or competed very successfully with the native bull and westslope cutthroat trout. As a result, bull and westslope cutthroat trout have virtually been eliminated from the river.

The most abundant of the sportfish is the Rocky Mountain whitefish (Figure 17). It spawns throughout the mainstem in the upper six reaches. Brown and rainbow trout are also common in the upper reaches. These species spawn at various locations in the Bow River, but several tributary streams and rivers are also very important spawning areas. Lake sturgeon are found primarily near the confluence with the Oldman River.

The state of Bow River fish varies considerably from the river's headwaters in Banff National Park to its confluence with the Oldman River in Southern Alberta. Overall, the river has been able to sustain one of the best recreational trout fisheries in North America.

Waterfowl live on rivers, lakes and wetland habitats (Figure 15). They often use different waterbodies and habitats at different times in their life cycle; in one area, some may only nest and rear their brood, some may assemble for migration (referred to as staging) and some may spend the winter. On rare occasions, waterfowl may spend their entire lives in one area.

Of the waterfowl species on the Bow River, mallard ducks and Canada geese are the most common. There are indications of more geese using the river in recent years.

Wetland habitat within the Bow River floodplain is sparse; however, there is extensive wetland habitat supported offstream by irrigation systems (not shown in Figure 15). Within the floodplain, there is little calm, shallow water that is optimal for brood rearing, and generally only a narrow margin of riparian veg-

etation that is important for waterfowl production. Wetlands along the Bow River are generally confined to braided and isolated side channels, backwaters and ponds on the river floodplain.

The river valley provides food, water and shelter in varying extents for a broad spectrum of wildlife. Wildlife species and their populations vary extensively over the length of the river.

Some species such as deer, beaver and coyotes live year-round in the river valley, while others such as geese and elk are primarily seasonal or migratory residents. The degree of human activity and development, the amount and diversity of habitat and the quality and quantity of river water all contribute to the state of the wildlife in the Bow River floodplains.

Reach 1 - Bow River Headwaters to Lake Louise

The Bow River originates in the heart of the Rocky Mountains and flows from Bow Lake through the magnificent wilderness within Banff National Park to near Lake Louise (Figure 18). This reach of the river is approximately 35 kilometres in length. About 15 percent of the annual flow of the Bow River originates from rain and melting snow in the catchment area of Reach 1 of the river.

Reach 1 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold Water Ecosystem	●
Drinking Water Supply	●

* All drinking water must be treated. ● 100% ● 75-100%

The area is renowned worldwide for its natural beauty, tranquillity and undeveloped surroundings. This natural state is highly valued by tourists as well as hikers, canoeists, white-water rafters and many others. The river supports cold-water fish and provides habitat for a variety of wildlife. River water in Reach 1 is not used for drinking by municipalities, but is occasionally used by campers and hikers.

Water Quality

In 1992, the Bow River flowing through Reach 1 is close to a pristine condition and there were no water quality concerns. In the detailed water quality data for Reach 1, all the variables measured were well within the guideline levels for the water uses determined for the reach (Figure 19) .

As in all reaches of the river, even though the water quality in this reach meets the drinking water guideline, any water taken from the river must be treated before drinking. *Giardia* and other parasites, bacteria and viruses are contributed naturally to the river by warm-blooded animals and can be harmful.

In a specific study, some low levels of insecticides and PCBs have been found in Reach 1 waters and fish; but not at levels of concern. Traces were found of DDE (a byproduct of the insecticide DDT) and lindane (also an insecticide) in most of the rainwater, snow and lakewater samples. PCBs were also detected occasionally. PCBs and pesticides were also found in fish tissue.

In the rainwater, snow and lakewater, the levels of pesticides were below drinking water guidelines. In the fish tissue, the levels of contaminants were usually well below Health and Welfare Canada regulatory limits with the exception of toxaphene (an organochlorine pesticide) levels in lake trout from Bow Lake. Nevertheless, Health and Welfare Canada advised that lake trout from Bow Lake would not pose a health hazard to consumers.

Atmospheric transport is suspected to carry these degradation products into Reach 1 from remote sources, possibly in the north-central Pacific or from industrial and agricultural regions in Asia. Thus, while these imported contaminants are at barely detectable levels and are not currently of concern, it is clear that local management of water quality in the river can be restricted.

Figure 18. Reach 1 Map

The time-series data on key water quality variables (Figure 20) indicate very consistent levels over the years shown. The levels are also very low compared to the guideline levels.

Variable	1992 Water Quality Test Results in Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Drinking Water Supply
Total Dissolved Solids				●
Colour				●
Temperature			●	
Turbidity	●			●
Secchi Depth	○			
Dissolved Oxygen			●	
pH	●		●	●
Sodium				●
Sulphate				●
Chloride				●
Floride				●
Nitrate				●
Ammonia			●	
Total Phosphorus				●
Aluminum			○	
Arsenic			●	●
Barium				○
Boron				●
Cadmium			○	○
Chromium			○	○
Copper			○	○
Iron			●	●
Lead			○	○
Manganese				●
Mercury			●	●
Nickel			○	
Selenium				●
Zinc			○	○
Phenols			○	
2,4-D			○	
Trace Organics				○
Total Coliforms	●			●
Fecal Coliforms	●			●
Planktonic Algae				●
Benthic Algae	○	○	○	
Aquatic Plants	○	○	○	

Percent of water samples meeting guideline levels:

●100% ●75-100% ●50-75% ●less than 50% ○no data

Note: Results are shown only where a variable is applicable to a specific water use.

Figure 19. Reach 1 Water Quality Assessment, 1992

In 1992, there were no data for benthic algae (primitive plants attached to the river bed) or aquatic plants, but they would not have been plentiful because low nutrient levels and other factors would have limited their growth.

There are also no 1992 data for several metals and organic variables (see Figure 19), but a study by Environment Canada showed they very seldom exceeded water quality guidelines in tests between 1973 and 1991. The concentrations that occasionally exceeded guidelines were reported to be caused by soil leaching, weathering of native rock or natural biological release.

Water Quantity

In Reach 1, water passes down the river from the source essentially unused by humans. River water is not withdrawn for consumptive uses (drinking water, irrigation or industrial uses), nor is it used for hydropower generation.

The total volume of water passing through Reach 1 in 1992 was 498 300 000 cubic metres. This was 84.9 percent of the average flow over the long-term for this reach (see Figure 21).

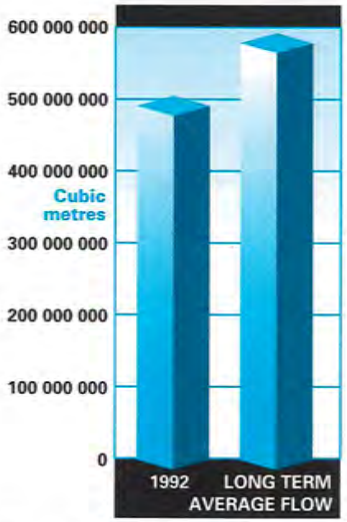


Figure 21. 1992 Annual Flow Compared with Long-term Average Flow at Lake Louise

Figure 22 shows the volume of water passing through Reach 1 each month in 1992, and compares them with average flows over the long term. Compared to the long-term average, 1992 May flows were higher, June flows were similar, July and August flows were lower, and September flows were similar.

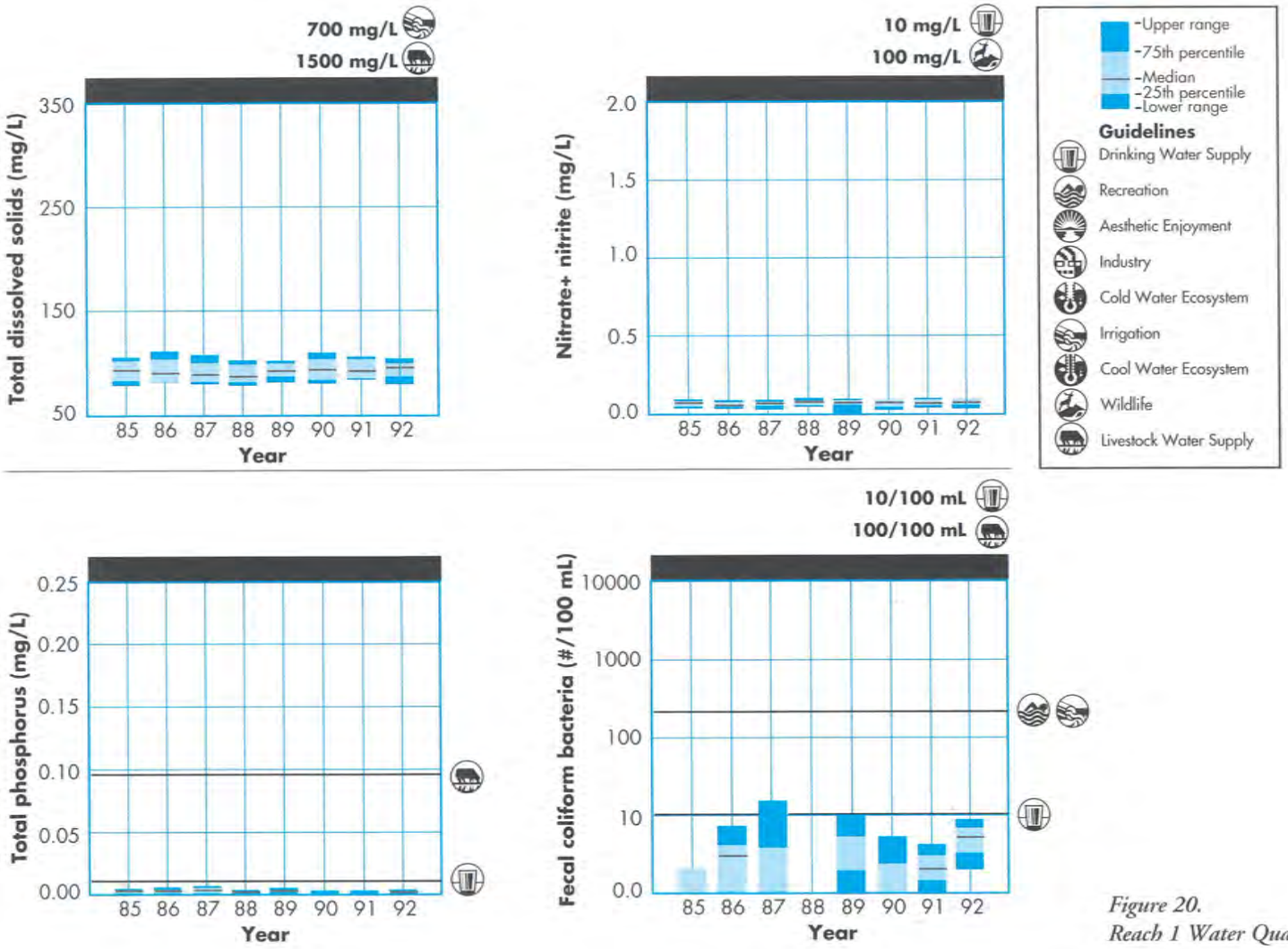


Figure 20.
Reach 1 Water Quality Variables, 1985 to 1992

Ecosystem

The riparian forests in Reach 1 are dominated by dense and open stands of white spruce with extensive shrublands north of Lake Louise (Figure 23). The current forest is healthy.

There is little wetland habitat in Reach 1 as a result of the high gradient of the Bow River and information on available wetlands and waterfowl is limited. Bow Lake and Hector Lake provide some nesting habitat for waterfowl.

Wildlife in Reach 1 is plentiful and varied because of the availability and variety of habitat types within the riparian zone of the Bow River valley. Within the park, elk, mule deer and moose feed on the floodplain during winter. Elk and deer tend to forage at higher elevations during the snow-free periods, whereas moose may move to higher elevations or remain on floodplains to eat aquatic plants and willows. Moose populations have declined over the past four decades.

Figure 23. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 1

Black bears frequent sites where they can eat lush green vegetation during spring and early summer; thereafter, they follow the greening of vegetation to higher elevations. Cougars, wolves and grizzlies are also present.

A variety of small mammals, which are prey for coyotes, weasels and mink, also live in the valley. Beaver and muskrat rarely live in the mainstem of the river but live in the deeper backwaters and marshy pools. These areas provide den sites and adequate water depths for surviving the winter.

Information on the fish of the Bow River in Reach 1 is limited. Both nutrients (which promote the production of important fish habitat components such as aquatic plants and invertebrates) and water temperatures are relatively low in Reach 1 and as a result, fish populations are sparse.

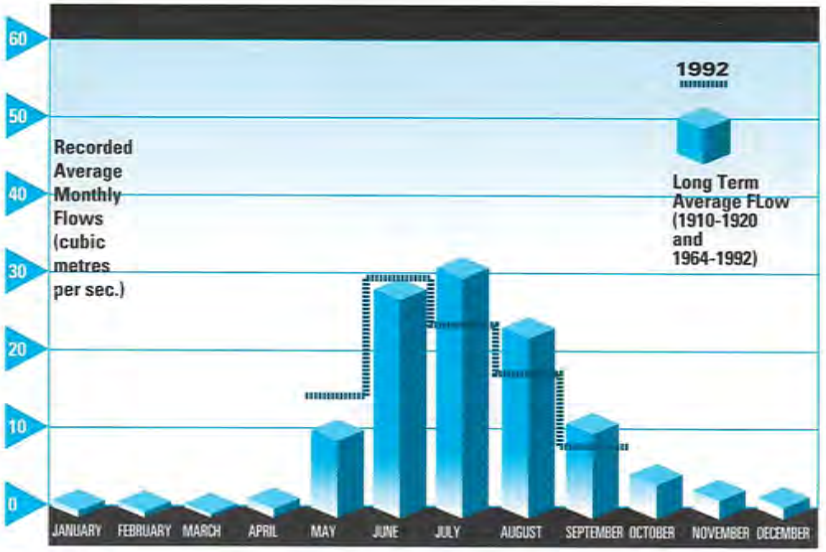


Figure 22. Monthly Flows at Lake Louise, 1992

Mountain whitefish and to a lesser extent, brook trout, are the most common sportfish species in Reach 1. Brown, cutthroat, rainbow, and bull trout are present, but in much lower numbers (Figure 24).

In Reach 1, brook trout spawn at the outlet of Hector Lake and are suspected of spawning in the Bow River. Spawning redds (sites where fish have spawned) of either brook trout or bull trout have been observed in Bath Creek, a Bow River tributary near Lake Louise.

Figure 24. Fish and Fish Habitat in Reach 1

Reach 2 - Lake Louise to the Banff National Park Boundary

Reach 2 of the river runs from just above the community of Lake Louise, downstream past Banff to the Banff National Park boundary, for a total length of 80 kilometres. The Pipestone River flows into the Bow at Lake Louise, and the Spray and Cascade rivers flow into the Bow just below Banff (Figure 25).

Reach 2 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold Water Ecosystem	●
Drinking Water Supply	●

* All drinking water must be treated.

● 100% ● 75-100% ● 50-75% ● less than 50%

As in Reach 1, this area is largely undeveloped, except for the communities of Lake Louise and Banff and the park facilities. The relative wildness is enjoyed by tourists and outdoor recreation enthusiasts. The river supports a modest cold-water trout and whitefish fishery and provides habitat for wildlife. Both Lake Louise and Banff, use groundwater sources for municiapl supply. Some park visitors likely draw river water for domestic use.

Human influence on the river is first noticed in Reach 2 through runoff and municipal wastewater treatment plant discharges to the river from Banff and Lake Louise. Banff has a relatively new wastewater treatment plant, commissioned in 1989. It disinfects the effluent to kill the bacteria before discharge to the river but does not have phosphorus removal. The Lake Louise plant is in need of upgrading and has been scheduled for improvement in the next one to two years. The current Lake Louise wastewater treatment plant also disinfects its effluent but does not remove phosphorus.

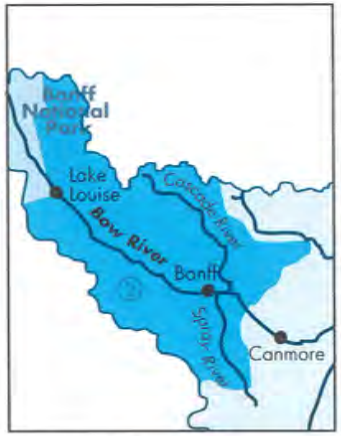


Figure 25. Reach 2 Map

Water Quality

In the detailed 1992 water quality data (Figure 26), the measured values of the water quality variables were within the guidelines for most water uses in the reach.

There was some deterioration from Reach 1 in water quality for drinking water supply. Levels of pH, total phosphorus, trace organics (organic compounds such as pesticides) and planktonic algae sometimes exceeded the guidelines for Level I treatment of drinking water.

There was also some deterioration in water quality when assessed against the guidelines for recreation use, although this is partially from natural processes. Levels of pH sometimes exceeded the guideline, although natural pH levels vary as a part of the natural daily cycle and periodically exceed the guideline level. The guideline for pH related to recreational use is set to protect the user from potential eye irritation. Benthic algae levels occasionally exceeded the guideline (1990 and 1991 data).

Water quality in 1992 was generally an improvement over earlier years, particularly for fecal coliform bacteria (Figure 26). Before 1992, levels of fecal coliform bacteria occasionally did not meet the guidelines for drinking water supply and recreation.

The time-series data for Reach 2 (Figure 27) show consistent levels of nitrate and nitrite over the years at levels far below guideline levels.

Variable	1992 Water Quality Test Results			
	Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Drinking Water Supply
Total Dissolved Solids				●
Colour				●
Temperature			●	
Turbidity	●			●
Secchi Depth	○			
Dissolved Oxygen			●	
pH	●		●	●
Sodium				●
Sulphate				●
Chloride				●
Floride				●
Nitrate				●
Ammonia			●	
Total Phosphorus				●
Aluminum			○	
Arsenic			●	●
Barium				○
Boron				●
Cadmium			○	○
Chromium			○	○
Copper			○	○
Iron			●	●
Lead			○	○
Manganese				●
Mercury			●	●
Nickel			○	
Selenium				●
Zinc			○	○
Phenols			○	
2,4-D			○	
Trace Organics				○
Total Coliforms	●			●
Fecal Coliforms	●			●
Planktonic Algae				●
Benthic Algae	○	○	○	
Aquatic Plants	○	○	○	

Percent of water samples meeting guideline levels:
●100% ●75-100% ●50-75% ●less than 50% ○no data
Note: Results are shown only where a variable is applicable to a specific water use.

Figure 26. Reach 2 Water Quality Assessment, 1992

Levels of fecal coliform bacteria and total dissolved solids have also remained very low. Levels of total phosphorus are low and declining.

Water Quantity

In Reach 2, water passes down the river from the source essentially unused by humans. As in Reach 1, river water is not withdrawn for consumptive uses (drinking water, irrigation or industrial uses), nor is it used for hydropower generation.

The total volume of water passing through Reach 2 in 1992 was 1 255 300 000 cubic metres. This was 82.9 percent of the long-term average flow for this reach (Figure 28).

The measuring station is located at Banff and is considered representative of flows for the reach. The measuring station includes effluent groundwater that is discharged to the river from the Lake Louise wastewater treatment plant. In 1992, effluent volumes were 2 812 000 cubic metres from Banff and 900 000 cubic metres from Lake Louise.

Figure 29 shows the monthly flows in 1992, and compares them with average flows over the long term. Monthly recorded flows were below average throughout the year with the exception of February to May.

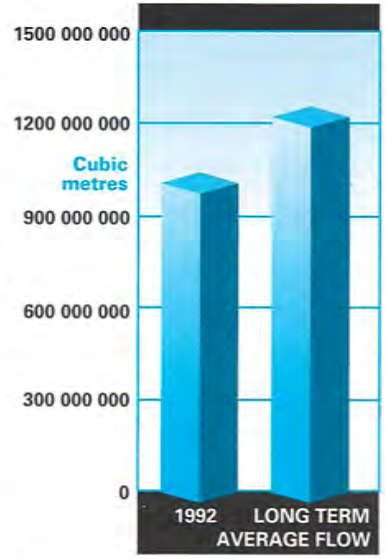


Figure 28. 1992 Annual Flow Compared with Long-term Average Flow at Banff

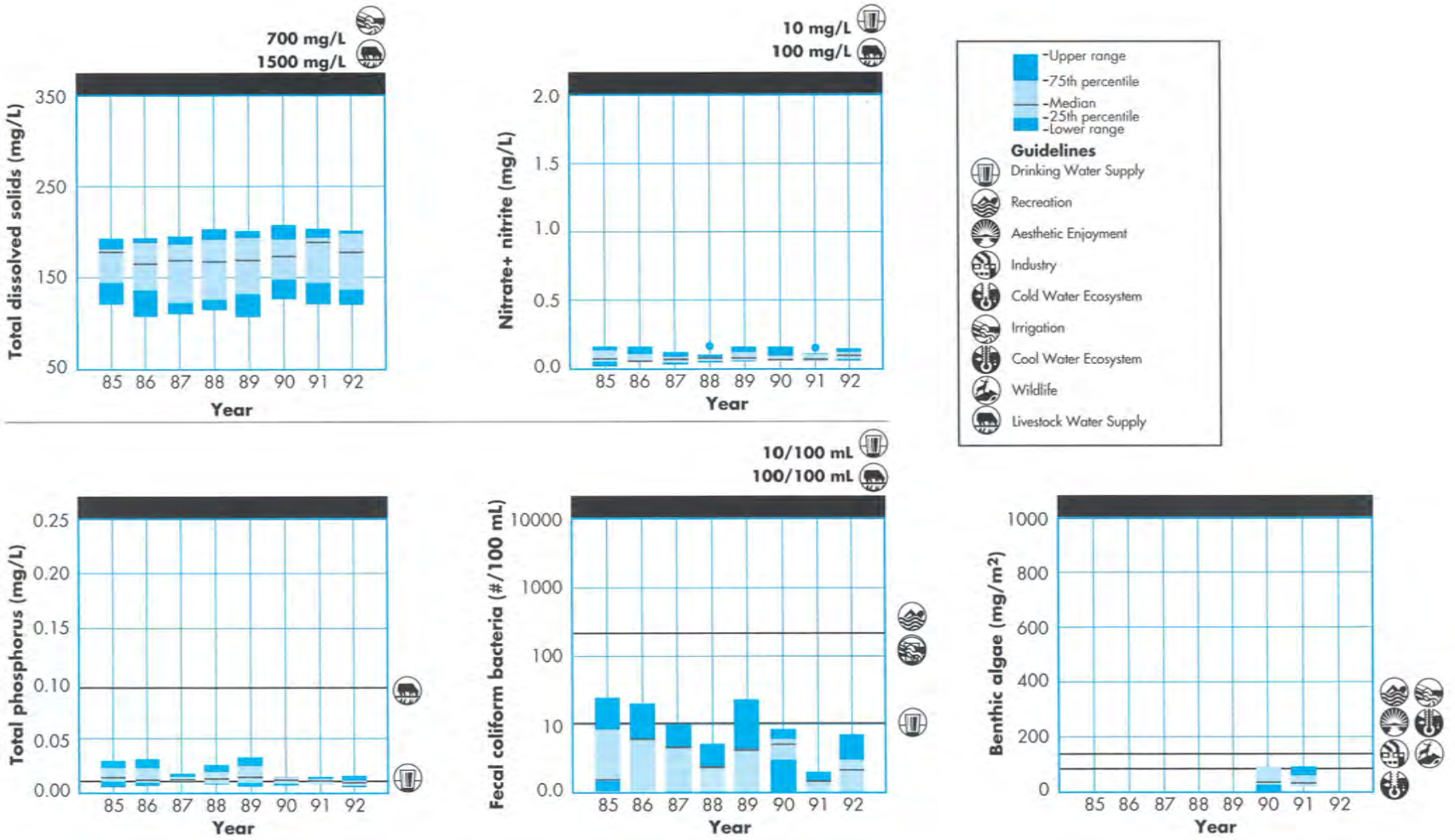


Figure 27. Water Quality Variables, 1985 to 1992

Ecosystem

As in Reach 1, the riparian forests are dominated by dense and open stands of white spruce (Figure 30). The current forest is healthy. Aside from relatively minor clearing in the communities of Lake Louise and Banff, and along the Trans Canada Highway, the forest has changed little over the past 100 years.

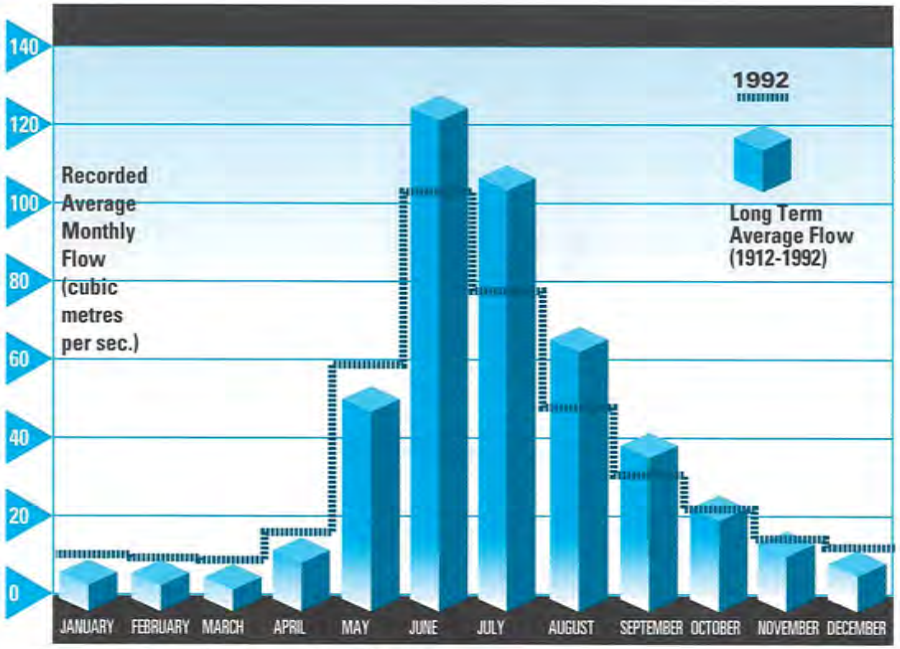


Figure 29. Monthly Flows at Banff, 1992

Wetland vegetation in the Bow Valley of Banff National Park covers an estimated 26 square kilometres. Most of the wetland vegetation types are present. The most extensive wetland habitat in Reach 2 is located downstream of Castle Junction toward Banff (Figure 30). These high-quality habitats are located where the river bank is flatter and the floodplain is broader.

Waterfowl nesting habitat in the Bow Valley in Banff National Park includes a few lakes, oxbows and backwaters. The Vermilion Lakes just west of Banff are the most important and extensive nesting areas in the park for at least ten species of waterfowl. As well, the pools and riffle areas (where shallow water flows swiftly and is broken into waves by the rocks on the streambed) on the Bow River between Lake Louise and Banff are important nesting areas for diving ducks. The portion of the reach from below Banff to the park boundary is important habitat for geese.

The Bow River, and lakes and wetlands in the floodplain, also provide at least moderately important habitats for migration and staging. The Bow River and the Vermilion Lakes are important during spring migration because they thaw earlier than other local water bodies. Waterfowl spend the winter in open water areas such as:

- the Cave and Basin Marsh
- portions of the Vermilion Lakes complex
- the Bow River downstream of Banff

Water levels in the Vermilion Lakes vary considerably, but the wetland habitats have remained relatively healthy. These habitats have been extensively monitored because of their importance to local waterfowl.

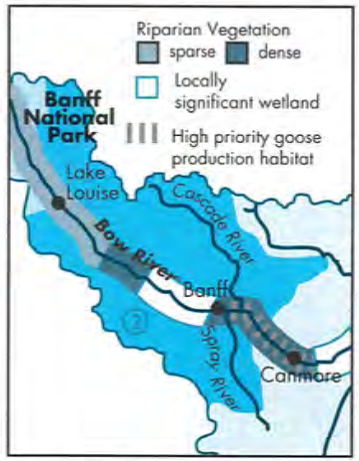
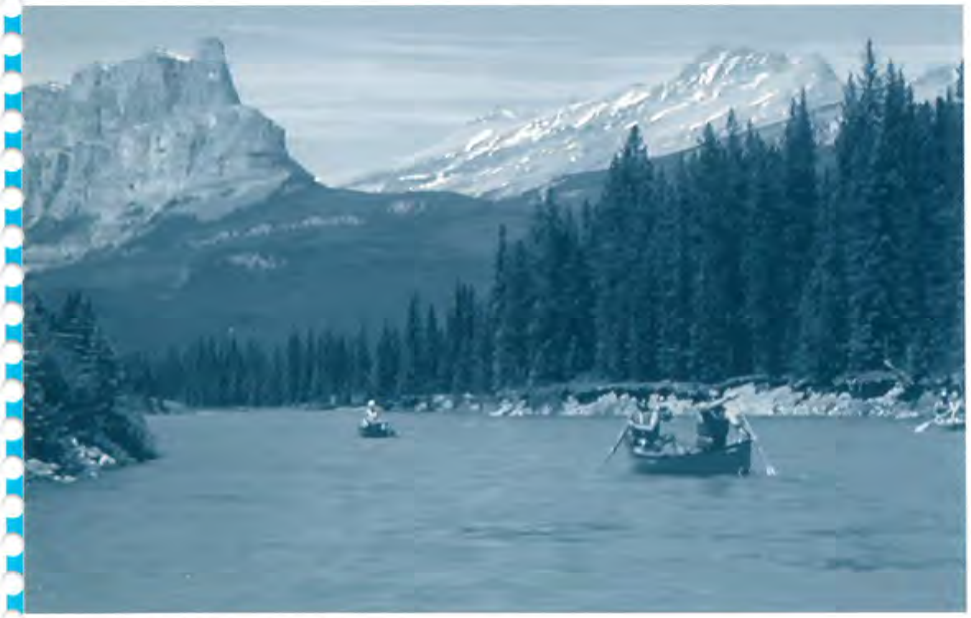


Figure 30. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 2

Wildlife is plentiful and varied in Reach 2 because of the availability and variety of habitats within the riparian zone of the Bow River valley. Within the park, elk, mule deer and moose feed on the floodplain during winter. Elk and deer generally feed at higher elevations when the snow is gone, whereas moose may move to higher elevations or remain on floodplains to feed on aquatic plants and willows. Black bears are common and cougars, wolves and grizzlies are also present, but avoid areas of human disturbance in the valley.

A variety of small mammals, which are prey for coyotes, weasels and mink, also live in Reach 2. Beaver and muskrat rarely live in the mainstem of the river but live in the deeper backwaters and marshy pools. These areas provide den sites and adequate water depths for surviving the winter.



Canoeing on the Bow River

Figure 31. Fish and Fish Habitat in Reach 2

The most important habitats along the Bow River within Banff National Park are associated with Vermilion Lakes and the open grassland/mixed forest near Banff. The coniferous and deciduous trees and shrubs, and aquatic plants in this reach attract a wide range of bird species, from passerines (warblers, sparrows, finches, and blackbirds) to ducks and birds of prey. Two osprey nest sites have been known since 1985 and one bald eagle nest is located near Vermilion Lakes. Species that stay over the winter depend on the mature coniferous trees for food and shelter.

Wildlife along the Bow River in Banff National Park is disturbed by the Trans Canada Highway, the railroad, secondary roads near the river and other facilities. Many deer, elk, moose, and bighorn sheep are killed by motor vehicles and trains. Parks Canada has installed heavy fencing and animal underpasses along the easterly 30 kilometres of the Trans Canada Highway to keep large mammals out of the highway right of way.

As in Reach 1, fish numbers in Reach 2 are limited by low temperatures and relatively low nutrient levels. There is some nutrient enrichment of the Bow River from wastewater treatment plants below Lake Louise and Banff.

Mountain whitefish is the most widespread of the sportfish in Reach 2, but brook trout are also common (Figure 31). Brown trout are more abundant than brook trout downstream of Bow Falls. There are relatively few cutthroat, bull and rainbow trout in Reach 2.

Brook trout are suspected of spawning in the Bow River mainstem and are known to spawn in backwaters upstream of the confluence of Redearth Creek and in the tributary Forty Mile Creek. Carrot Creek is an important spawning tributary for brown trout.

Bow Falls within the Town of Banff is a natural barrier to fish movement upstream from Reach 3.

Reach 3 - Banff National Park Boundary to Bearspaw Dam

In Reach 3, the river leaves the mountains to wind its way through the foothills onto the prairie. At the east boundary of Banff National Park, the river enters the MD of Bighorn and flows past Canmore, Exshaw, Seebe and the Stoney Nation. The river then enters the Stoney Nation and the MD of Rocky View and flows through Cochrane to the Bearspaw Dam. The total length of Reach 3 is 115 kilometres. The Spray Lakes drainage and the Kananaskis and Ghost Rivers are the major sources of water along this reach (Figure 32).

Reach 3 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold-Water Ecosystem	●
Drinking Water Supply	●*
Industry	●
Livestock Watering	●
Irrigation	●

* All drinking water must be treated.

● 100% ● 75-100% ● 50-75% ● less than 50%

In this reach, human demands on the river ecosystem increase substantially. Hydropower facilities, which include dams and some storage reservoirs, are common. Water is withdrawn for municipal use and treated wastewater effluents are added directly from Canmore, Deadman's Flats, Exshaw, Seebe and Cochrane. Also, agricultural use becomes more significant as the river flows through ranching country. Livestock are watered from the river and a small amount is diverted for irrigation both for agriculture and golf courses. Three industries discharge surface runoff, cooling water, and wastewater into the Bow River.

The major identified pollution sources in this reach of the river are the wastewater effluents from Canmore and Cochrane, as well as industrial effluents. Flow in this reach is affected by regulation of the hydropower installations of Lake Minnewanka, Spray Lakes, Barrier Lake, Upper and Lower Kananaskis Lakes, Seebe and Ghost Lake reservoirs.

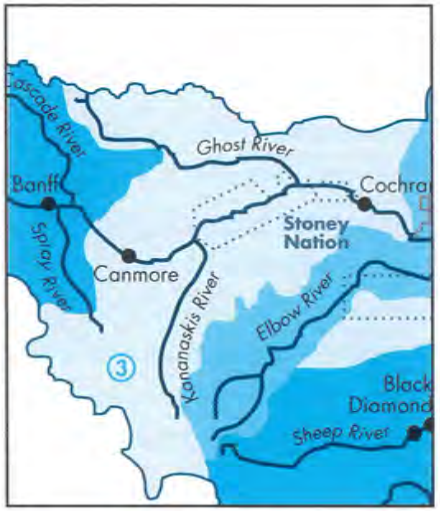


Figure 32. Reach 3 Map

Water Quality

In the detailed 1992 water quality data for Reach 3 (Figure 33), the variables were at acceptable levels for the specified uses. The water quality in 1992 was satisfactory for most uses determined for Reach 3. Figure 33 shows how often 1992 levels met the guidelines.

Compared to Reach 2, water treatment for drinking would have to be increased because of coliform bacteria levels. This means water treatment for drinking would have to be increased to make the water safe for drinking. Water quality has also deteriorated for several other uses (recreation, aesthetic enjoyment, industry, cold-water ecosystem, irrigation and wildlife) because of the amounts of benthic algae. The effects of the benthic algae may include unsightly scum and odour from algae decomposition, and reduction in oxygen levels (important to fish).

Water quality in this reach of the river should improve after the planned construction of new wastewater treatment plants at Canmore and Cochrane.

The time-series data for Reach 3 (Figure 34) show filterable residues to be at

Variable	1992 Water Quality Test Results						
	Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Drinking Water Supply	Industry	Livestock Watering	Irrigation
Total Dissolved Solids				●		●	●
Electrical Conductivity							●
Sodium Adsorption Ratio							○
Colour				●			
Temperature			●				
Turbidity	●			●			
Secchi Depth	○						
Dissolved Oxygen			●				
pH	●		●	●			
Sodium				●			
Sulphate				●		●	
Chloride				●			
Floride				●		●	●
Nitrate				●		●	
Ammonia			●				
Total Phosphorus				●		●	●
Aluminum			●			●	●
Arsenic			●	●		●	●
Barium				●			
Boron				●		●	●
Cadmium			●	●		●	●
Chromium			○	○		●	●
Cobalt						○	○
Copper			●	●		●	●
Iron			●	●			●
Lead			●	●		●	●
Manganese				●			●
Mercury			●	●		●	
Nickel			●	●		●	●
Selenium				●		●	●
Zinc			●	●		●	●
Phenols			●				
2,4-D			○				○
Trace Organics				○			
Total Coliforms	●			●			●
Fecal Coliforms	●			●			●
Planktonic Algae				●			
Benthic Algae	●	●	●		●		●
Aquatic Plants	○	○	○		○		○

Percent of water samples meeting guideline levels:
● 100% ● 75-100% ● 50-75% ● less than 50% ○ no data
Note: results are shown only where a variable is applicable to a specific water use.

Figure 33. Reach 3 Water Quality Assessment, 1992

steady levels and well within guideline limits. Fecal coliform bacteria levels have been erratic but within the guideline levels for irrigation and recreation. Total phosphorus levels have been low and steady, as have levels of nitrate and nitrite. Time-series data on benthic algae are limited.

Water Quantity

In Reach 3, river water is withdrawn for consumptive uses (drinking water, irrigation, industrial uses, livestock watering), and is used for a nonconsumptive use (hydropower generation). In 1991, the following water uses were licensed for Reach 3:

- 32 nonconsumptive licenses for a total of 6 691 000 cubic metres
- 74 consumptive licenses for a total of 14 831 000 cubic metres

A total of 10 152 000 cubic metres was withdrawn in 1991, primarily for industrial use, while 3 461 000 cubic metres were returned to the river (Figure 35).

Figure 36 shows monthly flows in 1992 and compares them with average flows over the

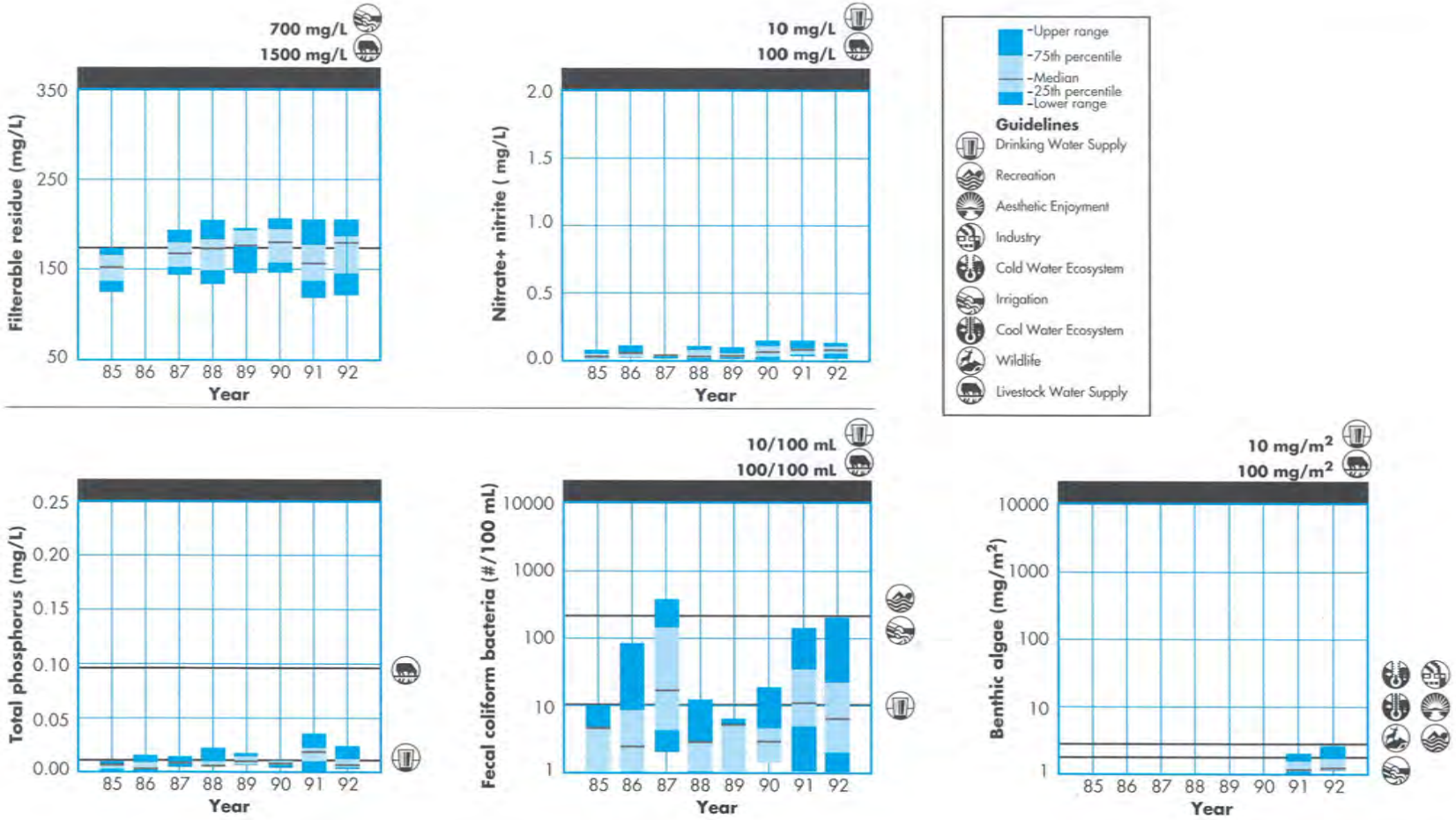


Figure 34. Reach 3 Water Quality Variables, 1985 to 1992

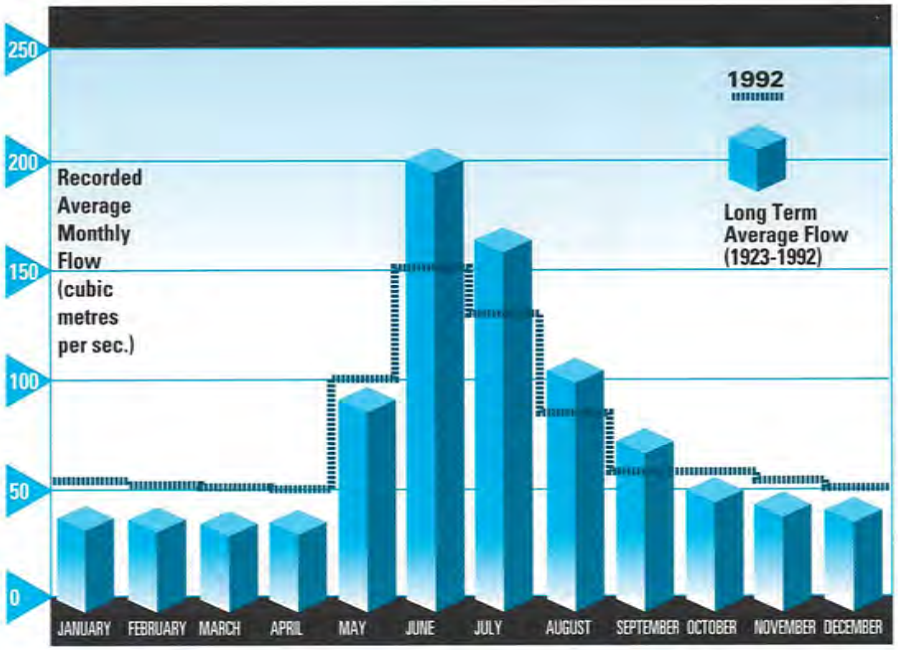


Figure 36. Monthly Flows at Seebe, 1992

long term. The measuring station is located upstream of the Ghost River discharge into the Bow River. The 1992 monthly recorded flows were above average for January to May (caused by releases for hydropower) and below average during the summer months of June to September.

The total volume of water passing through Reach 3 at Seebe in 1992 was 2 299 300 000 cubic metres. This was 91.4 percent of the long-term average flow (Figure 37).

Ecosystem

White spruce forests are common from Banff National Park to the Ghost Reservoir (Figure 38). Balsam poplar forests are typical from the Ghost Reservoir to the Bearspaw Reservoir. Reach 3 has had approximately 45 square kilometres (7 percent of its riparian forest cover existing in 1884) cleared for on-stream hydropower reservoirs, urban development and cattle grazing.

Wetland habitats are limited over most of Reach 3 (Figure 38). The river valley is deeply incised below the Kananaskis Dam at Seebe and the habitat is unstable as a result of fluctuating discharges from the Kananaskis and Ghost dams. However, there is considerable wetland habitat in the braided channel and back-water portions of the Bow River between Lac des Arcs and the Highway 1 crossing below Canmore.

The Canada goose, an adaptable bird, is likely the most common waterfowl nesting in Reach 3. The area between Banff National Park and Ghost Dam is important nesting and brood rearing habitat for geese. Canada geese are increasingly using Reach 3 for staging.

Use	Amount Licensed by Government (cubic metres)	Amount Diverted from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Industrial[1]	7 011 000	5 397 000	1 041 000	4 356 000
Irrigation	1 328 000	1 328 000	0	1 328 000
Municipal[2]	5 529 000	2 714 000	2 420 000	294 000
Others[3]	963 000	713 000	0	713 000
Totals	14 831 000	10 152 000	3 461 000	6 691 000

1 Primarily cement manufacturing near Exshaw.
2 Canmore and Cochrane.
3 Primarily domestic and agriculture uses.

Figure 35. Water Withdrawals and Consumption in Reach 3, 1991

Between Lac des Arcs and Ghost Dam, the river provides staging habitat for ducks. Duck staging between Ghost Dam and Bearspaw Dam increases during drought years.

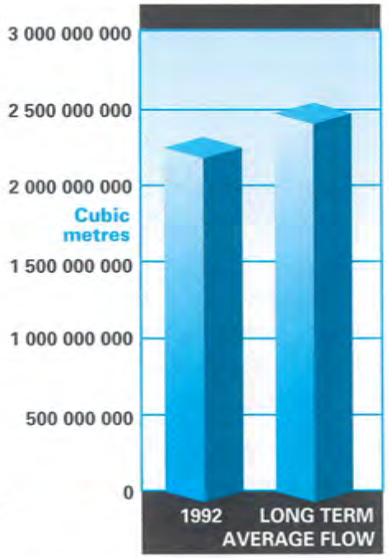


Figure 37. Annual Flow Compared with Long-term Average Flow at Seebe

Mallard ducks appear to be the most abundant waterfowl spending the winter in Reach 3. Most mallards have been observed in Canmore (Policeman's Creek) and Cochrane (at least 1 000 and 300 birds, respectively).

The diversity and extent of wildlife habitat decrease progressively downstream throughout this reach. From the Banff National Park boundary to the Lac des Arcs area, habitat is similar to that within the park except the river banks are lower, accommodating more braided channels and associated habitat.

Moose, elk, white-tailed deer, mule deer and black bears are the most common large mammals upstream of Lac des Arcs. Only deer live further downstream where the river valley flows through more grassland than forests. The grasslands also support small mammals that are food for coyotes, foxes and weasels. Beaver and muskrat feed and make dens in the quiet backwater areas.

The mix of shrubs and grasses attracts a wide range of bird species, particularly during migration periods in both spring and fall. The limited availability of habitat restricts the number of species that live year-round and breed in Reach 3.

The portion of Reach 3 extending from the boundary of Banff National Park to Kananaskis Dam at Seebe is important habitat for trout and whitefish (Figure 39). Between Seebe and the downstream Bearspaw Dam, fish numbers are limited by the habitat instability caused by fluctuating water releases from the hydropower facilities at the Kananaskis and Ghost dams. The Horseshoe Dam, downstream of Seebe, has limited impact on fish habitat because water flows through relatively unrestricted.

Mountain whitefish is the most common sportfish species in Reach 3. Whitefish use the river for spawning and seasonal migrations up and down the river

Canmore Corridor

between wintering and summer feeding areas.

Brook and brown trout are common between the park boundary and the Seebe area hydro installations while brown and rainbow trout are common below Seebe to the Bearspaw dam. Brook and brown trout to spawn in certain side channels, seepage channels and tributaries near Canmore (i.e., Policeman, Canmore and Pigeon creeks). Jumpingpound Creek is an important spawning and rearing tributary for Bow River rainbow trout.

Other sportfish species found in relatively low numbers in Reach 3 include:

- lake, bull and cutthroat trout
- lake whitefish
- burbot

Lake trout are suspected of spawning in the Ghost River arm of Ghost Reservoir.

All mainstream dams in Reach 3 are barriers to fish migrations upstream of Reach 3, while Bearspaw Dam prevents upstream migrations from Reach 4 into Reach 3. The Ghost and Bearspaw reservoirs are generally unproductive from a biological perspective, but they provide angling opportunities at certain locations. They also likely provide areas for sportfish to spend the winter.

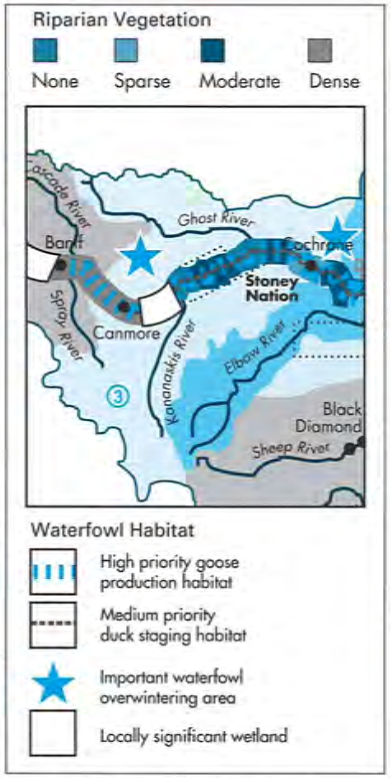


Figure 38. Waterfowl, Wetland and Riparian Vegetation in Reach 3

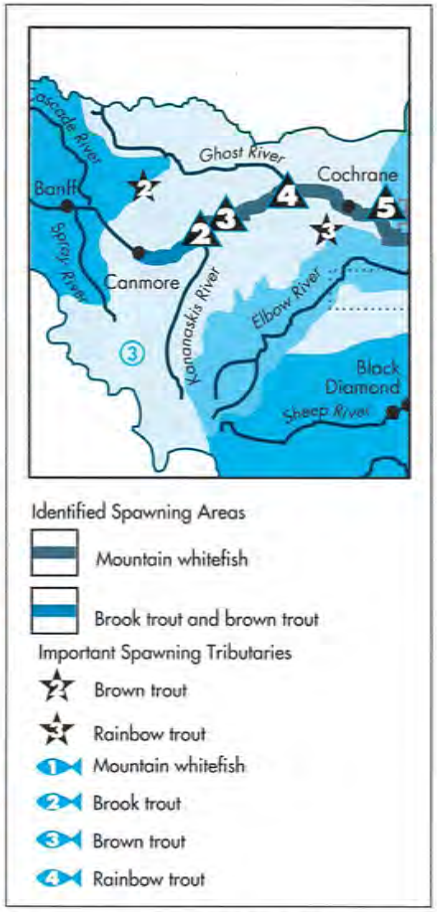


Figure 39. Fish and Fish Habitat in Reach 3

Reach 4 - Bearspaw Dam to the Western Irrigation District Headworks Weir

Reach 4 begins below the Bearspaw Dam at the western limits of the City of Calgary and continues through the City for 28 kilometres to the Western Irrigation District weir. The Elbow River and Nose Creek are the major tributaries within this reach (Figure 40).

Reach 4 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold-Water Ecosystem	●
Drinking Water Supply	●* +
Industry	●
Livestock Watering	●
Irrigation	●

* All drinking water must be treated.
\+ Localized areas of concern within Reach 4.
● 100% ● 75-100% ● 50-75% ● less than 50%

Reach 4 is a cold-water ecosystem and encounters many and varied human demands. This reach of the river provides drinking water (along with the Elbow River) for over 87 percent of the basin's population. A high level of recreation and aesthetic enjoyment of the river in this reach is evidenced by the large numbers of fishermen, kayakers, rafters and canoeists that dot the waterways.

A major amount of the river water is diverted into the Western Irrigation District and used seasonally for crop irrigation, livestock watering, recreation, and municipal and domestic drinking water supply. Most of the recreational use is on Chestermere Lake, a WID irrigation reservoir.

A major contaminant entering the river in Reach 4 is stormwater from the City of Calgary, directly as well as through the Elbow River and Nose Creek. Organic contamination from the former Canada Creosote location has been a pollution concern in Reach 4 and downstream, but extensive cleanup and control measures have significantly reduced the scale of the problem.

Water Quality

The detailed 1992 water quality data for this reach were limited (Figure 41) and therefore the assessment is not as complete as for the first three river reaches. Furthermore, the location of the main sampling site at the upstream portion of the reach (at 85th Street bridge in Calgary) seriously limits its representation of the reach as a whole because the majority of the City's stormwater outfalls are further downstream.

The available data indicate that benthic algae may have impacted six of the water uses to some degree because of unsightly scum, odour from decomposition, and clogging of pumps. Aquatic plants may also have limited recreational use because the plants are offensive and entangled users or their equipment.

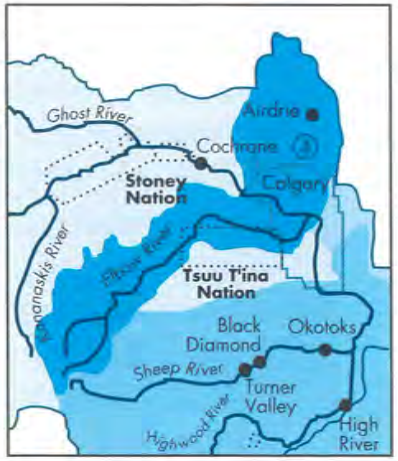


Figure 40. Reach 4 Map

Organic contamination from the former Canada Creosote location near the middle of the reach has been a major pollution concern in Reach 4 and downstream. Data on organic contaminants were collected by Alberta Environmental Protection in Reaches 4 and 6 from 1989 to 1992 and in Reaches 3, 5, and 7 in 1989 and 1990.

Data collected from Reach 4 in 1992 indicate that the concentration of organic contaminants has decreased since 1989, when the problem was first monitored.

Variable	1992 Water Quality Test Results						
	Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Drinking Water Supply	Industry	Livestock Watering	Irrigation
Total Dissolved Solids				○		○	○
Electrical conductivity							●
Sodium Adsorption Ratio							○
Colour				○			
Temperature			●				
Turbidity	○			○			
Secchi Depth	○						
Dissolved Oxygen			●				
pH	●		●	●			
Sodium				○			
Sulphate				○		○	
Chloride				○			
Floride				○		○	○
Nitrate				●		●	
Ammonia			●				
Total Phosphorus				●		●	●
Aluminum			○			○	○
Arsenic			○	○		○	○
Barium				○			
Boron				○		○	○
Cadmium			○	○		○	○
Chromium			○	○		○	○
Cobalt						○	○
Copper			○	○		○	○
Iron			○	○			○
Lead			○	○		○	○
Manganese				○			○
Mercury			○	○		○	
Nickel			○			○	○
Selenium				○		○	○
Zinc			○	○		○	○
Phenols			○				
2,4-D			○				○
Trace Organics				●			
Total Coliforms	●			●			●
Fecal Coliforms	●			●			●
Planktonic Algae				○			
Benthic Algae	●	●	●		●		●
Aquatic Plants	●	●	○		●		●

Percent of water samples meeting guideline levels:
●100% ●75-100% ●50-75% ●less than 50% ○no data
Note: Results are shown only where a variable is applicable to a specific water use.

Figure 41. Reach 4 Water Quality Assessment, 1992

In addition, extremely high values were less frequently recorded in 1992 than in 1990 and 1991. It appears that the containment berm constructed in 1989 and other remedial measures have reduced the amount of organic contaminants entering the river.

Both phosphorus and fecal coliforms exceeded guideline levels on occasion. As the sampling site is near the upstream end of Reach 4, the sources are probably related to upstream activities in Reach 3.

Stormwater is an unquantified source of contamination in the Bow River. Trace metals, hydrocarbons and bacteria are often a concern in urban runoff, but no 1992 data were available within Reach 4 to evaluate this impact.

The time-series data for Reach 4 (Figure 42) are also limited. Fecal coliform levels have been somewhat erratic, but well within the guideline levels for irrigation and recreation. There are no apparent trends or concerns with respect to the guidelines in the other variables shown in Figure 41.

Water Quantity

Major uses of water in Reach 4 are for

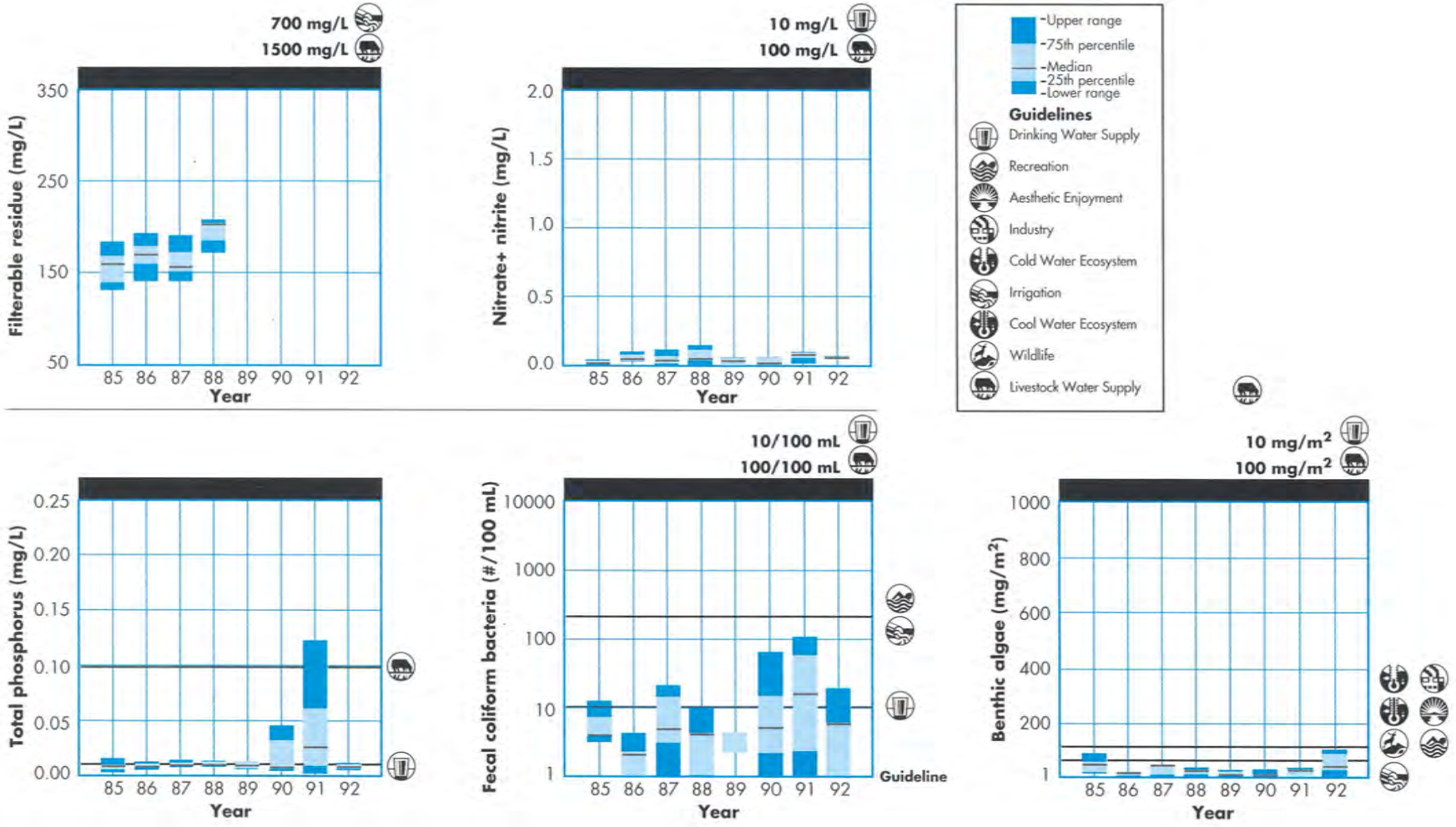


Figure 42. Reach 4 Water Quality Variables, 1985 to 1992

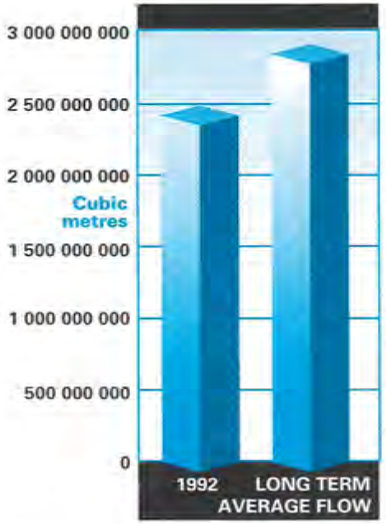


Figure 46. Annual Flow Compared with Long-term Average Flow at WID Weir

hydropower, irrigation and municipal water supply for Calgary. In 1991, the following water uses were licensed for Reach 4:

- 38 nonconsumptive licenses for a total of 12 496 000 cubic metres
- 151 consumptive licenses for a total of 927 721 000 cubic metres

A total of 352 867 000 cubic metres was withdrawn from the river in 1991, primarily for irrigation and municipal use (Figure 43). Of this, 4 740 000 cubic metres were returned to Reach 4. Also, some of the irrigation water was returned to the river in Reaches 6 and 7. Most of the municipal water was returned to the river in Reach 5 through wastewater plant discharges (all but 565 000 cubic metres is returned).

The total volume of water in 1992 passing by the measuring station, just above the Western Irrigation District weir, was 2 453 800 000 cubic metres. This was 85.4 percent of the long-term average for this reach (Figure 44). The station includes the drainage of both the tributaries entering this reach of the river.

Figure 45 shows the monthly flows through Reach 4 in 1992, and compares them with average flows over the long term. Flows in 1992 were at or above the long-term average between January to May and October to December due to hydropower releases. Between June and September, flows were well below the long-term average.

Use	Amount Licensed by Government (cubic metres)	Amount Diverted from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Industrial	11 262 000	6 191 000	4 740 000	1 451 000
Irrigation[1]	446 097 000	183 180 000	0	183 180 000
Municipal[2]	462 264 000	155 398 000	0	155 398 000
Others	8 098 000	8 098 000	0	8 098 000
Totals	927 721 000	352 867 000	4 740 000	348 127 000

1 Primarily cement manufacturing near Exshaw.
2 Canmore and Cochrane.
Note: 2 033 000 cubic metres of the consumption shown for irrigation are actually used for municipal purposes; 12 municipalities are licensed to draw water from WID canals

Figure 43. Water Withdrawals and Consumption in Reach 4, 1991

Ecosystem

Balsam popular is the most common tree species in Reach 4 and several stands of mature trees are found in the parks along the river. White spruce grow in a number of locations from Bearspaw to the area of Edworthy Park (Figure 46). Other trees and tall shrubs in riparian groves include water birch, willow and dogwood. Sandbar willow are abundant and widespread near the river's edge.

There has been no significant change in the distribution of the riparian vegetation over the last 100 years although some trees and shrubs have been lost to urban development. Flood control provided by the Bearspaw Dam could have long term downstream effects on riparian vegetation by interrupting natural reproduction cycles.

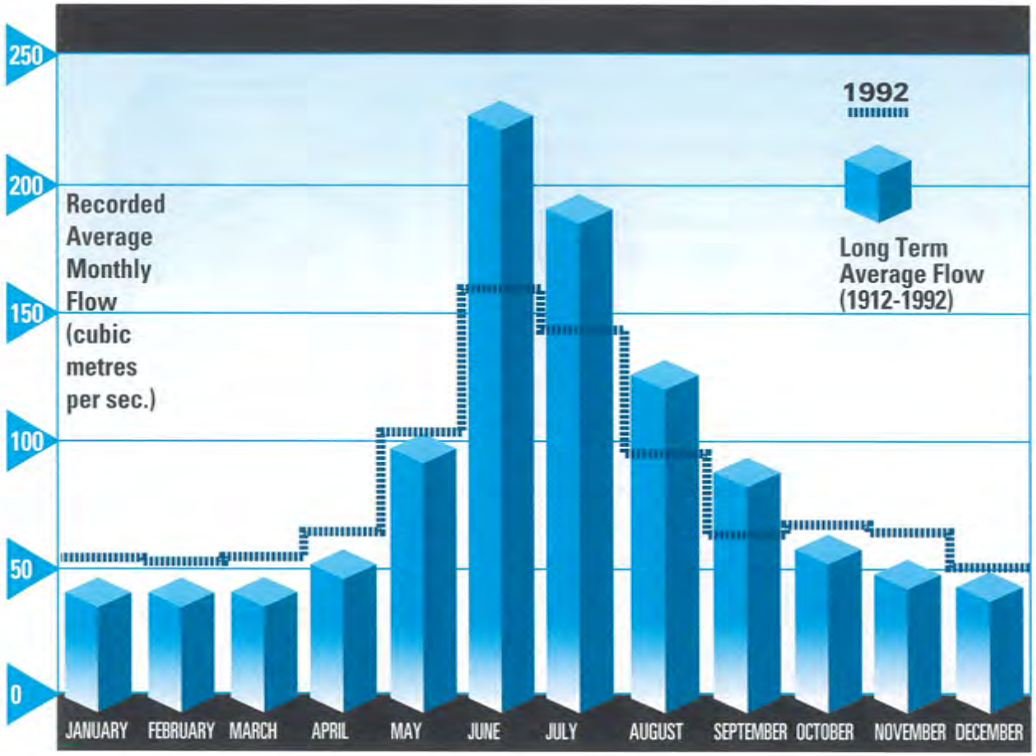


Figure 45. Monthly Flows Just Upstream of the Western Irrigation District Weir, 1992

There are few wetlands within the floodplain in Reach 4. Some abandoned channels and oxbow lakes have shoreline and aquatic vegetation including sedge, bullrush, rush and pondweed. While urban development and human activity encroach on the wetlands in Reach 4 (Figure 46), there are substantial numbers of waterfowl in the environs of the river.

Canada geese are common because the reach provides important nesting and brood rearing habitat. Nesting and wintering by geese in Reach 4 has been steadily increasing in recent years.

The Western Irrigation District supports approximately 9 500 acres of wetland habitat (including storage reservoirs) in the district with water drawn from Reach 4 in the river. As Reach 4 is all within the limits of the City of Calgary, the riparian habitat for wildlife is restricted. Sparse numbers of mule deer, white-tailed deer and coyote can be seen in the upper part of the reach. Few backwaters exist to provide den sites for muskrat or beaver, but some beaver can be found along the main stream of the river where dens can be excavated into the river banks. Small

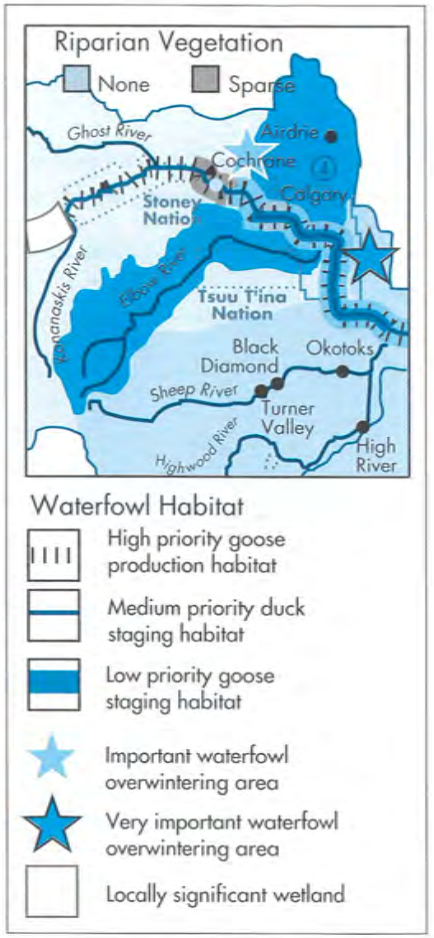


Figure 46. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 4

mammals and bird prefer areas where mature riparian trees and shrubs grow next to grassland sites on valley slopes. This habitat is found in Bankview and Edworthy Parks.

Wildlife generally avoid contact with humans but some deer, coyotes, birds and small mammals have become tolerant to human disturbance. However, they are still wild animals and problems include deer eating plants, getting killed or injured in collisions with vehicles and does with fawns becoming aggressive. Coyotes and foxes scavenge for garbage and kill domestic animals such as cats and small dogs.

City of Calgary on the Bow River

Reach 4 is the beginning of a highly productive fishery that extends downstream for over 100 kilometres. The relatively stable flows controlled by the Bearspaw Dam and the generally cool water temperatures contribute to ideal habitat conditions for the fish.

Mountain whitefish, brown trout and rainbow trout are the most common sportfish species found in Reach 4 (Figure 47). Bull trout, lake trout cutthroat trout and northern pike are present in scarce numbers.

Mountain whitefish spawn throughout the reach and rainbow and brown trout spawn at various locations. The Elbow River which joins the Bow in Reach 4 is an important spawning tributary for brown trout below the Glenmore Dam. The Western Irrigation District weir at the lower end of Reach 4 contains a fish ladder to aid upstream fish migrations from Reach 5.

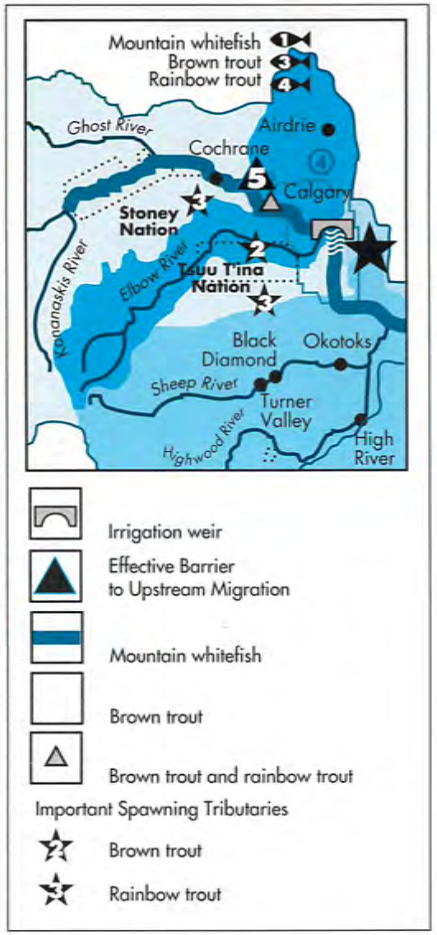


Figure 47. Fish and Fish Habitat in Reach 4

Reach 5 - Western Irrigation District Weir to Highway 22X

Reach 5 of the river lies entirely within the City of Calgary (Figure 48). It has a length of 25 kilometres, extending from just below the Western Irrigation District weir to Highway 22X near the south end of the city. This reach includes Fish Creek Provincial Park and the Inglewood Bird Sanctuary.

Reach 5 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold-Water Ecosystem	●
Industry	●
Irrigation	● *

* Localized areas of concern within Reach 5.

● 100% ● 75-100% ● 50-75% ● less than 50%

Reach 5 contains a cold-water ecosystem and is used for recreation, aesthetic enjoyment, and to a lesser extent industry and irrigation (largely for golf courses). Angling along the shore and from boats is very common.

The most significant pollution sources in this reach of river are treated effluents from Calgary's wastewater treatment plants (Bonnybrook and Fish Creek plants), and stormwater from Calgary's stormsewers. Seepage of hydrocarbons from abandoned industrial sites such as oil refineries is a potential problem which is under investigation. In 1992, Cominco Ltd.'s fertilizer plant (since decommissioned) also discharged a relatively insignificant amount of wastewater, primarily cooling water.

Water Quality

Detailed 1992 water quality data for Reach 5 are very limited (Figure 49). Information is presented here only for aquatic plants (1992 data), nitrate and nitrite (1989 data), and fecal coliforms (1991 data). No time-series data are available. Until new data are collected, evaluations of other water quality variables in Reach 5 are not possible.

Data are limited because river water quality immediately downstream of municipal wastewater treatment plants is not routinely monitored, although the wastewater effluents themselves are monitored before discharge into the river. It is difficult and expensive to monitor downstream of the plants because the mixing zone, the area where the effluents and the river water gradually mix, requires sampling at several locations down and across the river to accurately measure water quality. The mixing zone for the Calgary treatment plants ends several kilometres below the city in the vicinity of Policeman's Flats.

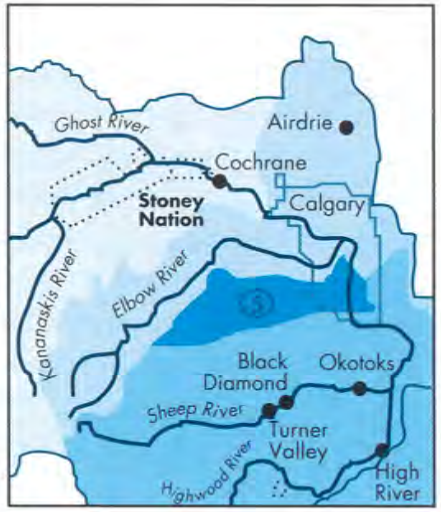


Figure 48. Reach 5 Map

In 1992, levels of aquatic plants (promoted by the nutrients in Calgary's wastewater and stormwater effluents) did not meet the guideline levels for the water uses identified for Reach 5 (Figure 49). Aquatic plants can be unsightly, restrict flow in canals, clog irrigation pump intakes and interfere with recreational use by causing the user or the user's equipment to become entangled. Alternately, when the biomass levels are relatively low, the aquatic plants provide important habitat for brown trout and other species.

Variable	1992 Water Quality Test Results				
	Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Industry	Irrigation
Total Dissolved Solids					○
Electrical conductivity					○
Sodium Adsorption Ratio					○
Colour					
Temperature			○		
Turbidity	○				
Secchi Depth	○				
Dissolved Oxygen			○		
pH	○		○		
Sodium					
Sulphate					
Chloride					
Floride					○
Nitrate					
Ammonia			○		
Total Phosphorus					○
Aluminum			○		○
Arsenic			○		○
Barium					
Boron					○
Cadmium			○		○
Chromium			○		○
Cobalt					○
Copper			○		○
Iron			○		○
Lead			○		○
Manganese					○
Mercury			○		
Nickel			○		○
Selenium					○
Zinc			○		○
Phenols			○		
2,4-D			○		○
Total Coliforms	○				○
Fecal Coliforms	○				○
Planktonic Algae					
Benthic Algae	○	○	○	○	○
Aquatic Plants					

Percent of water samples meeting guideline levels:
●100% ●75-100% ●50-75% ●less than 50% ○no data
Note: Results are shown only where a variable is applicable to a specific water use.

Figure 49. Reach 5 Water Quality Assessment, 1992

Nitrate and nitrite levels were within the guidelines in 1989. Fecal coliform bacteria levels exceeded the guideline levels in 1991 for all water uses defined for the reach. These levels would be high because of the wastewater and stormwater effluents from the City of Calgary, which are added to the river upstream of the sampling point. Coliform levels in Reach 5 associated with Calgary's wastewater treatment plants should be virtually eliminated by the ultra-violet disinfection of the wastewater effluents from the Bonnybrook Wastewater Treatment Plant in 1994 and from the Fish Creek Wastewater Treatment Plant in 1996. The wastewater treatment plant improvements will also include biological removal of phosphorous.

Water quality in Reach 5 is affected by the withdrawal of water from the river to supply the Western Irrigation District (at the downstream part of Reach 4). The more water that is withdrawn, the less water is available to dilute wastewater treatment plant effluents and stormwater being added to the river.

Water Quantity

In Reach 5, water is withdrawn primarily for industrial use. Smaller amounts are withdrawn for irrigation and other agricultural uses. In 1991, the following water uses were licensed for Reach 5:

- 8 nonconsumptive licences for a total of 733 000 cubic metres
- 50 consumptive licences for a total of 15 549 000 cubic metres

A total of 13 003 000 cubic metres of water were withdrawn in 1991, primarily for industrial use, while 165 118 000 were returned to the river (primarily through treated wastewater effluents from Calgary). The water returned to the river from all uses resulted in 152 115 000 cubic metres more water being returned to the river in Reach 5 than was withdrawn (Figure 50).

Flow information is not presented for Reach 5 as for other reaches, as representative data are not collected.

Ecosystem

The characteristic tree species in Reach 5 is balsam poplar, which occurs in large stands, particularly in Fish Creek Provincial Park (Figure 51). Urban development, gravel pits and beaver activity have removed some poplar; however, the riparian forest has not changed significantly during the last 100 years.

Reach 5 provides important nesting and brood production habitat for Canada geese. As discussed in Reach 4, goose nesting in Reach 5 has been steadily increasing and is reaching the saturation point. Geese are using every available site, particularly islands.

Reach 5 is low-importance staging habitat for geese and medium-importance staging habitat for ducks. Most of the mallards that spend the winter in Reach 5 use open water downstream of stormwater outlets and thermal effluents, such as those from the Bonnybrook Wastewater Treatment Plant (up to 30 000 birds have been observed at this site). Oiling of feathers (at certain stormwater outlets) and avian cholera are problems facing waterfowl that spend the winter in Reach 5. The number of Canada geese staying the winter in Reach 5 has also been steadily increasing in recent years.

Reach 5 is completely within the City of Calgary and is extensively developed, both on the floodplain and the adjacent valley slopes and uplands. Residential and industrial developments, roadways, railways, and human use of the river banks and parks limit riparian habitats for wildlife.

Where the floodplain has not been developed, it provides grassland habitats, with scattered, mostly mature poplar and other deciduous trees. Small mammals and their predators, a few coyotes, live in the grasslands. Mule and white-tailed deer are scattered in small groups along the length of this reach throughout the year but most commonly frequent the area downstream of the Glenmore Trail crossing of the river. The greatest threat to the survival of the deer has been unnatural death from motor vehicle collisions.

The large numbers of ducks and geese staying the winter in this reach attract bald eagles, golden eagles and a variety of hawks (Figure 51). Red-tailed and Swainson's hawks are common in the summer, feeding on the small rodents and nesting in the larger trees. There is an active great blue heron rookery just downstream of the

Use	Amount Licensed by Government (cubic metres)	Amount Withdrawn from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Agriculture	324 000	324 000	0	324 000
Industrial[1]	13 962 000	11 416 000	11 155 000	261 000
Irrigation	881 000	881 000	0	881 000
Municipal[2]	0	0	153 963 000	-153 963 000
Others[3]	382 000	382 000	0	382 000
Totals	15 549 000	13 003 000	165 118 000	-152 115 000

1 Primarily cement manufacturing near Exshaw.
2 Canmore and Cochrane.
3 Primarily agriculture and golf courses.
Note: 2 033 000 cubic metres of the consumption shown for irrigation are actually used for municipal purposes; 12 municipalities are licensed to draw water from WID canals.

Figure 50. Water Withdrawals and Consumption in Reach 5, 1991

Glenmore Trail crossing. As well, in the spring of 1994, up to six pairs of herons were nesting in the previously abandoned rookery along Fish Creek in Fish Creek Provincial Park. During the summer, more and more juvenile (i.e., nonbreeding) white pelicans and double-crested cormorants visit the lower portions of Reach 5.

There are some signs of beaver in Reach 5, but neither beaver nor muskrat are common because there are few marshy, undisturbed backwaters.

As in Reach 4, Reach 5 also provides prime habitat for trout and whitefish. Flows are more stable than above the Bearspaw Dam and water temperatures are cool. Nutrients from Calgary's wastewater treatment plant effluents enrich the water, but also add trace amounts of contaminants such as lead.

This highly productive reach falls within the portion of the Bow River recognized as a world-renowned sportfishery for large brown and rainbow trout. Mountain whitefish, brown trout and rainbow trout are the most common sportfish species (Figure 52). Bull trout, cutthroat trout and northern pike can also be found in this reach, but in low numbers.

Mountain whitefish spawn throughout the river in Reach 5 and brown trout spawn in the mainstream at various locations, including near the Inglewood Bird Sanctuary. Fish Creek was historically important as a spawning tributary for Bow River rainbow trout; however, spawning is minimal now. An investigation is needed to assess possible causes for the loss of this habitat which could include water withdrawals for golf course irrigation, artificial urban lakes, contaminating effects of City of Calgary stormwater discharges and beaver dams near the mouth of the stream.

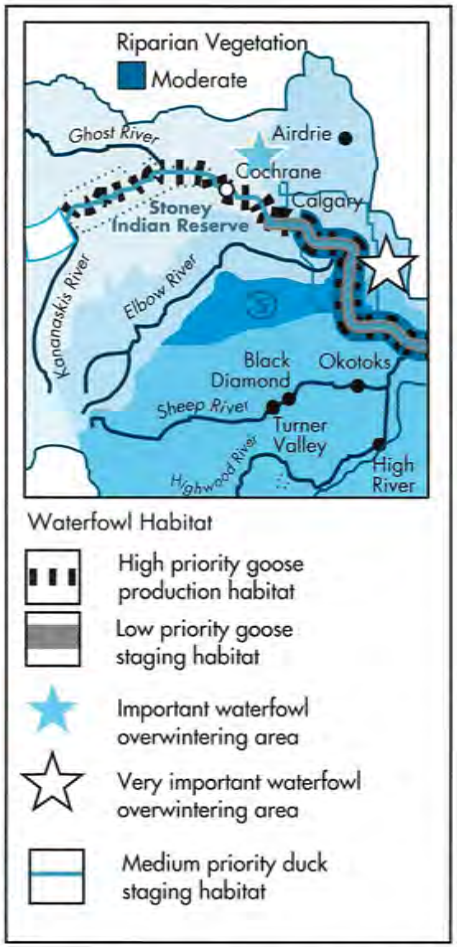


Figure 51. Waterfowl, Wetlands and Riparian Vegetation in Reach 5

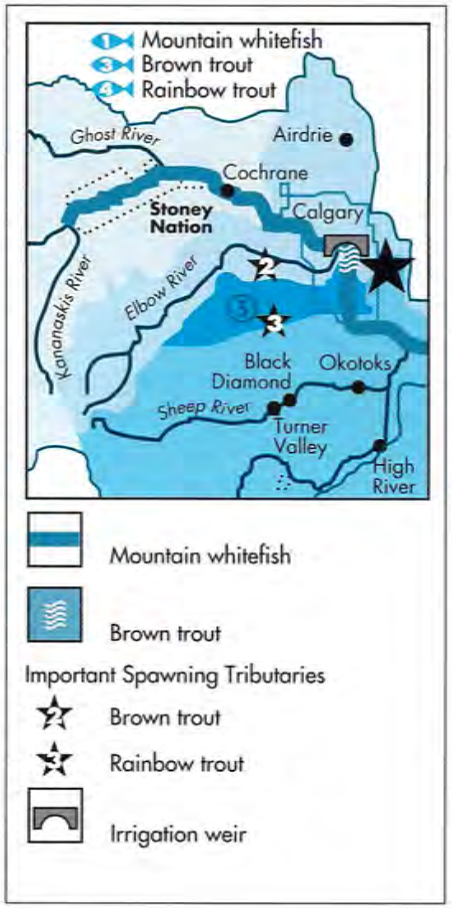


Figure 52. Fish and Fish Habitat in Reach 5

Reach 6 - Highway 22X to Bow River Irrigation District Headworks Weir (Carseland)

In Reach 6, the river leaves Calgary, cutting deeply and flowing more slowly through 53 kilometres of prairie to the Bow River Irrigation District Headworks weir at Carseland (Figure 53). 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.

Water from Reach 6 is used for drinking water supply, recreation, aesthetic enjoyment, wildlife, industry, irrigation and livestock watering. 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.

Reach 6 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold-Water Ecosystem	●
Drinking Water Supply	● +
Industry	●
Livestock Watering	●
Irrigation	● *

\+ All drinking water must be treated.
* Localized areas of concern within Reach 6.
● 100% ● 75-100% ● 50-75% ● less than 50%

Water Quality

Detailed 1992 water quality data for Reach 6 for 1992 are available for a limited number of water quality variables (Figure 54). These data give a good perspective on the water quality in this reach as they were collected downstream of the mixing zone for Calgary's wastewater effluents. These data do not reflect water quality from the Highwood River as they were collected upstream of that river. Water quality was poor enough in this reach to affect, to some degree, all water uses specified for this reach except livestock watering (Figure 54). Concentrations of ammonia were high enough that the health of cool-water ecosystem fish in the river and Bow River Irrigation District reservoirs could be affected. The phosphorus levels are a concern for irrigation as phosphorus increases weed growth in the canals, which can restrict canal flow and clog irrigation pumps.

The fecal coliform bacteria counts were above guideline levels for irrigation as well as recreation. Plant communities, both benthic algae and aquatic plants, were consistently restrictive for all uses.

Organic contaminants, which are known to enter the river in Reach 4 from the former Canada Creosote site, were at very low levels in 1992.

Figure 53. Reach 6 Map

Time-series data for Reach 6 indicate filterable residues at low levels (Figure 55). Fecal coliform bacteria are consistently at levels exceeding the guideline limits for irrigation and contact recreation. Phosphorus levels appear to be in a downward trend and are well within the guideline levels for watering livestock. Benthic algae levels have been erratic, but in the 1990s have been rising. In 1991 and 1992, benthic algae levels were above the guideline levels for

Variable	1992 Water Quality Test Results						
	Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Drinking Water Supply	Industry	Livestock Watering	Irrigation
Total Dissolved Solids				○		○	○
Electrical conductivity							●
Sodium Adsorption Ratio							○
Colour				○			
Temperature			●				
Turbidity	○			○			
Secchi Depth	○						
Dissolved Oxygen			●				
pH	●		●	●			
Sodium				○			
Sulphate				○		○	
Chloride				○			
Floride				○		○	○
Nitrate				●		●	
Ammonia			●				
Total Phosphorus				●		●	●
Aluminum			○			○	○
Arsenic			●	○		○	○
Barium				○		○	
Boron				○		○	○
Cadmium			○	○		○	○
Chromium			○	○		○	○
Cobalt						○	○
Copper			○	○		○	○
Iron			○	○			○
Lead			○	○		○	○
Manganese				○			○
Mercury			○	○		○	
Nickel			○			○	○
Selenium				○		○	○
Zinc			○	○		○	○
Phenols			○				
2,4-D			○				○
Trace Organics				●			
Total Coliforms	●			●			●
Fecal Coliforms	●			●			●
Planktonic Algae				○			
Benthic Algae	●	●	●		●		●
Aquatic Plants	●	●	●		●		●

Percent of water samples meeting guideline levels:
●100% ● 75-100% ●50-75% ● less than 50% ○ no data
Note: Results are shown only where a variable is applicable to a specific use.

Figure 54. Reach 6 Water Quality Assessment, 1992

all uses in the reach. Hydropower releases by TransAlta Utilities in the winter contribute to winter water quality by increasing dilution.

Water Quantity

In Reach 6, water is withdrawn primarily for irrigation. Smaller amounts are used for other agricultural uses, and domestic, industrial and municipal uses (along the Bow River Irrigation District canal system). In 1991, the following water uses were licensed for Reach 6:

- 21 nonconsumptive licences for a total of 105 000 cubic metres
- 384 consumptive licences for a total of 517 497 000 cubic metres

Within Reach 6 in 1991, 452 064 000 cubic metres were withdrawn, primarily for irrigation in the Bow River Irrigation District (95 percent of total 1991 withdrawals in Reach 6) (Figure 56). A total of 7 703 000 cubic metres, about 2% of total withdrawals from the reach, were returned to the river within Reach 6.

Flow information is not presented for Reach 6 as for other reaches, because representative data are not collected.

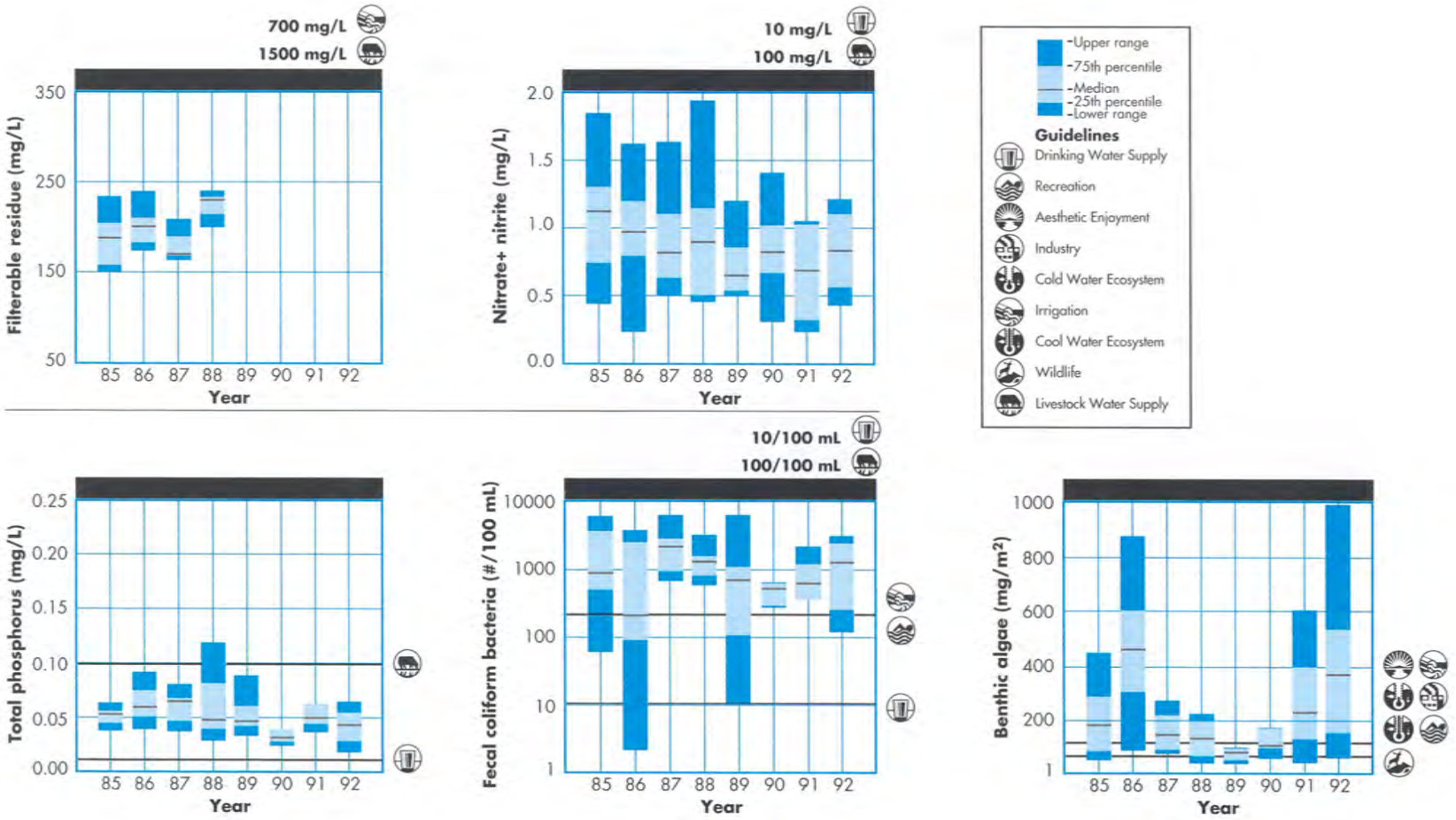


Figure 55. Reach 6 Water Quality Variables, 1985 to 1992

Ecosystem

Reach 6 contains extensive riparian forest dominated by balsam poplar. Gravel pits, limited residential development, cattle grazing and beaver activity have reduced the forest by small amounts in some locations, but overall there has been no significant change over the past 100 years.

Wetland habitat in Reach 6 is limited by the steep banks of the Bow River valley (Figure 57). However, there is more waterfowl food than would occur naturally because of nutrient enrichment in this reach. As well, stable water levels within the network of side channels directly above the Carseland weir create locally important habitat for brood rearing.

Overall, Reach 6 is highly important habitat for geese. Geese nest on the cliffs in addition to their more common nesting sites (e.g., abandoned nests and islands). The reach also provides staging habitat for geese and ducks.

The water withdrawals for irrigation at the Carseland weir help to support approximately 30 100 acres of wetland habitat (including storage reservoirs) within the Bow River Irrigation District.

In Reach 6, mature deciduous trees grow on the river valley floor, conifers cover the north-facing slopes, and shrubs and grasses blanket the drier south-facing slopes. Both mule deer and white-tailed deer use the valley year round for shelter, food and water. They also regularly feed on agricultural crops such as hay and grain on the surrounding uplands.

The mature trees provide nest sites for red-tailed and Swainson's hawks. The few spots with exposed vertical cliff faces offer nest sites for swallows, falcons and feral rock doves. Beavers commonly use the marshy backwaters of former stream channels for den sites. A great blue heron rookery is located approximately 5 kilometres upstream of the weir.

Use	Amount Licensed by Government (cubic metres)	Amount Diverted from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Agricuture	2 506 000	2 506 000	0	2 506 000
Domestic	4 951 000	4 951 000	0	4 951 000
Industrial	21 264 000	6 159 000	76 000	6 083 000
Irrigation[1]	479 204 000	429 920 000	7 627 000[2]	422 293 000
Municipal	1 504 000	460 000	0	460 000
Others[3]	8 068 000	8 068 000	0	8 068 000
Totals	517 497 000	452 064 000	7 703 000	444 361 000

1. Primarily Bow River Irrigation District. This District exports 26 262 000 cubic metres of its return flows to the Oldman River. There are 32 licences for diverting water from irrigation canals for non-irrigation uses included in the irrigation consumption. In 1991, these uses totalled 8 910 000 cubic metres.
2. 20 percent of return flows from the Western Irrigation District.
3. Primarily Highwood Diversion project (4 834 000 cubic metres) and Ducks Unlimited Canada's Frank Lake Wetlands project (3 718 000 cubic metres). Return flows are exported by interbasin transfer to the Oldman River.

Figure 56. Water Withdrawals and Consumption in Reach 6, 1991

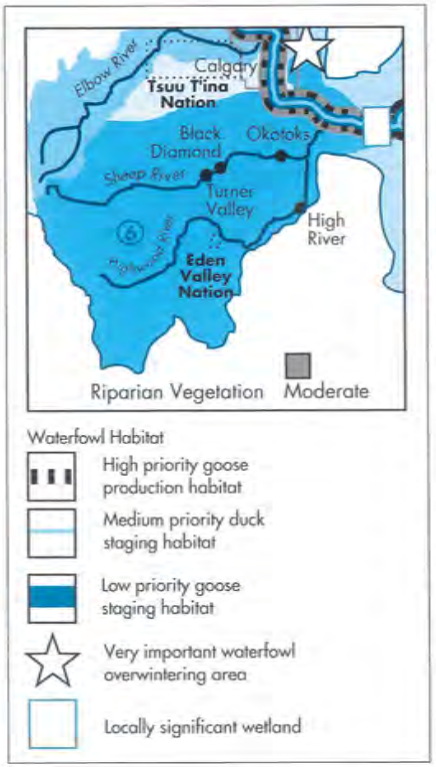


Figure 57. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 6

There are few public access points along this reach and human disturbance in the valley is low affording wildlife extensive areas of good habitat year round.

The prime trout and whitefish habitat and renowned brown and rainbow trout sportfishery in Reaches 4 and 5 continues into Reach 6 (Figure 58). In fact, Reach 6 is the most productive reach of the Bow River for fish. As in the previous reach, this is a result of nutrient enrichment from Calgary's wastewater treatment plant effluents, moderated river flows and cool water temperatures.

Mountain whitefish, brown trout and rainbow trout are the most common sportfish in Reach 6. Other sportfish found in this reach, but in low numbers, include bull and cutthroat trout, and northern pike.

Mountain whitefish spawn throughout the river in Reach 6. Trout spawning habitat in the mainstream has not been documented. Although good spawning gravels are available in the reach, dissolved oxygen levels may drop too low to support egg incubation. The Highwood River system provides important spawning habitat for large numbers of Bow River rainbow trout (the exact proportion is unknown). The Carseland weir is a barrier to upstream fish movements. There is a fish ladder at the weir, but its success for fish migrations is unknown.

Nutrient enrichment in Reach 6 has caused considerable aquatic plant growth within the reach, although there is less growth since Calgary installed phosphorus removal at its wastewater treatment plants in 1985. The plants provide important overhead cover for trout, and habitat for macroinvertebrate food organisms. However, the plants consume oxygen from the water through respiration at night, reducing it to the point where fish, particularly incubating eggs and early life stages, are threatened.

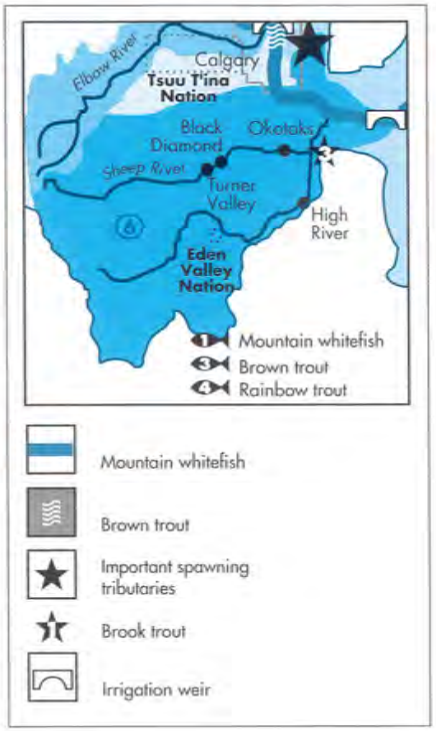


Figure 58. Fish and Fish Habitat in Reach 6

Historically, anglers have reported that fish captured in Reach 6 have tainted flesh and taste oily. This situation has been steadily improving since the removal in the 1970s of oil refineries along the river in the Alyth area of Calgary.

Reach 7 - Bow River Irrigation District Headworks Weir (Carseland) to Bassano Dam

In Reach 7, the river continues to cut deeply across the prairie but the valley is wider, and the slopes are gentler. This 136-kilometre reach of the river passes through rural municipalities and for most of its length, through the Siksika Nation Reserve (Figure 59).

Reach 7 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cold-Water Ecosystem	●
Cool-Water Ecosystem	● +
Drinking Water Supply	●
Livestock Watering	●
Irrigation	●

+ All drinking water must be treated.

● 100% ● 75-100% ● 50-75% ● less than 50%

The water demands for irrigation, municipal supply, recreation and wildlife in Reach 7 are high. In this reach, the river also supports both cool and cold water species of fish.

The major contaminants in this reach of the river appear to be transported from upstream. A significant impact on the flow, physical characteristics and water quality of the river within this reach is the withdrawal of water to the Bow River Irrigation District at the downstream boundary of Reach 6.

Water Quality

The detailed 1992 water quality data for Reach 7 (Figure 60) were from two sites: one at the upstream boundary of the reach and one at mid-reach. For all the water uses identified for this reach, 1992 values of water quality variables fell outside the guidelines to varying degrees (Figure 60).

As in reaches just upstream, phosphorus, ammonia, fecal coliform bacteria and benthic algae did not meet guideline levels. These conditions would be attributable to upstream factors and agricultural activities in the reach. Also, concentrations of aluminum and phenols exceeded the guidelines for the protection of both the cool-water and cold-water ecosystems. If some of the aluminum in the river is from wastewater treatment effluents from Calgary this will be relieved by the installation of biological nutrient removal facilities in the Calgary wastewater treatment plants during the period 1994 to 1996.

The high phenol levels may be natural as rivers in Southern Alberta have been found to occasionally exceed water quality guidelines because of phenols derived from natural sources. Fecal coliform bacteria levels may decrease because of improved tertiary treatment including ultra-violet disinfection in the Calgary wastewater treatment plants during the period 1994 to 1996.

The time series data for Reach 7 (Figure 61) show that filterable residues have remained steady and well below the guideline limits for irrigation and livestock watering. Fecal coliform levels have been increasing since the late 1980s and are generally at the guideline limits for irrigation and recreation. Phosphorous levels

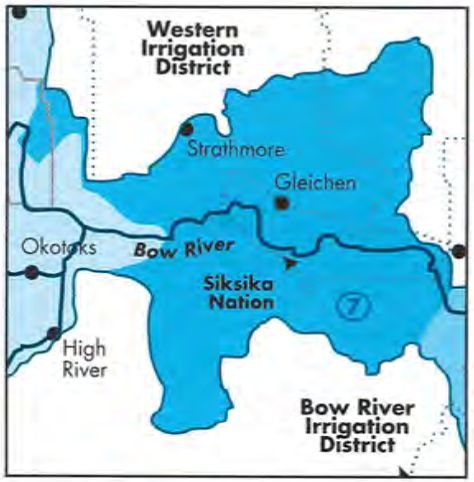


Figure 59. Reach 7 Map

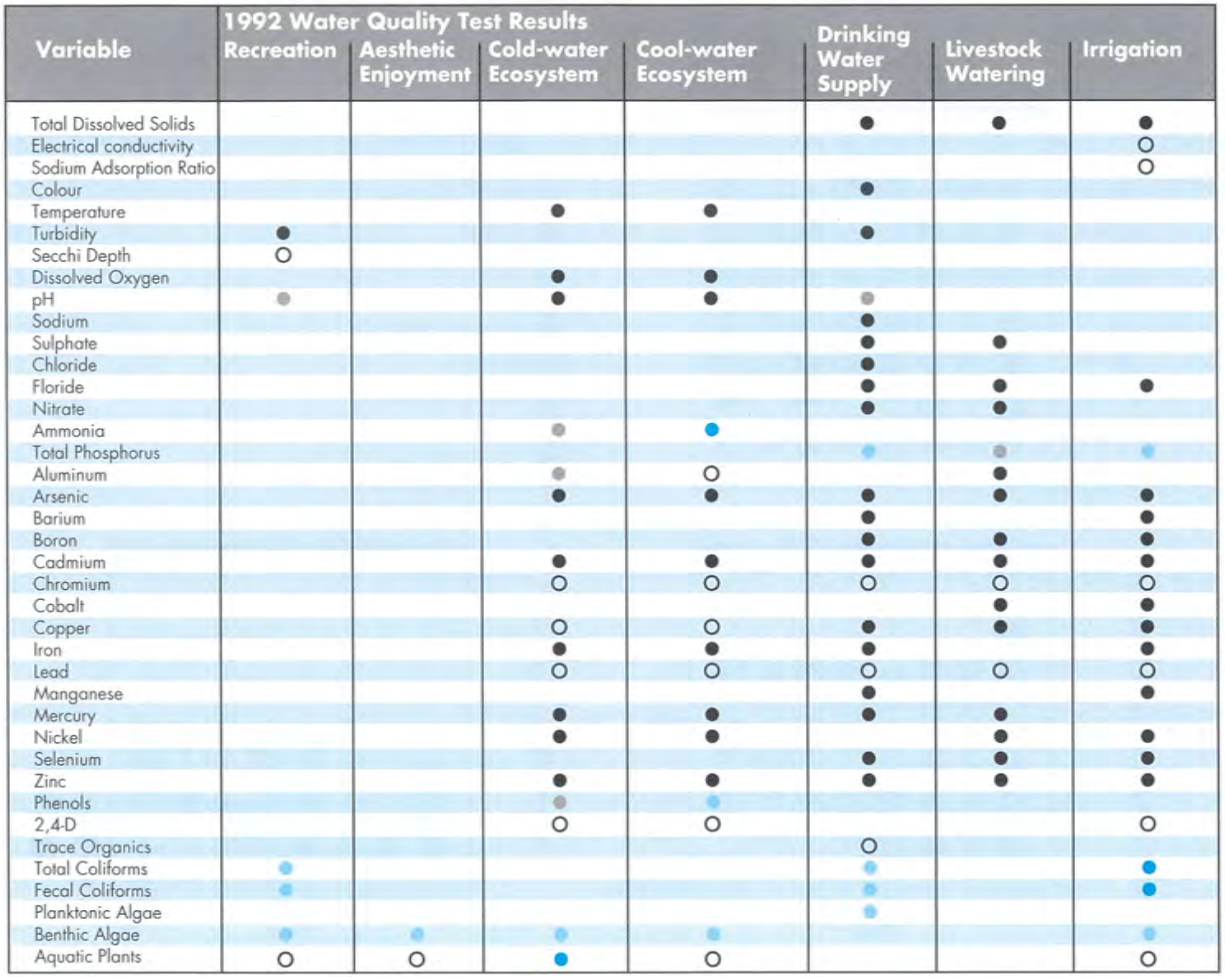


Figure 60. Reach 7 Water Quality Assessment, 1992

have remained steady and within the guideline limits for livestock watering. Nitrate and nitrite levels have remained as fractional in terms of the guideline limits for livestock watering. Benthic algae levels have been somewhat erratic but consistently in excess of the guideline limits for most activities.

Water Quantity

In Reach 7, river water is used largely for irrigation. Smaller amounts are used for other agricultural uses, industry and municipal use (Figure 62). In 1991, the following water uses were licensed for Reach 7:

- 29 nonconsumptive licences for a total of 472 000 cubic metres
- 187 consumptive licences for a total of 959 942 000 cubic metres

Total overall withdrawals in 1991 were 680 910 000 cubic metres, 99 percent of which was for irrigation within the Eastern Irrigation District. Return flow reduced the total water consumption in Reach 7 to 650 402 000 cubic metres.

The total volume of water passing through Reach 7 below Carseland was 3 564 000 000

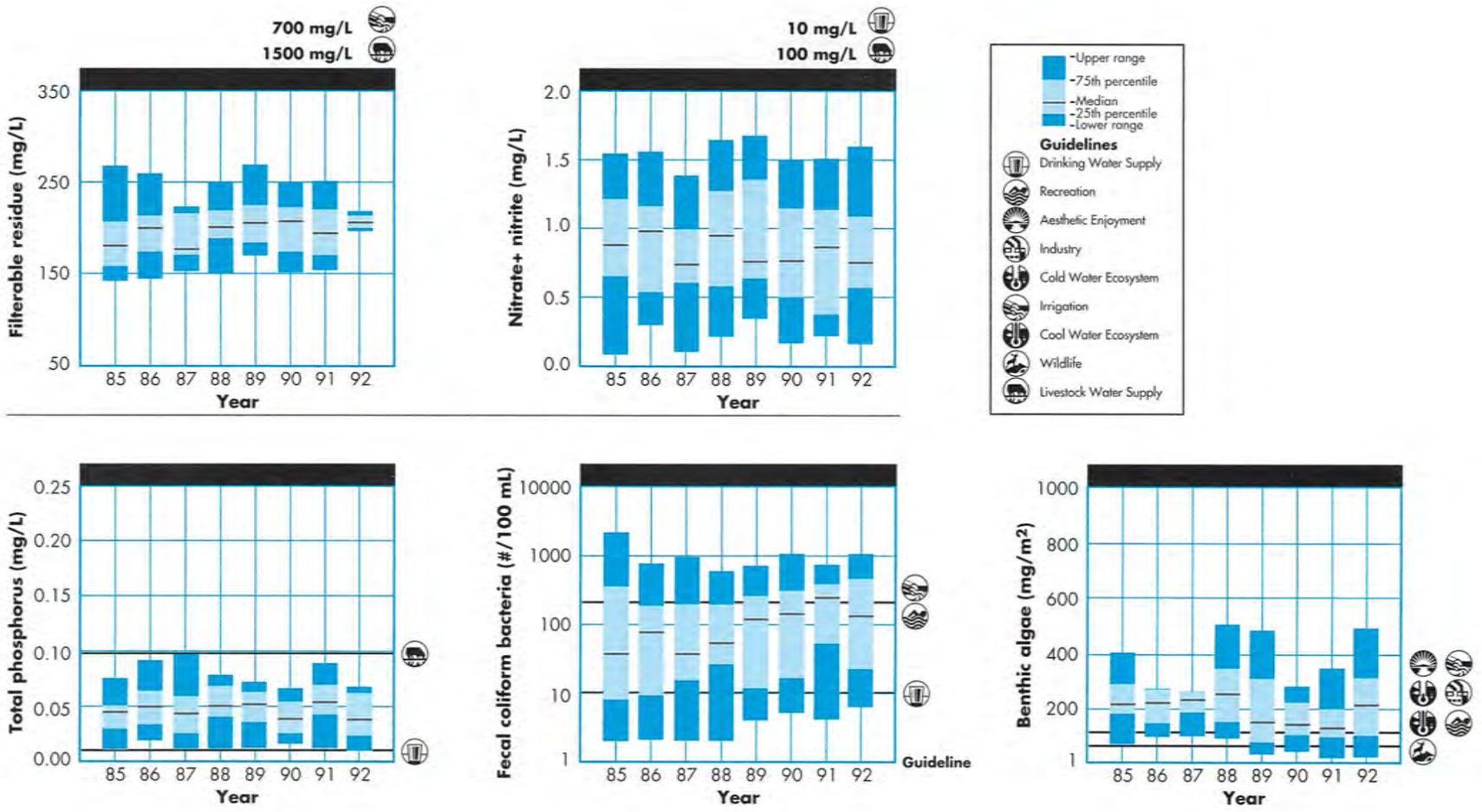


Figure 61. Reach 7 Water Quality Variables, 1985 to 1992

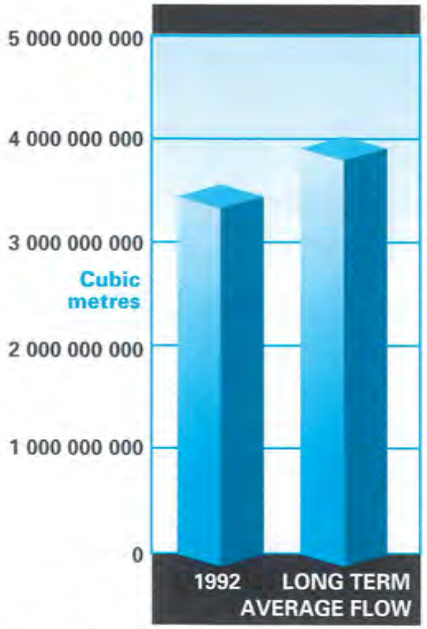


Figure 63. 1992 Annual Flow Compared with Long-term Average Flow Below Carseland

cubic metres. This was 88.8 percent of the long-term average for this reach (see Figure 63).

Figure 64 shows monthly flows in 1992 and compares them with average flows over the long term. Monthly flows in 1992 were below historical averages during most of the year.

Ecosystem

This reach contains the largest and densest stands of balsam poplar along the river valley (Figure 65). Aside from minor agricultural uses, beaver activity and clearing for a riverside golf course, the forest has changed little since the 1880s.

As in Reach 6, wetland habitats in Reach 7 are limited by the steep banks of the Bow River valley. However, food resources are plentiful for waterfowl as a result of nutrient enrichment and Reach 7 provides important nesting and brood rearing habitat for geese. Cliffs along the river provide additional nesting areas for Canada geese and Reach 7 provides important staging habitat for geese and ducks.

The water withdrawals for irrigation help to support approximately 40 000 acres of wetland habitat (including storage reservoirs) in the Eastern Irrigation District.

In Reach 7, the valley floor is generally open pasture lands with groups of mature poplars and individual trees along the river bank.

There is little information on the wildlife using this habitat. It is known that the minimal amount of human activity throughout much of the river valley makes it a prime area for wildlife, including sharp-tailed grouse, pheasants, coyotes mule and white-tailed deer. Red-tailed and Swainson's hawks nest in the mature trees, and great blue herons have at least two rookeries. Nonbreeding white pelicans and doubled-crested cormorants, probably from Lake Newell, commonly visit

Use	Amount Licensed by Government (cubic metres)	Amount Diverted from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Agricuture	1 452 000	1 456 000	0	1 456 000
Industrial	2 185 000	1 470 000	0	1 470 000
Irrigation[1]	948 997 000	674 927 000	30 508 000[2]	644 419 000
Municipal	7 250 000	2 999 000	0	2 999 000
Others	58 000	58 000	0	58 000
Totals	959 942 000	680 910 000	30 508 000	650 402 000

1. Primarily Eastern Irrigation District. This District exports 139 543 000 cubic metres of its return flows to the Red Deer River. There are 16 licences for diverting water from irrigation canals for non-irrigation uses included in the irrigation consumption. In 1991, these uses totalled 7 681 000 cubic metres.
2. 80 percent of return flows from the Western Irrigation District.

Figure 62. Water Withdrawals and Consumption in Reach 7, 1991

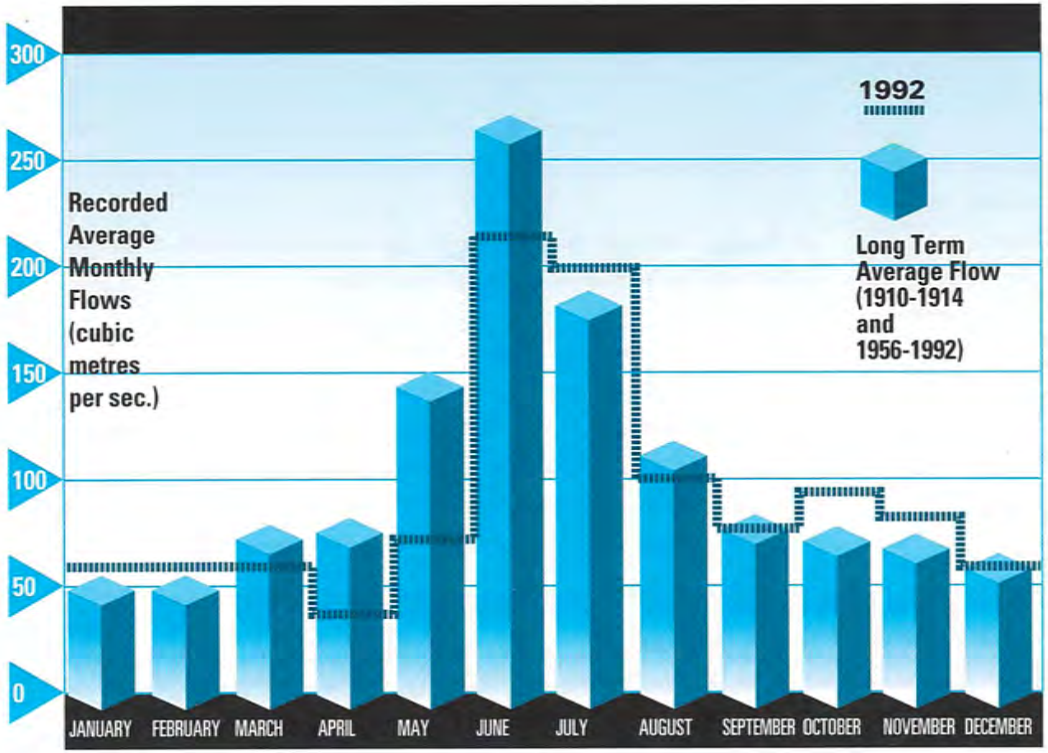


Figure 64. Monthly Flows Downstream of Carseland Weir, 1992

the Bassano Dam and occasionally upstream on the river throughout the summer and early fall.

In Reach 7, the Bow River gradually increases in temperature downstream. Fish production is still high, probably because of nutrient enrichment upstream. However, populations can be affected by:

- reduced flows downstream of the Carseland weir
- depressed dissolved oxygen levels (from large plant communities stimulated by nutrient enrichment)
- high water temperatures, particularly during late summer

(See Section 4.0 for more information on aquatic plants and dissolved oxygen levels).

Most of the reach falls within the Siksika Nation and has not been intensively studied. The reach contains mountain whitefish and to a lesser extent, rainbow and brown trout in the upper portions of the reach (Figure 66). Northern pike are the most abundant non-salmonoid fish and walleye are also present.

Mountain whitefish are expected to spawn on suitable gravel substrates throughout the reach. Seasonal migrations of mountain whitefish have been observed, but specific feeding, spawning and wintering habitats have not been identified.
Brown trout are known to spawn immediately below the Carseland weir. Specific northern pike spawning sites have not

Spray Irrigation

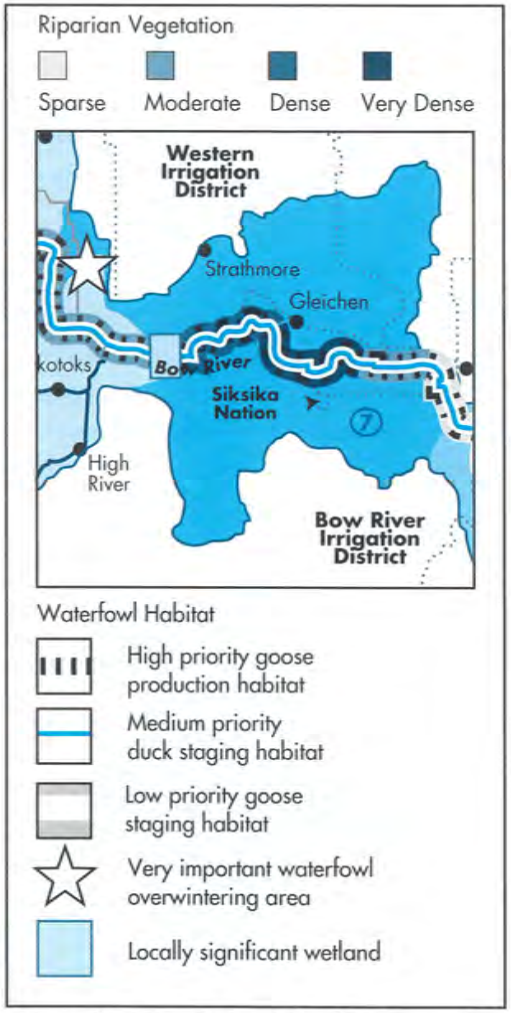


Figure 65. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 7

been identified, but the fish likely spawn in weedy side channels and backwaters of the river, and in quiet shallow waters of the Bassano Reservoir. The Bassano Dam is a barrier to upstream fish movements from Reach 8 to Reach 7.

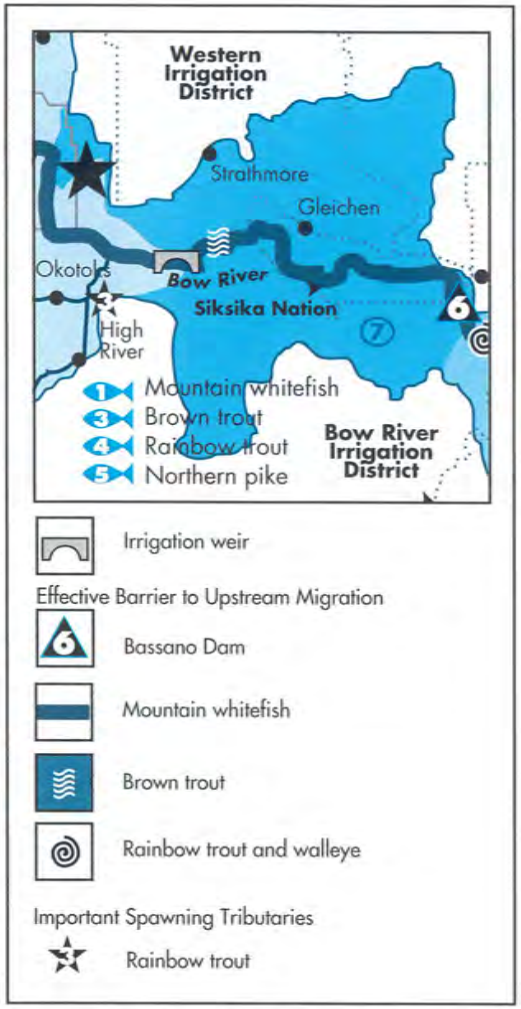


Figure 66. Fish and Fish Habitat in Reach 7

Reach 8 - Bassano Dam to the Confluence with the Oldman River

In Reach 8, the river flows from Bassano Dam cutting a fairly deep valley cross mostly undulating prairie lying within rural municipalities. The river ends where it joins the Oldman River and forms the South Saskatchewan River (Figure 67). This is the longest reach of the river at 185 kilometres. The South Saskatchewan River flows eastward through Medicine Hat into Saskatchewan, where it eventually drains via the Saskatchewan-Nelson River system into Hudson Bay.

Reach 8 Uses	Overall Water Quality Assessment
Contact Recreation	●
Aesthetic Enjoyment	●
Cool-Water Ecosystem	●
Drinking Water Supply	● +
Industry	●
Livestock Watering	●
Irrigation	●

\+ All drinking water must be treated.

● 100% ● 75-100% ● 50-75% ● less than 50%

This reach of the river is used less intensively than other reaches. Anglers enjoy the cool-water and cold-water fish species and the river is important for wildlife as well as livestock watering. Relatively less water is taken directly from the river for irrigation, industrial and domestic use.

As in Reaches 5, 6 and 7, the most significant pollution sources within this reach are upstream sources and local runoff from livestock operations and agricultural lands. A major influence on river water quality is also the withdrawal of water at the downstream boundary of Reach 7 for irrigation within the Eastern Irrigation District.

Water Quality

The 1992 detailed water quality data for Reach 8 (Figure 68) were collected from two sites in the reach: one at mid-reach and one near the downstream end of the reach. In 1992, all of the water uses specified for this reach were affected to some degree by the water quality, with the exception of livestock watering.

Levels of temperature, pH, ammonia, phosphorus, aluminum, phenols, total coliforms, fecal coliforms, planktonic algae and benthic algae all failed in varying degrees to meet the relevant guidelines. Nutrient levels, fecal coliform bacteria and benthic algae were the most frequent causes.

The time-series data for Reach 8 (Figure 69) show filterable residues steady and well within use guidelines. Fecal coliform bacteria levels appear to be climbing since the late 1980s and are approaching the guideline levels for irrigation and recreation. Total phosphorous levels have been declining and fall well within the guideline levels for livestock watering. Nitrate and nitrite values are somewhat erratic but fractional in terms of guideline levels. Benthic algae levels have been declining and in 1992 were generally within the guideline levels for all uses except recreation.

Figure 67. Reach 8 Map

Water Quantity

In Reach 8, river water is withdrawn largely for irrigation; smaller amounts are withdrawn for other agricultural uses. In 1991, the following water uses were licensed for Reach 8:

- 12 nonconsumptive licenses for a total of 751 000 cubic metres

Variable	1992 Water Quality Test Results Recreation	Aesthetic Enjoyment	Cold-water Ecosystem	Cool-water Ecosystem	Drinking Water Supply	Industry	Livestock Watering	Irrigation
Total Dissolved Solids					●		●	●
Electrical conductivity								○
Sodium Adsorption Ratio								○
Colour					●			
Temperature			●	●				
Turbidity	●				●			
Secchi Depth	○							
Dissolved Oxygen			●	●				
pH	●		●	●	●			
Sodium					●			
Sulphate					●		●	
Chloride					●			
Floride					●		●	●
Nitrate					●		●	
Ammonia			●	●				
Total Phosphorus					●		●	●
Aluminum			●	●			●	●
Arsenic			●	●	●		●	●
Barium					●		●	
Boron					●			●
Cadmium			●	●	●		●	●
Chromium			○	○	○			
Cobalt							○	○
Copper			●	●	●		●	●
Iron			●	●	●			●
Lead			○	○	○		○	○
Manganese					●			●
Mercury			●	●	●		●	
Nickel			●	●			●	●
Selenium					●		●	●
Zinc			○	○	●		●	●
Phenols			●	●				
2,4-D			○	○				○
Trace Organics					○			
Total Coliforms	●				●			●
Fecal Coliforms	●				●			●
Planktonic Algae					●			
Benthic Algae	●	●	●	●		●		●
Aquatic Plants	○	○	○	○		○		○

Percent of water samples meeting guideline levels:
●100% ●75-100% ●50-75% ●less than 50% ○ no data
Note: Results are shown only where a variable is applicable to a specific water use

Figure 68. Reach 8 Water Quality Assessment, 1992

- 130 consumptive licenses for a total of 8 914 000 cubic metres

Large return flows within Reach 8 resulted in a net increase in flow within the reach during 1991. Total withdrawals were 8 417 000 cubic metres, while return flows totalled 207 594 000 cubic metres (Figure 70).

Although there are large additions in downstream flows in this reach at times during the irrigation season, flows during summer months just below Bassano Dam can be very low (as low as 3 cubic metres per second).

The total volume of water passing through Reach 8 below Bassano in 1992 was 2 337 100 000 cubic metres . This was 54.5 percent of the long-term average for this reach (Figure 71).

Monthly flows were above average during the winter months (January to February and October to December) and below average during the remainder of the year (Figure 72).

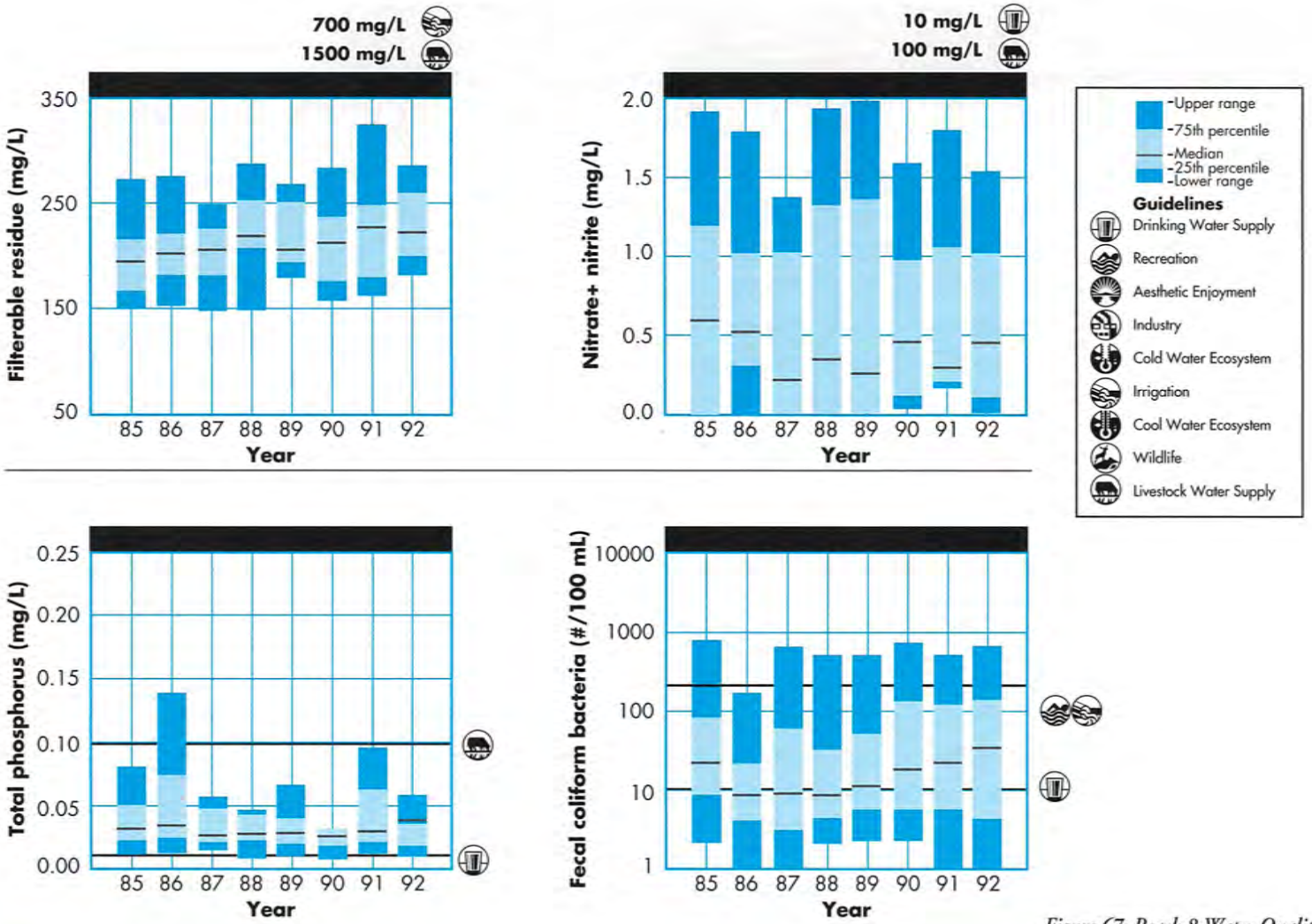


Figure 67. Reach 8 Water Quality Variables, 1985 to 1992

Use	Amount Licensed by Government (cubic metres)	Amount Diverted from River (cubic metres)	Amount Returned to River (cubic metres)	Amount Consumed (cubic metres)
Agricuture	1 417 000	1 417 000	0	1 417 000
Irrigation	6 878 000	6 381 000	207 594 000[1]	-201 213 000
Others	619 000	619 000	0	619 000
Totals	8 914 000	8 417 000	207 594 000	-199 176 000

[1] Return flows from the Eastern Irrigation District were 128 809 000 cubic metres and from the Bow River Irrigation District were 78 785 000 cubic metres.

Figure 70. Water Withdrawals and Consumption in Reach 8, 1991

Ecosystem

In this reach, tree cover diminishes to scattered clumps of balsam poplar and plains cottonwood (Figure 73). Grasses and shrubs dominate the valley. Cattle grazing and beaver activity have not caused any changes in riparian vegetation since the 1880s.

As in Reaches 6 and 7, food resources for waterfowl in Reach 8 are plentiful as a result of nutrient enrichment from upstream sources and runoff from agriculture operations in the reach.

Wetland habitats along the reach are limited because of the steep banks of the Bow River valley (Figure 73). Also, withdrawals of significant amounts of water in the summer at Bassano Dam probably restrict downstream brood production. The water is too shallow to provide protection from predators and feeding habitat for diving ducks. Within the irrigation district, approximately 40 000 acres of wetland habitat is maintained by irrigation withdrawals.

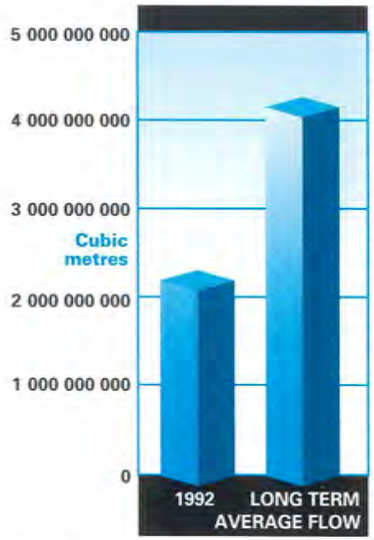


Figure 71. 1992 Annual Flow Compared with Long-term Average Flow Below Bassano Dam

Reach 8 provides highly important nesting and brood rearing habitat for geese. As in Reaches 6 and 7, cliffs along the river in Reach 8 provide additional nesting areas for Canada geese. Reach 8 is low importance staging habitat for geese and medium importance staging habitat for ducks.

Reach 8 does not support a substantial wildlife population as there is little cover available from trees, shrubs and rough terrain. Prairie grasslands are most common in Reach 8. Where there is cover, mule and white-tailed deer live year round, as do small numbers of pheasants and sharp-tailed grouse. One great blue heron rookery is located a few kilometres upstream of the Oldman River confluence.

Small groups and individual white pelicans and double-crested cormorants, probably from nearby Lake Newell, commonly live on the Bow River during the summer. Near the Oldman River confluence, the Bow River valley is key habitat for pronghorns (antelope).

Reach 8 is warm, highly productive biologically

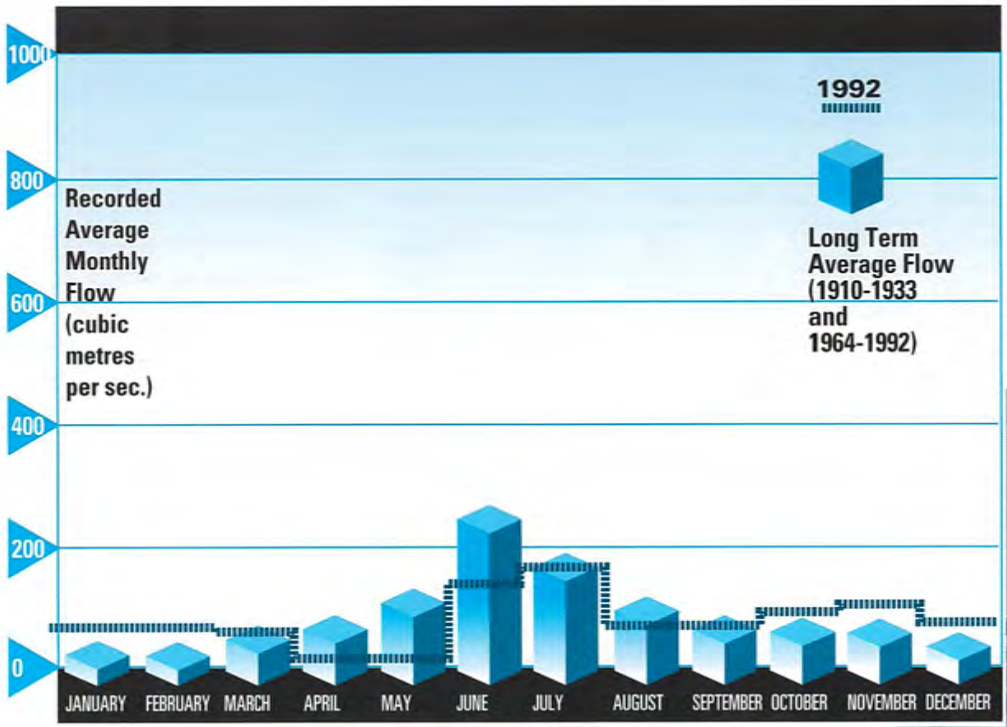


Figure 72. Monthly Flows Compared Below Bassano Dam, 1992

and frequently very shallow. A combination of low flows and warm-water temperatures in Reach 8, particularly in late summer, can decrease dissolved oxygen levels to the point where fish may be harmed (see Section IV for further information on aquatic plants and dissolved oxygen).

The low flows also force fish to concentrate in a few deep pools where they can be easily eaten by pelicans and cormorants. Although summer flows in Reach 8 are typically low, they may, at times, fluctuate drastically (shot term range between 3 and 110 cubic metres per second) in response to irrigation requirements due to climatic conditions and TransAlta upstream storage needs. These irregular flows create unstable downstream habitat.

Sportfish identified in the reach include rainbow and brown trout, lake and mountain whitefish, northern pike, walleye, sauger, yellow perch, goldeye and lake sturgeon (Figure 74). Northern pike, walleye and lake whitefish are apparently the most abundant fish species in the reach. Trout and mountain whitefish are rare and decrease in number downstream. In the lower portion

Bassano Dam

of the reach, increased flows from irrigation return water increase sportfish numbers.

Critical habitat areas have not been identified in this reach. Some rainbow trout and walleye spawning activity has been observed immediately below the Bassano Dam. Sauger spawning is suspected. Egg hatching is likely to have limited success because of lower summer flows, elevated summer water temperatures and river siltation. Irrigation return flows can cause erosion and carry sediments, which affect water quality and smother gravel areas with silt and sand.

Figure 73. Waterfowl, Wetland Habitat and Riparian Vegetation in Reach 8

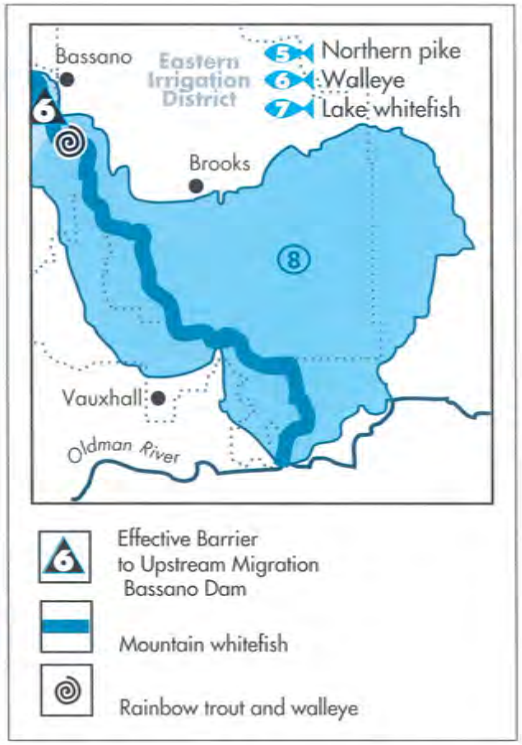


Figure 74. Fish and Fish Habitat in Reach 8

However, lake whitefish, walleye and northern pike often use the areas around irrigation return discharges for rearing. Habitat for sportfish to spend and survive the winter is not likely affected in Reach 8 as flows are not diverted during the winter and natural flows are supplemented by releases by TransAlta Utilities.

Opportunities for River Improvement

5.0

This report on the state of the Bow River shows the areas along the river where water quality and the river ecosystem can be improved. It also describes the data needed to add to knowledge of the river and water quality problems. The Bow River Water Quality Council sees these improvement areas and data gaps as opportunities for concrete actions to improve the river and its management.

This section presents the opportunities most directly related water quality and riparian habitat. Most of these opportunities are additional to the recommendations of the Bow River Water Quality Task Force, which are still relevant and are being closely monitored by the Council. For information on the task recommendations, see the task force report or contact the Executive Director of the Bow River Water Quality Council.

These opportunities for river improvement will be undertaken directly by or promoted by the Bow River Water Quality Council. In promoting opportunities, the Bow River Water Quality Council acts as a catalyst and leader for change. It promotes improvements in current practices, initiates new activities, and coordinates and communicates with others to expand the benefits of individual activities or programs.

In addition to the opportunities described here, many projects for improving the river or its usage have been initiated over the past several years by various groups and companies. Many of these projects are a direct result of the recommendations of the Bow River Water Quality Task Force, the predecessor to the Council, which published its report in 1991. These additional projects are presented in the supplemental section Projects by Community Groups, Governments and Organizations on page 77.

Assessment and Accountability

1. Prepare Detailed Status Reports or "Report Cards" on the Major Water Uses Affecting River Water Quality.

Detailed reviews of the status of water uses with the greatest impact on the river would assist in judging the current state of affairs and where improvements could be made. The status reports could also make comparisons with other locations in Canada and the world. Status reports could be prepared on sewage treatment, hydropower generation effects, littering, development controls along the river, riparian zone disturbance and irrigation efficiency.

2. Prepare a Self-Assessment Tool for Riparian Landowners to Measure the Environmental Impacts and Liabilities of Activities or Developments on the Bow River.

A method of assessing impact of developments, activities and operations on the river could be of assistance to riparian landowners in their planning and decision making. This could be a self-assessment tool available for voluntary use.

3. Develop Objective Goals and Effective Indicators of all Aspects of the River's Health.

Currently, the Bow River Water Quality Council has goals and guidelines for water quality for various uses of river water. Similar goals and guidelines are needed for other aspects of the river ecosystem: water quantity, riparian vegetation, fish and fish habitat, waterfowl and wetland habitat, and wildlife and wildlife habitat.

Indicators for measuring the health of the river should:

- be sensitive enough to detect changes over time and between river reaches

- be based on conventional scientific technology and straightforward methods which are readily reproducible
- ideally, build on data from current monitoring programs to provide an historical perspective and avoid the need for new programs (and costs) in cases where existing data will suffice

State-of-the-River Measurement and Monitoring

1.Monitor the State-of-the-River Indicators for all Aspects of the River.

Water Quality: A complete water quality monitoring program is needed at an appropriate location in each reach. This monitoring is essential to a full analysis of the river health on a reach-by-reach basis. As can be seen in this report, only limited data are presently available on several sections of the river.

Riparian Cottonwoods: Riparian cottonwood populations could be surveyed every five to ten years. These surveys would involve monitoring of cottonwood establishment and survival within permanent transects. These data would provide an estimate of long-term changes in the composition and distribution of riparian vegetation in the basin. Results could be related to hydrologic change and land use.

Fisheries and Fish Habitat: To evaluate the health of the Bow River fishery, densities of fry (a young fish, especially a salmonid where the yolk sac has been absorbed and is feeding independently in the stream) and habitat utilization could be surveyed for each reach at least every five years. This data would supplement Alberta Environmental Protection's management activities and would contribute significantly to understanding the fish population dynamics in the river.

Also, known spawning areas in the river could be surveyed on a regular basis for spawning activity by all sportfish species. The resulting data would provide year-to-year comparisons of the spawning activity and identify variations in activity.

Waterfowl and Wetland Habitats: Canada goose nesting areas, heron rookeries and localities where other species such as pelicans live in the river environment could be surveyed on a regular basis. The resulting data would be used to compare the nesting activity and use of these areas from year to year.

Stormwater Outfall

2.Review the Water Quality Guidelines used in this Report.

The Bow River Water Quality Council will continuously review the water quali-

ty guidelines used in this report and will refine them where appropriate. It is important the guideline levels accurately portray water quality concerns. The Council welcomes external input into this process.

3.Conduct Regular Visual Assessments of the River.

Every several years, the river could be toured and activities affecting the river's quality could be noted, videoed and mapped. Aerial photography to add to these records would be very useful. This information would help determine the reasons for current water quality and changes in water quality over time. This analysis would assist in revising management practices, where necessary.

4.Establish a Volunteer Water Quality Monitoring Program.

With ever-tightening government budgets. government funds for expanded water quality monitoring programs will be restricted. Volunteers could help to expand or maintain monitoring programs by taking water samples, or sponsoring analytical costs. For example, the Eastern Irrigation District started its own monitoring program four years ago. This water quality data would be added to the provincial government database, analyzed and used in decision making.

5.Prepare Water Quality Models for the River.

Water quality models or calculations should be developed for the areas of greatest water quality concern along the river, such as below Calgary. The "models" can be used to predict the downstream effects on water quality of activities such as changes in effluents discharge, housing developments and water diversions.

Water Quality and Ecosystem Investigations

1.Investigate the Water Quality Trends Presented in this State-of-the Bow River Report.

This report on the state of the Bow River discusses some trends or possible trends in water quality. These trends or possible trends should be investigated to determine if they exist, whether they will continue and their implications for the river and its uses.

2.Determine the Effects of Water Quality Limitations on Fish and other Aquatic Life in Reaches 6, 7 and 8 of the Bow River.

Little is known about the effects of water quality limitations on fish and other aquatic life in the lower Bow River. An opportunity exists to research this.

3.Determine the Relative Contributions of Wastewater Effluents, Stormwater and Agricultural Runoff to Changes in Water Quality in the River.

Wastewater effluents, stormwater and agricultural runoff all affect water quality, although their relative contributions are not documented. An opportunity exists to determine both the absolute and relative contributions of each contaminant source within each river reach.

4.Measure the Improvements in Water Quality Resulting from New or Improved Wastewater Treatment Plants in Calgary, Canmore, Cochrane and Lake Louise.

Calgary completed its Bonnybrook Wastewater Treatment Plant upgrade with ultra-violet disinfection in 1994. Canmore, Cochrane and Lake Louise plan to complete their new wastewater treatment plants or upgrades in 1995. The effects of these improvements on the river's water quality could be measured.

5.Research the Extent and Location of Threats to the Riparian Cottonwood Forests along the Bow River.

An opportunity exists to locate and rank the environmental significance of damage to the riparian forests along the Bow River by cattle grazing, beaver, cultivation and human development.

Where necessary, the riparian forests could be restored and protected. For example, where existing trees are sparse but healthy, scarification and shallow cultivation would promote growth of new shoots. Transplanting of saplings may be considered in cleared areas. In selected areas, trees could be wrapped with wire mesh to deter beaver. Trout Unlimited Canada has wrapped 5 000 trees to date.

6.Gather Fisheries Information to Assist in Updating and Improving the Provincial Government's Strategies for Managing the Bow River Fisheries.
The following information is needed to improve the fisheries management strategies for the Bow River:

*a.*Headwaters to Banff National Park boundary (Reaches 1 and 2):
- productivity and population estimates
- recreational use
- critical habitat components

*b.*Banff National Park to Bearspaw Dam (Reach 3):
- productivity and population estimates
- recreational use
- critical habitat components
- the limitations place on production by discharge fluctuations

*c.*Below Bearspaw Dam to Carseland Weir (Reaches 4, 5 and 6):
- mountain whitefish utilization of and dependency upon the major tributaries
- the impact of Highwood River diversions on the fish populations
- the timing of rainbow trout smolt emigration from the Highwood system
- further investigation of dissolved oxygen conditions
- continued monitoring of macrophyte growth
- further investigation of brown trout spawning in the main stem Bow River

*d.*Below Carseland Weir to the confluence with the Oldman River (Reaches 7 and 8):
- potential fish production in response to improved flow regimes (e.g., increases of 6 to 8 cubic metres per second) and the economic importance of such pro duction
- more information on fish populations
- seasonal movements and restrictions within the reaches and between Reach 8 and the Oldman River
- critical habitat components
- recreational use of the existing populations

Planning Considerations

1.Establish a "River Management Zone".
A "river management zone" could be established along part of the river where developments and other activities would be reviewed for their impacts on the river. This review process would be coordinated with existing government planning controls. Such reviews would assist developers, communities and the river ecosystem. The review group could include appropriate experts, stakeholder groups and governments and would advise on how to minimize impacts. As an example, the effects of gravel mining on riparian habitat could be reviewed and the alternatives to undesirable effects could be provided.

Community Stewardship

1.Adopt Segments of the Bow River and Tributaries.
Organizations could adopt segments of the Bow River and its tributaries. They would then work to promote protection of the river's health or aspects of it, such

as water quality or fish habitat.

2.Develop Stormwater Control Measures in Communities.
The easiest way to maintain a river's water quality is to prevent contaminants from entering the river. Communities could develop measures to manage their stormwater to prevent river contamination. This is particularly important for communities that are forecast to grow significantly.

3.Set Up and Promote "Model Intensive Livestock Operations".
Intensive livestock operators could set up and promote "model facilities" that reflect the spirit and letter of the provincial government's new intensive livestock permitting process (see Section VII for more information). Among other things, these facilities would demonstrate the recommended methods of manure management and water quality protection.

4.Clean Up Litter Along the Riverbanks.
Some areas of the Bow River are littered with trash or garbage. This detracts from the river's attractiveness and can harm waterfowl or wildlife who may eat it or get caught on it. Cleanup campaigns anywhere on the upper or lower river banks to supplement the annual events in some communities (e.g., Calgary and Canmore) would be an opportunity to improve the river valley. In many parts of the river, the lower banks would have to be cleaned from boats because the banks are steep.

5.Individuals Take Personal Action.
Individuals should take personal action to protect the Bow River. Some of these include:
- setbacks for development
- buffer zones
- less lawn fertilizer
- water conservation
- lawn watering
- not feeding ducks and geese

6.Improve Fish Creek and Nose Creek.
Nose Creek and Fish Creek, two relatively small tributaries that enter the Bow River within the City of Calgary, suffer from a variety of problems ranging from stormwater contamination to excessive withdrawals for irrigation. Opportunities exist to restore these streams to health with programs similar to the one currently underway the lower Elbow River below the Glenmore Reservoir (see page 87 for more information).

Appendices

6.0

Appendix A - Bow River Water Quality Guidelines

The water quality guidelines used throughout this report are presented below. The guidelines were developed by the Bow River Water Quality Task Force and are discussed in detail in their report.

Uses	Goals	Important Variables	Guideline Levels	Important Variables	Guideline Levels
Drinking Water Supply	•A minimum of treatment to achieve Canadian Drinking Water Guidelines, which is water without harmful levels of bacteria, viruses, toxic chemicals and trace metals	Total Coliforms Fecal Coliforms Turbidity Colour pH TDS Sodium Sulphate Arsenic Barium Boron Cadmium Chloride	<100 counts/100 mL <10 counts/100 mL <10 (JCU) <15 TCU >6.5-8.5 <500 mg/L <200 mg/L <500 mg/L <0.05 mg/L <1.0 mg/L <5.0 mg/L <0.005 mg/L <250 mg/L	Chromium Copper Fluoride Iron Lead Manganese Mercury Nitrate Selenium Zinc Chlorophyll a Total Phosphorus Trace Organic Contaminants	<0.05 mg/L <1.0 mg/L <1.5 mg/L <0.3 mg/L <0.01 mg/L <0.05 mg/L <0.001 mg/L <10 mg/L <0.01 mg/L <5 mg/L <2 mg/m^3 ≤0.010 mg/L Absent
Contact Recreation	•absence of turbidity resulting from human activity •low risk of bacterial or viral infection •limited weeds and algae •no odour, oily sheen or hazardous chemicals •no litter or garbage	Fecal Coliforms Total Coliforms Secchi Depth	200 counts/100 mL 1000 counts/100 mL >1.2 m	River Benthic Chlorophyll Turbidity pH	75 g/m^2 dry wt 50 NTU 8.5

Uses	Goals	Important Variables	Guideline Levels	Important Variables	Guideline Levels
Aesthetic Enjoyment	•weed and algal growth that is not unsightly •no odour or oily sheen	River Aquatic Plants	200 g/m^2 dry wt	River Benthic Chlorophyll	100 mg/m^2
Irrigation	•low salt content •levels of trace metals and herbicides that are non-toxic to plants •no bioaccumulative contaminants or disease-causing organisms •levels of nutrients that to not produce weeds in rivers or irrigation canals •low suspended solids levels	Total Dissolved Solids Electrical Conductivity Sodium Adsorp. Ratio Boron Aluminum Arsenic Chromium Copper Cobalt Fluoride Iron Manganese	700 mg/L 1.0 mS/cm 4 0.5 mg/mL 5 mg/L 0.1 mg/L 0.1 mg/L 0.2 mg/L 0.05 mg/L 1.0 mg/L 5.0 mg/L 0.2 mg/L	Nickel Zinc 2,4-D Total Coliform Bacteria Fecal Coliform Bacteria Cadmium Lead Selenium River Benthic Chlorophyll River Aquatic Plants Total Phosphorus	0.2 mg/mL 1.0 mg/mL 0.1 mg/mL 1000 counts/100 mL 200 counts/100 mL 0.2 mg/mL 0.2 mg/mL 0.02 mg/mL 100 mg/m^3 200 g/m2 dry wt. 0.025 mg/L
Livestock Watering	•no bioaccumulative contaminants or disease-causing organisms •low to moderate salt content •non-toxic levels of nitrogen, pesticides and trace metals •levels of nutrients that will not stimulate growth of toxic blue- green algae	Total Dissolved Solids Nitrate + Nitrite Total Phosphorus Sulphate Aluminum Arsenic Boron Chromium Cobalt	1500 mg/L 100 mg/L 0.100 mg/L 1000 mg/L 5.0 mg/L 0.5 mg/L 5.0 mg/L 1.0 mg/L 1.0 mg/L	Copper Fluoride Nickel Selenium Zinc Cadmium Lead Mercury	0.5 mg/L 1.0 mg/L 1.0 mg/L 0.05 mg/L 50 mg/L 0.02 mg/L 0.1 mg/L 0.003 mg/L
Industry	•levels of nutrients that do not produce sufficient weed or algae growth to impair water withdrawal	River Benthic Chlorophyll	100 mg/m^2	River Aquatic Plants	200 mg/m^3 dry wt
Hydropower Generation	•no specific water quality requirements				

Uses	Goals	Important Variables	Guideline Levels	Important Variables	Guideline Levels
Cold-water Ecosystem	•consistently high oxygen content and cool water temperatures to ensure a diverse coldwater plant and invertebrate community •non-toxic environment for aquatic life •fish with pleasant taste and odour, and levels of chemicals below guidelines for human consumption	Dissolved Oxygen Water Temperature pH Ammonia River Benthic Chlorophyll River Aquatic Plants Aluminum Arsenic	>6.5 mg/L 22°C 9.0 0.32 mg/L 100 mg/m^2 200 g/m^2 dry wt 0.1 mg/L 0.05 mg/L	Cadmium Chromium Copper Iron Lead Mercury Nickel Zinc Phenolic Compounds 2,4-D	0.0013 mg/mL 0.002 mg/mL 0.003 mg/mL 0.3 mg/mL 0.004 mg/mL 0.0001 mg/mL 0.110 mg/mL 0.03 mg/mL 0.001 mg/mL 0.004 mg/mL
Cool-water Ecosystem	•consistently moderate oxygen content and water temperatures to ensure a diverse warmwater plant and invertebrate community •non-toxic environment for aquatic life •fish with pleasant taste and odour, and levels of substances below guidelines for human consumption	Dissolved Oxygen Water Temperature pH Ammonia River Benthic Chlorophyll River Aquatic Plants Aluminum Arsenic Cadmium	>5.0 mg/L 29°C 9.0 0.11 mg/L 100 mg/m^2 200 g/m^2 dry wt 0.1 mg/L 0.05 mg/L 0.0013 mg/L	Chromium Copper Iron Lead Mercury Nickel Zinc Phenolic Compounds 2,4-D	0.002 mg/L 0.003 mg/L 0.3 mg/L 0.004 mg/L 0.0001 mg/L 0.110 mg/L 0.03 mg/mL 0.001 mg/mL 0.004 mg/L

Appendix B - Water Quality Variables not Meeting Guideline Levels by Reach

Use	Reach Number 1	2	3	4	5	6	7	8
Recreation		pH ●	pH ● Benthic Algae ●	Benthic Algae ● Aquatic Plants ◐	Aquatic Plants ◐	pH ● Total Coliforms ◐ Fecal Coliforms ◐ Benthic Algae ◐ Aquatic Plants ◐	pH ● Total Coliforms ● Fecal Coliforms ● Benthic Algae ◐	pH ● Fecal Coliforms ● Benthic Algae ●
Aesthetic Enjoyment				Benthic Algae ●	Aquatic Plants ◐	Benthic Algae ◐ Aquatic Plants ●	Benthic Algae ◐	Benthic Algae ●
Cold-water Ecosystem			Benthic Algae ●	Benthic Algae ●	Aquatic Plants ◐	Benthic Algae ◐ Aquatic Plants ●	Ammonia ● Aluminum ● Phenols ● Benthic Algae ◐	–
Cool-water Ecosystem	–	–	–	–	–	–	Ammonia ● Aluminum ● Phenols ● Benthic Algae ◐	Ammonia ● Aluminum ● Phenols ● Benthic Algae ●
Drinking Water Supply		pH ● Total Phosphorus ● Trace Organics ● Planktonic Algae ●	Turbidity ● pH ● Total Phosphorus ● Total Coliforms ◐ Fecal Coliforms ● Planktonic Algae ● Benthic Algae	Total Phosphorus ● Trace Organics ● Fecal Coliforms ●	N/A	pH ● Total Phosphorus ◐ Trace Organics ● Total Coliforms ◐ Fecal Coliforms ◐	pH ● Total Phosphorus ◐ Total Coliforms ◐ Fecal Coliforms ◐ Planktonic Algae ◐	Temperature ● pH ● Total Phosphorus ◐ Total Coliforms ● Fecal Coliforms ◐ Planktonic Algae ◐
Industry	–	–	Benthic Algae ●	Benthic Algae ●	Aquatic Plants ◐	Benthic Algae ◐ Aquatic Plants ●		Benthic Algae ●
Livestock Watering	–	–					Total Phosphorus ●	
Irrigation	–	–	Benthic Algae ●	Benthic Algae ●	Aquatic Plants ◐	Total Phosphorus ◐ Total Coliforms ◐ Fecal Coliforms ◐ Benthic Algae ◐ Aquatic Plants ●	Total Phosphorus ◐ Total Coliforms ● Fecal Coliforms ● Benthic Algae ◐	Total Phosphorus ● Fecal Coliforms ● Benthic Algae ●

Percent of water samples meeting guideline levels:
●100% ● 75-100% ● 50-75% ■ less than 50% – not applicable

Supplemental Section 7.0

Projects by Community Groups, Governments and Organizations

Many community groups, governments and other organizations within the Bow River Basin have undertaken or are starting projects that will protect or enhance the Bow River. A large number of these projects are a result of the recommendations of the Bow River Water Quality Task Force or involvement with the Bow River Water Quality Council.

These projects show some of the current initiatives to improve water quality in the Bow River Basin. They also provide examples of projects that can be helpful in guiding other groups who may want to undertake similar projects in their areas. Brief project descriptions are provided, along with a contact name for further information.

Not all the water management initiatives ongoing in the Bow River Basin are included in this section. The emphasis is on projects that have been started since about 1991, when the Bow River Water Quality Task Force Report was published.

Wastewater Treatment

Wastewater effluent is a major contributor of contaminants to the Bow River. There are approximately 50 municipalities licensed by Alberta Environmental Protection to discharge treated wastewater within the Bow River Basin. Nine of these discharge directly to the Bow River; the others discharge their effluent into tributaries of the Bow or irrigate farm land with the effluent. A number of initiatives described below are underway to improve wastewater treatment in the Bow River Basin.

City of Calgary Improvements in Wastewater Treatment

Calgary's two wastewater plants account for nearly 90 percent of all wastewater effluents entering the Bow River. Calgary has been upgrading its facilities regularly over the years, and as a result has one of the most effective treatment facilities in Canada.

In a recent study of 20 Canadian cities by the Vancouver-based Sierra Legal Defence Fund, Calgary received the top mark (A-) in Canada for its high-level, tertiary sewage treatment facility. In contrast, 17 of the 20 cities studied dump raw sewage at some point in the year into water bodies.

Even though Calgary has a high level of wastewater treatment, the Sierra Legal Defence Fund reports that Calgary's effluents still contain high levels of coliform bacteria, nutrients and toxins (for example, ammonia). However, coliforms levels have decreased dramatically in the effluent from the Bonnybrook Wastewater Treatment Plant because of installation of ultra-violet disinfection in December of 1993 [see below]. Also, phosphorus will soon be removed from the effluents biologically, rather than the current alum process, which produces aluminum byproducts of concern.

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Ultraviolet Disinfection of Wastewater Effluents

Five of the major sewage treatment plants along the Bow River have been or soon will be upgraded to use ultraviolet light to disinfect the wastewater before discharge to the Bow River or its tributaries. These plants are Banff, Canmore, Kananaskis (Evan Thomas), Cochrane and Calgary (Bonnybrook and Fish Creek plants).

Use of ultra-violet light, rather than chlorination or no disinfection process at all, is a considerable improvement in wastewater treatment. The process is effective in killing bacteria (at the Bonnybrook plant, fecal coliforms in the effluent were reduced by 99.99 percent). One of the benefits of ultra- violet disinfection over chlorination is that it does not leave residues in the water, which can be toxic to fish and other organisms within the aquatic ecosystem.

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Sewage Sludge Recycling

In an example of an excellent joint venture between industry and government, Canmore and TransAlta Utilities have formed a partnership in a pilot project to produce fertilizer and soil enhancer from a mixture of semi-liquid sewage sludge; dry organic material such as paper, grass clippings; and other municipal solid wastes. Both the solid and liquid end products from the process can be used as fertilizers or soil enhancers by municipalities, farmers, forestry companies, road builders and reclamation industries.

The pilot plant is scheduled to be transported to Canmore and installed in the wastewater treatment plant in late July, 1994. The cost to TransAlta Utilities for building and operating the pilot plant for the trial period is expected to be $350,000.

Following the successful completion of the trial operation, the Town of Canmore plans to install a full-scale plant to accommodate all of the town's sewage sludge and organic municipal solid waste.

Based on a submission by: Roger Drury; Water Management Planner; TransAlta Utilities Corporation; Box 1900, Station M; Calgary, Alberta T2P 2M1 Telephone: (403)267-4639

Sewage Sludge Use

Treatment of municipal wastewater results in two different end products: treated wastewater effluents and sludge. To recycle the valuable sludge from this process, the City of Calgary distributes the 18 000 tonnes of sludge produced through its two wastewater treatment plants to Calgary area farmers through its program called Calgro. This provides a fertilizer value of approximately 990 tonnes of nitrogen, 720 tonnes of phosphorus, 63 tonnes of potassium, plus micronutrients. Sludge also improves the tilth and water-holding capacity of the soil. Farmers who apply sludge usually do not have to apply fertilizer for the next two years.

The Calgro program is carried out under Alberta Environmental Protection guidelines, which are designed to maximize benefits and minimize risk. Under these guidelines, sludge may be applied only to soil with a minimum pH of 6.5 and cropped with forages, oilseed crops, small grains, commercial sod or trees. Soil can be reapplied with sludge no sooner than three years, provided the available nitrogen levels in the top 150 centimetres are less than 250 kilograms per hectare. Regular laboratory analyses are used to ensure nutrient and heavy metal levels are within guideline levels.

Based on a submission by: Wolf Kellar; Water Treatment Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-3853

Water Conservation

Water conservation efforts provide benefits to both the Bow River and all water users. The less water that is consumed, the more remains in the river for other uses or to maintain aquatic habitat.

Municipal Water Conservation Projects

As well as benefitting the Bow River and downstream water users, municipal water conservation programs provide economic benefits to the municipality and individual municipal water users. The less water that is used, the more money is saved on water treatment, wastewater treatment and related infrastructure costs. The most effective programs promote the environmental benefits through education and meter individual usage to pass on the cost savings.

Calgary, Cochrane and other municipalities within the Bow River Basin have water conservation programs. In Calgary, meters are installed in all new homes and can be installed free of charge in existing homes if homeowners wish. In most instances, the bills of metered customers are lower. The City has a goal of installing 10,000 new residential meters every year.

Cochrane's water conservation program includes loss detection in water supply lines and universal metering of residences. Residents were provided free water-saving devices such as low-flow heads for showers and taps, as well as toilet dams, which reduce the water volume required for each flush from 24 to 19 litres. New homes are required by bylaw to have water conservation fixtures. Low-flow toilets require as little as 6 litres of water for flushing.

Cochrane's program has reduced overall residential water consumption by 15 percent in less than 2 years. Cochrane's water treatment plant needed to produce less water in 1993 than in 1988 when the population was 30 percent less.

Based on a submission by: Martin Schmitke; Town Manager; Town of Cochrane; Box 10; Cochrane, Alberta T0L 0W0 Telephone: (403)932-2075 and Paul Fesko; Technical and Administrative Engineer; City of Calgary; Water Works Division; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2178

Eastern Irrigation District's Water Conservation Project

With irrigation using approximately 96 percent of all water consumed from the Bow River, irrigation districts are beginning to examine the efficiency of their water use. In 1993, the Eastern Irrigation District started a comprehensive flow monitoring pilot project in the Rolling Hills area. This project will establish the relationships between management of the irrigation system, on-farm water demands, rainfall and temperature. This is primarily a conservation initiative aimed at ensuring the most effective use of water licensed to the Eastern Irrigation District.

Based on a submission by: Jim Webber; General Manager; Eastern Irrigation District; P.O. Bag 8; Brooks, Alberta T1R 1B2 Telephone: (403)362-1425

Urban Stormwater Management

Urban stormwater is considered the second largest contributor of contaminants to the Bow River. This stormwater includes runoff from roads and other impervious surfaces, which drains to the underground stormsewer system and directly to the river without any treatment, except for occasional sedimentation, to decrease contaminant levels.

Urban runoff contains nutrients (phosphorus and nitrogen compounds) from fertilizers and other sources, trace metals from the operation of automobiles, coliform bacteria, largely from dog feces, pesticides, and suspended solids from road sanding, dust and the erosion of disturbed soil. Another potential source of contaminants is hazardous industrial or household chemicals dumped down the storm drains.

Throughout the basin, a number of important initiatives described below are underway to improve the quality of storm runoff.

Trout Unlimited Canada's Yellow Fish Storm Drain Program

Trout Unlimited Canada has initiated its Yellow Fish Road program to raise public awareness of the hazards to human health and river life of dumping toxic, household compounds down storm drains. Under the program, volunteers from the community paint a yellow symbol of a fish next to storm drains to alert people that the storm drain is a direct link to the river. Volunteers also pass out information on the program to households.

Trout Unlimited Canada initiated the Yellow Fish Road Program in Calgary in May, 1991 and has since spread the program throughout Alberta and other provinces. The organization provides the educational material, stencils and support for the program.

For the program to be successful, it is critical that people have convenient access to centres that accept hazardous household chemicals for proper disposal. Most communities stage "Toxic Round Ups" at their firehalls at least yearly. The City of Calgary accepts households chemicals daily at designated firehalls in each quadrant of the city. Used engine oil can be recycled at some gas stations and at the Calgary sanitary landfills.

Based on a submission by: Judy McKearney; Storm Drain Marking Program Coordinator; Trout Unlimited Canada; P.O. Box 6270, Station D; Calgary, Alberta T2P 2C8 Telephone: (403)221-8373

City of Calgary's Hazardous Spills and Emergency Response Programs

The City of Calgary has developed two programs to respond to emergencies within the City. Their Managing Dangerous Spills Program addresses spills of dangerous materials, and their Localized Emergency Response Program addresses events that could threaten life or cause substantial property damage in any specific geographical area within the City.

The Managing Dangerous Spills Program includes detailed procedures for spill assessment and cleanup, and notification of necessary parties of spills. Response procedures are specified for City departments (e.g., Fire Department, Police Department, Waterworks Division, Streets Division, Sewer Division, and Solid Waste Services Division) well as Calgary Health Services and Alberta Environmental Protection. The program specifies four levels of spills, each with different degrees of response. A Level 4 incident is a major uncontrolled spill with escaping gases, explosive conditions, or escape into a sewer system or adjacent watercourse. In a Level 4 spill, the Sewer Division or Streets Division handles cleanup, Calgary Health Services is notified, and samples of spilled materials are collected.

In the Localized Emergency Response Program, the Sewer Division, Waterworks Division or Streets Division manages the response, including notifying the Fire Department, requesting additional manpower and equipment, and reporting to agencies and authorities.

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Storm Sewer Outfall Reporting

Three years ago, the City of Calgary changed all the signs on its stormsewer outfalls, most of which discharge directly to a river or reservoir. The signs now clearly indicate that the structure is a stormwater outfall, the structure number and the Sewer Division's 24-hour emergency phone number.

With this information, the public can now easily report any unusual conditions

at the outfall. Trouble crews investigate and follow up on any complaints. As well, storm outfalls that discharge to the Glenmore Reservoir are checked daily.

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Erosion and Sedimentation Controls

In 1992, the City of Calgary developed and published Erosion and Sediment Control Guidelines for developers, contractors and City crews undertaking new subdivision development or construction projects. These guidelines have also been adopted by the Town of Cochrane.

Erosion and sedimentation control prevents large amounts of sediment-laden water from running off a site during construction. Sediment can settle out in stormsewers and cause costly blockages which must be cleared by municipal crews. In addition, large amounts of sediment can interfere with fish spawning and degrade habitat in the river.

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Urban Runoff Quality Monitoring

The City of Calgary, through the Engineering and Environmental Services Department, Sewer Division, is undertaking an extensive urban runoff quality research and monitoring program. The goal is to prepare computer models for predicting the effects of urban runoff on the receiving water bodies such as the Bow River. The monitoring efforts are modeled after a program designed by the United States Environmental Protection Agency.

The Sewer Division began its program in 1992, when it manually monitored the quality of water from specific stormsewer outfalls (one in an industrial area, one in an area under construction, two downtown, and one downstream of a large former industrial site). In 1993, the Sewer Division began using automated sampling equipment. The 1994 program will monitor the same outfalls as in 1993.

The Sewer Division has already collected and analyzed numerous samples, although more data are needed for conclusive results.

City of Calgary

Bonnybrook Wastewater Treatment Plant

Based on a submission by: Barry Bohn; Water Quality Engineer; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-2185

Constructed Wetlands Treatment of Stormwater

The City of Calgary will begin work in 1994 on its first constructed wetlands for

improving stormwater quality before its discharge to the river. A constructed wetlands is an artificial re-creation of a natural wetlands, where the land is depressed, water accumulates and aquatic plants and animals live. The stormwater is retained in the wetlands long enough for sediments to settle out and possibly for some of the nutrients to be removed by the plants.

The wetlands will be an experimental pilot project where the effects of various flow conditions on the stormwater quality will be tested. The results of this pilot project will provide useful information for stormwater management projects in the entire Bow River Basin.

Water Quality Monitoring

Eastern Irrigation District's Monitoring Program

Since 1990, The Eastern Irrigation District has monitored the quality of water it both receives from and returns to the Bow River. In 1993, the effects of intensive livestock facilities on water quality were also assessed. With this knowledge, the district can better manage its irrigation activities. This information can also be used in state-of-the-river assessments.

Based on a submission by: Jim Webber; General Manager; Eastern Irrigation District; P.O. Bag 8; Brooks, Alberta T1R 1B2 Telephone: (403)362-1425

Industrial Contamination Control

Bow River Valley Survey

In 1994, Alberta Environmental Protection completed a study recommended by the Bow River Water Quality Task Force to identify the sites of industries that once operated within Calgary's Bow River floodplain and used chemicals that could cause harm if they entered the river. The study also analyzed the floodplain for gravel and groundwater conditions that could allow chemicals to enter the river. Information from the study will be used by the City of Calgary for planning and cleanup purposes.

The industries identified include those whose type of process, raw material handling methods and waste management practices could be of concern. They also include selected industries of concern, principally automobile service and fuelling, and early dry cleaning operations.

Based on a submission by: Walter Ceroici; Head, Contaminated Sites and Decommissioning Branch; Alberta Environmental Protection; 5th Flr., 9820-106 St.; Edmonton, Alberta T5K 2J6 Telephone: (403)427-6182

Agricultural Impacts Management

Riparian Habitat Management Program

The interaction of grazing management strategies and riparian habitat are being assessed under a new project called the Riparian Habitat Management Project. This four year-project is being run by a partnership of livestock producer groups (Alberta Cattle Commission and Canadian Cattlemen's Association), Trout Unlimited Canada and the provincial government.

The management options are being demonstrated to cattle producers, conservation groups and recreationists on five working ranches in south-western Alberta. The demonstrations will show how best to manage activities such as grazing and recreation to reduce their impact on the riparian zone and particulary fish and wildlife habitat.

Based on a submission by: Peggy Strankman; Manager, Environmental Affairs; Canadian Cattlemen's Association; 215, 6715 - 8 St. NE; Calgary, Alberta T2E 7H7 Telephone: (403)275-8558

Voluntary Permitting Program for Intensive Livestock Operations

Intensive livestock operations are a potential source of nuisance, and environmental and health problems because of their associated odours, flies and wastes. Improperly managed wastes can run off or be washed off by rain into watercourses.

The number of conflicts between the agricultural industry and the local community is expected to increase as the livestock industry expands and rural residential developments continue to expand into traditional farming areas. As intensive livestock operations become larger many municipalities will require technical assistance to ensure these facilities are properly sited and designed.

The livestock industry, the provincial government and two rural municipal associations have all participated in designing an intensive livestock development permitting process. This process helps local governments make development approval decisions for new and expanding intensive livestock facilities. It is a cooperative approach providing provincial direction on technical matters while ensuring that the final decision rests with the local decision making authority.

As of March, 1994, the intensive livestock development permitting process has been offered to all rural municipalities on a voluntary basis. The goal is to have 80 percent of rural municipalities using the permitting process by December, 1996.

Based on a submission by: Tamara Hursin; Resource Planner; Resource Planning Branch, Alberta Agriculture, Food and Rural Development; 206, 7000-113 St.; Edmonton, Alberta T6H 5T6 Telephone: (403)427-5359

Bow River Basin Planning

One of the most significant recommendations of the Bow River Water Quality Task Force Report is the recommendation for a Bow Basin planning program. This program is to address concerns related to river flow regulation, water withdrawal and water quality. The following projects describe some of the progress on this recommendation.

Bow River Basin Study

Alberta Environmental Protection, with the assistance of other government agencies, the Bow River Water Quality Council and members of the public, has prepared a study design for the Bow River Basin planning program.

The study will result in an information base, analytical tools, and recommendations to support and direct environmental management in the Bow River Basin. At this time, the study design provides for instream flow needs and objectives for the Bow River and major tributaries, information for the Year 2000 review of irrigation expansion guidelines, urban and rural runoff, protection of riparian habitat, access to the river, a guidebook on current water management, and timely, efficient, and effective public consultation.

The study is currently under review and is scheduled to take five years. Currently, the resource requirements for the study are $1.9 million, with 46 person-years of professional and technical time from study participants.

Based on a submission by: Bob Morrison; Acting Bow Basin Planner; Planning Division, Alberta Environmental Protection; 203, 2938 - 11 St. NE; Calgary, Alberta T2E 7L7 Telephone: (403)297-6462

Eastern Irrigation District Computer Modelling

The Eastern Irrigation District has developed computer models to assist it in evaluating various strategies for managing water uses. The Eastern Irrigation District has focused its efforts on changes in management of its irrigation network to provide benefits to the Bow River.

Based on a submission by: Jim Webber; General Manager; Eastern Irrigation District; P.O. Bag 8; Brooks, Alberta T1R 1B2 Telephone: (403)362-1425

Minimum Releases in the Bow River Between the Ghost and Bearspaw Reservoirs

TransAlta Utilities is presently assessing the minimum amounts of water it releases from the Ghost Power Plant reservoir on the Bow River. The company may be able to increase minimum flows to enhance the riparian habitat and recreation opportunities.

During most of the year the Ghost Plant is operated to pass higher flows during the day and much lower flows at night. This pattern reflects electrical power demand, which is higher during the day and lower at night. The exception to this operating pattern is the period from late May through July, when the primary mountain runoff is occurring in the Bow River. During this period, higher releases are maintained during the night as well to prevent the water level in the reservoir from getting too high.

In fall of 1994, TransAlta Utilities tested a pattern of higher minimum releases from the Ghost Plant. Individuals and groups with concerns had the opportunity to observe the resulting flow conditions in the river and provide feedback to the company.

Based on a submission by: Roger Drury; Water Management Planner; TransAlta Utilities Corporation; Box 1900, Station M, Calgary, Alberta T2P 2M1 Telephone: (403)267-4639

Other Initiatives

Bow Corridor Weed Control Program

The Bow Corridor Weed Control Program has been established to control two very invasive weeds, purple loosestrife and scentless chamomile, which have recently spread to the Bow River Valley. Both these weeds are non-natives and therefore do not have any natural enemies to keep their populations in check. Both plants spread rapidly and replace natural vegetation, thus destroying the natural diversity of an area.

Purple loosestrife is a recently growing problem in Alberta whereas farmers have battled scentless chamomile for twenty years. A single chamomile plant can produce as many as 300 seeds per plant. The seeds can float for 12 hours and thus the spread along a river can be dramatic.

Through the joint efforts of over a dozen cooperators in the program, including landowners; environmental groups; provincial, municipal and city governments; corporations and First Nations, awareness and control efforts have been coordinated along the Bow River from the Banff National Park boundary through to the County of Newell at Brooks. Weeds are also being handpicked to stop the production and spread of seed.

To date, the result are positive. Chamomile levels have decreased by about 50 percent in the last two years and numbers of purple loosestrife have also decreased.

Based on a submission by: Tim Dietzler; Agricultural Fieldman; MD of Rocky View; P.O. Box 3009, Station B; Calgary, Alberta T2M 4L6 Telephone: (403)230-1401

Elbow River Water Quality Task Force

In 1991, Alberta Environmental Protection established a task force to examine the water quality of Elbow River, a major tributary of the Bow River. The task force was established at the request of the Calgary Board of Health and other stakeholders. It and its steering committee consisted of representatives from Alberta Environmental Protection, Calgary Board of Health, City of Calgary, Mountview Health Unit, MD of Rocky View, Calgary Regional Planning Commission and Kananaskis Country.

The task force studied the impacts of land development on downstream users of the Elbow River, most notably the 300 000 plus residents of Calgary served by the Glenmore reservoir. Emphasis was placed on development pressures immediately upstream of Calgary and the regulatory processes necessary to protect the integrity of the river along its entire length.

The task force report, which was released in October, 1993, recommends greater involvement of public health agencies in the land development approval processes along the river to ensure more formal consideration of long-term public health concerns. It also highlights the importance of effectively managing the contaminant loadings (e.g., sewage and stormwater) on the river from existing and prospective land developments. The report has received public input and will soon be distributed in its final form.

Based on a submission by: Norm Carlson; Assistant Director; Environmental Services, Calgary Health Services; Box 4016, Station C; Calgary, Alberta T2T 5T1 Telephone: (403)228-7589

Bow Valley Study

Parks Canada emphasizes ecological integrity and is facing a major challenge to achieve that goal in Banff National Park. Development control is critical to maintenance of ecological integrity—the main value in the international recognition of this unique area as a World Heritage Site.

Current priorities in the Bow River Basin within the park include cleanup of contaminated sites (some of them created decades ago), finding alternate road de-icing products, treating parking lot runoff, and prohibiting snowmaking enhancement products (because of concerns for microbiological pollution). Also, new fishing regulations have been introduced to protect threatened species such as bull trout, and enhance survivability of native species such as cutthroat.

The impact of improvements to the TransCanada Highway on the Bow River will be minimized. Aquatic habitat will be enhanced and riparian habitat disturbed during construction 40 years ago will be repaired. Sunshine Village Corporation ski area development proposals will be examined by a Federal Environmental Assessment and Review Panel.

Parks Canada will also be assessing the cumulative impacts of past projects in the Bow River Valley and determining action needed to restore and maintain the ecological integrity of the Bow River Basin within Banff National Park.

Based on a submission by: Dr. Bruce Leeson; Chief, Environmental Assessment Division; Parks Canada, Alberta Region; P.O. Box 2989, Station M; Calgary, Alberta T2P 3H8 Telephone: (403)292-4438

Hazardous Spill Response in the Upper Reaches of the Bow River

The Bow River Water Quality Task Force recommended that emergency response measures to deal with a spill of hazardous materials into the Bow River in Banff National Park be reviewed and improved where necessary. Response to a simulated spill of a hazardous material into the Bow River within the Banff National Park is planned for fall, 1994. Stakeholder response plans will be reviewed for their role in a multi-agency overall response to a spill into the Bow River. Stakeholders will also participate in the planning and conducting of the spill-simulation exercise. Following the exercise, the responses will be reviewed and, if necessary, plans will be amended.

Golf Course Management

The Alberta Golf Course Superintendents Association has prepared environmental policy and practice statements for its members to follow in golf course management. The information includes measures to protect water quality, conserve water, and protect wetlands and aquatic habitat. The water quality guidelines cover procedures to help prevent contamination of surface and groundwater with pesticides and fertilizers.

The guidelines do not cover golf course construction; however, they do state the association fully supports research and construction methods that are sensitive to the environment.

Based on a submission by: Jay Leach; Public Relations Committee Chairman; Alberta Golf Superintendents Association; 104, 4116 - 64 Ave SE; Calgary, Alberta T2C 1B3 Telephone: (403)236-4616

TransAlta Utilities Fish and Recreation Enhancement Working Group

In 1992, TransAlta Utilities formed the Fisheries and Recreation Enhancement Working Group. The goal of this group is to explore ways of improving fish habitat and recreational opportunities on the company's hydropower reservoirs and the rivers that support them.

The group's first project is on Lower Kananaskis Lake, a hydropower reservoir on the Kananaskis River which flows into the Bow River. The fluctuating water level in the reservoir limits its use for recreation and fish habitat.

The various strategies that will be examined are stabilizing the water level in the reservoir, partially stabilizing the level, stocking the reservoir with fish and fertilizing the reservoir to increase fish production. The effects on Bow River water quality, irrigation, municipal water supply, wildlife and riparian habitat on downstream recreation will be examined.

Based on a submission by: Lyle Nelson (retired), former Supervisor, Water Management Power Planning; TransAlta Utilities Corporation; Box 1900, Station M; Calgary, Alberta T2P 2M1

Bridge Design for River Protection

In the past, bridges that cross rivers were built to drain directly into the river. If a truck accidentally spilled hazardous goods on the bridge, the materials would contaminate the river. Spills into flowing water typically mix quickly with the water and are difficult to clean up.

Recognizing this concern, the City of Calgary is improving its key bridge crossings and new bridge crossings. The causeway across Glenmore Reservoir, a major City water supply, has been improved to reduce the risk of a spill entering

the reservoir. Two emergency telephones, linked directly to the 911 Centre, have also been installed and spill response materials placed in lockers nearby.

On new river bridges, the City is taking specific engineering precautions. Drainage from the bridge deck will be channelled to retention ponds rather than directly to the river, the drainage will be held in the ponds for at least 24 hours to allow settling. Retrofitting of existing bridges (there are six crossing the Bow River) is difficult and extremely expensive.

Based on a submission by: William Bruce; Traffic Services Coordinator; Traffic Operations Division, Transportation Department; City of Calgary; P.O. Box 2100, Station M; Calgary, Alberta T2P 2M5 Telephone: (403)268-1576

Elbow River Fish Habitat Improvement Project

The Elbow River Valley Conservancy is preparing a concept plan for renaturalizing the Lower Elbow River (below Glenmore Dam) and restoring fish habitat. This Bow River tributary is important for its aesthetic appeal to the communities along the river, the spawning habitat it provides for Bow River brown trout and whitefish and for habitat for songbirds and waterfowl.

The Conservancy is working with Trout Unlimited and local community agencies in first developing a concept plan that will graphically show the renaturalization options available. The concepts will be reviewed through a public participation program and the most acceptable options then carried forward to the City and province for approvals. The plan will largely be funded by environmental groups, corporate donors and local initiatives.

Based on a submission by: Ron Ellis; President; Elbow River Valley Conservancy; 919-49 Ave. SW; Calgary, Alberta T1R 1B2 Telephone: (403)243-4569

Eastern Irrigation District's Environmental Assessment

In May 1991 the Eastern Irrigation District (Eastern Irrigation District) completed an initial environmental assessment of its water management operations. The objectives of the assessment were:

- to identify positive and negative impacts of irrigation on the environment in the Eastern Irrigation District region
- to compare environmental costs and benefits (net impact)
- to identify opportunities to increase positive environmental impacts
- to compile baseline biophysical data

The major findings of the report focused on management and policy initiatives that could be implemented.

Based on a submission by: Jim Webber; General Manager; Eastern Irrigation District; P.O. Bag 8; Brooks, Alberta T1R 1B2 Telephone: (403)362-1425

Highwood and Sheep River Fisheries Project

In the spring of 1994, Alberta Environmental Protection initiated a study to gather information on fish in tributaries to the Bow River. Those tributaries include the Sheep and Highwood rivers, and the Ware, Pekisko and Sullivan creeks

The study will determine:

- whether there are distinct rainbow trout populations resident to the Highwood and Bow rivers
- the movement and life history of resident rainbow trout and bull trout in the Highwood and Sheep rivers

• how long Bow-River rainbow-trout spawners spend in the tributaries

Information is gathered using electrofishing, fish tagging and insertion of radio transmitters in some larger fish.

Other Projects

Other projects as well as those described above include:

• the Siksika Water Authority Project
• use of carp (a fish) to control aquatic weeds
• work on the effects of agriculture on water quality under the Canada- Alberta Environmentally Sustainable Agriculture Agreement
• study of brown trout spawning in the Canmore area
• health units' public notification regarding potable waters

For further information on these projects, contact the Bow River Water Quality Council.

Supplemental Section

Bow River Water Quality Council Profile

The Bow River Water Quality Council was established in June 1992 to address water quality issues in the Bow River basin of Southern Alberta. Through the Council, stakeholders along the Bow River can communicate directly with all levels of government and with each other.

Council Membership

The Bow River Water Quality Council has 17 members, representing the stakeholder groups along the Bow River. Members include representatives from rural and urban municipalities, recreation, wildlife, fisheries, agriculture, irrigation, health units, first nations, parks, industry and interest groups. The entire Bow River basin is represented through the members (see page 91).

The group is led by a chairman and administrative and technical support is provided by an Executive Director.

Terms of Reference

The Bow River Water Quality Council's terms of reference are to:

1. Provide advice and make recommendations to the Minister on policy and program issues related to Bow River water quality improvement and protection.

2. Promote awareness, improvement and protection of Bow River water quality.

3. Foster cooperation, consistency and efficiency among agencies with responsibilities for water quality management in the Bow River basin.

4. Provide communication links between government agencies, stakeholders, and the general public.

5. Address and provide advice on other specific matters that may be referred to Council by the Minister.

Council Background

The Bow River Water Quality Council was established as a result of the work of the Bow River Water Quality Task Force, the Council's predecessor.

The task force was struck in May 1990 by the Honourable Ralph Klein, then Minister of Environment, in response to longstanding concerns by many agencies and water users downstream of Calgary over deteriorating water quality. They were particulary concerned over health risks from using the water.

The task force was comprised of 21 representatives from urban and rural municipalities, interest groups, irrigated and dryland agriculture, and first nations peoples. It included many of the same individuals who now sit on the Council.

The task force spent many hours acquiring information, defining and studying issues, and making recommendations to improve water quality in the Bow River. In November 1991, it presented its work to the Minister in a report containing 33 recommendations for improving water quality. The first recommendation was to create the Bow River Water Quality Council to implement the task force recommendations. Some of the other recommendations were to:

- identify how much pollution the river can receive without ecological harm
- improve and regionalize sewage treatment at municipal sewage treatment plants
- control runoff from urban and agricultural areas
- improve regulation of river flow
- better coordinate and increase water quality monitoring

- report on the health of the river
- investigate contaminated industrial sites
- conduct river basin planning
- clarify water quality legislation

Council Activities

The Council has been working with various agencies on the task force recommendations and other water quality issues. Council also publishes a newsletter and operates a Resource Centre of materials on the Bow River and its water quality.

In working with agencies, the Council functions as a catalyst in promoting change, communication and coordination among agencies and groups to expand the benefits of individual projects.

- state-of-the-river reporting
- expanded and coordinated a water monitoring program
- control of runoff from intensive livestock operations
- water conservation and public education programs
- newsletter publishing
- establishing a resource centre

Through various actions taken to date the Council supports:

- public education and discussion about water management principles and policies
- active stakeholder and public involvement in river basin planning that integrates local and regional considerations
- integrated resource development and water management planning activities with water management objectives incorporated into land use by-laws and regional plans.
- river management that recognizes the interdependence of both water quality and quantity
- wide distribution of water protection guidelines for water use and development activities
- minimal flow objectives to meet instream flow needs
- improved management and use of wetlands, lake and reservoirs

For More Information

For more information on the Bow River Water Quality Council or water quality in the Bow River, please contact:

Bow River Water Quality Council
Room 203, 2938 - 11 St. N.E.
Calgary, Alberta T2E 7L7
CANADA

Bow River Water Quality Council Members

Menno Homan, Calgary
Chairman

Martha Andrews, Brooks
Bow River Water Users Association

Heather Callaghan, Cochrane
Town of Cochrane

Norm Carlson, Calgary
Health Units: Mount View, Barons-Eureka- Warner, Southeastern Alberta, Calgary, Foothills, Banff, Drumheller

Roger Drury, Calgary
TransAlta Utilities Corporation

Jean Franklin, Brooks
Communities of Strathmore, Chestermere Lake, Gleichen, Bassano, Brooks, Vauxhall, Redcliff, Medicine Hat

Jean Isley, Strathmore
M.D. of Rocky View #44, M.D. of Foothills #31

Fin McPherson, Vauxhall
Bow River Irrigation District, Western Irrigation District

Hugh Quintilio, Calgary
City of Calgary

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Banff National Park, Kananaskis Country, M.D. of Bighorn, Banff, Canmore

Jim Rouse, Calgary
Trout Unlimited Canada, Alberta Fish & Game Assoc., Bow River Angling Outfitters Assoc.

Al Taylor, Calgary
Calgary Area Outdoor Council

Lorraine Thiessen, Strathmore
County of Wheatland #16, County of Vulcan #2
County of Newell #4, M.D. of Taber #14

Jim Turner, Cochrane
Alberta Cattle Commission, Western Stockgrowers Association, Cattle Breeders Association, Western Stockgrowers Association, Action for Agriculture

Jim Webber, Brooks
Eastern Irrigation District

Joe Weasel Child, Siksika Nation
Siksika Nation

John Zeinstra, Picture Butte
Unifarm

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Glossary

algae - primitive, chiefly aquatic, one-celled or multi-celled plants that lack true stems, roots and leaves but that contain chlorophyll

backwaters - accumulations of relatively still water resulting from or held back by obstructions

basin (or drainage basin) - the area drained by a given stream and all its tributaries

benthic algae - algae living on the bottom of a river or other water body

braided channels - several separate channels of the same stream that divide and reunite repeatedly along a watercourse

cold-water ecosystem - an aquatic ecosystem with fish and other aquatic organisms that are generally suited to water temperatures ranging up to 20°C with a maximum permissable level of 22°C

consumptive water uses - uses for which water is withdrawn from the river and not returned to it, resulting in a net decrease in downstream river flow

critical habitat - habitat that is critical to the survival of the animal

dissolved oxygen - oxygen dissolved in the water

diversion - direction of water out of the river to a canal or some other manmade structure or use

ecosystem - a functional system which includes the organisms of a natural community together with their environment

coliforms - a type of bacteria occurring as part of the normal intestinal flora in vertebrates

cool-water ecosystem - an aquatic ecosystem with fish and other aquatic organisms that are generally suited to temperatures ranging up to 25°C with a maximum permissable level of 29°C

filterable residue - dry residue remaining after passing river water through a 0.45 micron filter and then evaporating it

fishery - an industry or human activity involving the catching of fish or other aquatic life

floodplain - the relatively level valley floors formed by, and subject to flooding by, alluviating rivers

Giardia - a protozoan that inhabits the intestine of vertebrates and may cause diarrhea in humans (sometimes called Beaver fever)

habitat - the particular physical environment in which a plant or animal lives nonconsumptive water uses - uses for which no water is withdrawn from the river or the amount withdrawn is also returned

oxbows - a closely looping, U-shaped stream meander whose curvature is so extreme that only a narrow neck of land remains between the two parts of the stream. Also known as a horseshoe bend.

oxbow lake - a crescent-shaped lake created in an oxbow after the oxbow's neck is cut off by the stream and the open ends of the oxbow are closed cy stream sediment. Also known as a horseshoe lake, crescentic lake or cutoff lake.

phenols - organic compounds released in low concentrations in aquatic environments by aquatic plants and decaying vegetation. Phenols can be toxic at high concentrations. Higher concentrations can come from byproducts of industrial processes, livestock dips, animal and human wastes, and pesticide breakdown.

reach - a segment of the river

spawning redds - sites where fish spawn

riffle areas - sites where shallow water flows swiftly and breaks into waves as a result of impact with objects on the riverbed

riparian - living or located along a riverbank

rookery - a location used by several pairs of birds, often of the same species, for breeding and nesting. Tall trees and islands are usual locations as they provide protection from predators.

salmonoid - pertaining to or one of a family (Salmonidae family) of soft-rayed fish including the trouts, salmons, whitefishes and graylings

spawning - the production or depositing eggs, or discharging of sperm by aquatic organisms

staging - birds gathering in large congregations before migration

stormsewers - a system of pipes that drains stormwater into the river or other collection area

stormwater - water that flows from land surfaces into stormdrains in the roads, and through a stormsewer system into a river or other collection area

dissolved solids - an index of the amount of dissolved substances in water. The presence of such substances alters the water's physical and chemical properties.

turbidity - a measure of clarity of the water. Clarity can be altered by the varying the amount of suspended solids.

water quality - the quality of water as defined by variables such as oxygen dissolved in the water, suspended solids, bacteria, toxic chemicals and nutrients such as phosphorus and nitrates

weir - a dam in a waterway over which water flows, serving to regulate water level

Comment Form

The Bow River Water Quality Council welcomes comments or suggestions for its report, ***Preserving Our Lifeline: A Report on the State of the Bow River.*** In future reports, the Council will answer and address your concerns in an effort to best communicate on Bow River water quality.
Please complete the comment sheet below and send to:

Bow River Water Quality Council
Room 203, 2938 - 11 Street N.E.
Calgary Alberta T2E 7L7
CANADA

Name

Address

Street *City* *Province/State* *Code*

Telephone

Comments or Suggestions