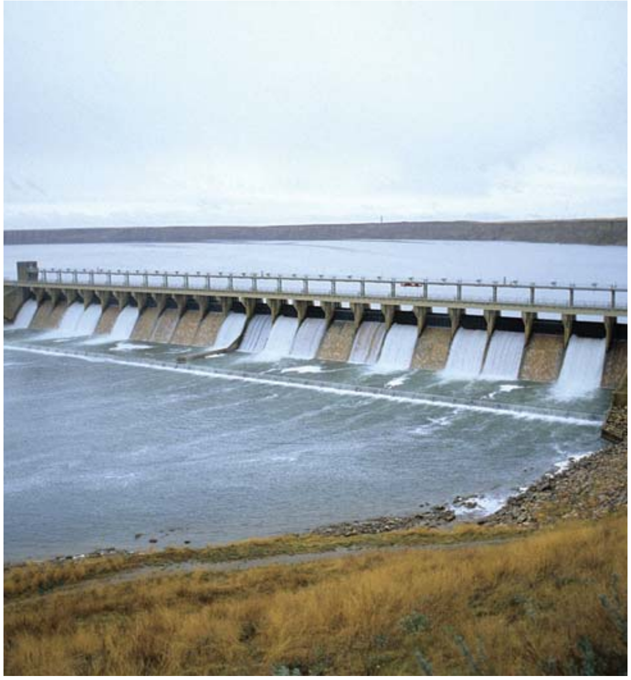
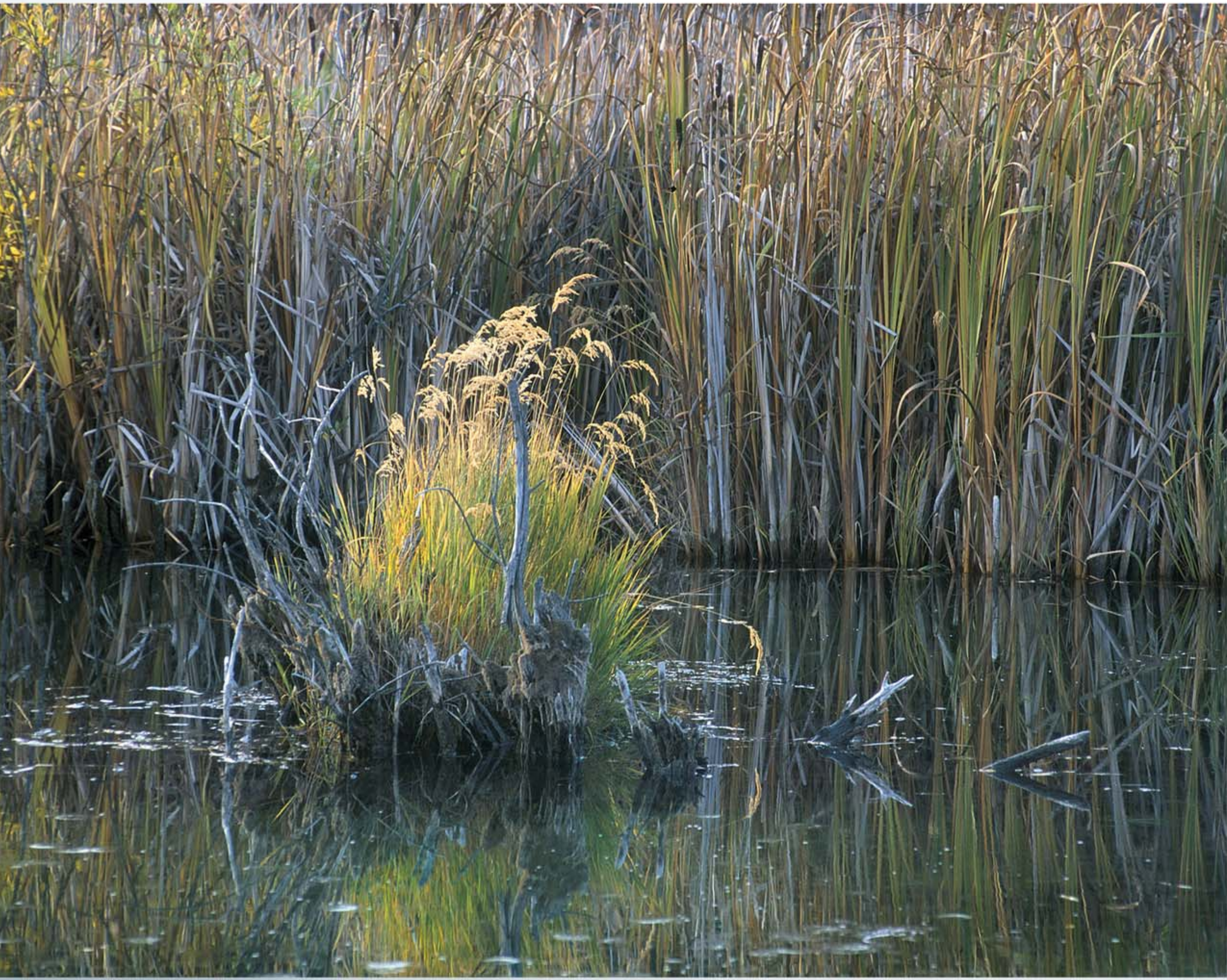


CHAPTER TWELVE

BASIN-WIDE VULNERABILITIES



CHAPTER TWELVE
BASIN-WIDE VULNERABILITIES

The Saskatchewan River basin has been profoundly altered by human activities such as agricultural development, drainage, forest harvesting, oil and gas exploration and development, and mining. Natural streamflows have been altered because of these landscape changes, and through construction of dams and diversions. The basin is also vulnerable to stresses that may originate beyond its boundary. Changes and environmental stresses introduced by human activity will ultimately affect the environmental quality of the basin's receiving water body, Lake Winnipeg.

Key vulnerabilities of the basin are related to physical and ecological effects of landscape modification, water supplies to meet human and other needs, effects of urban development on water quality, natural hazards such as floods and droughts, and invasive species. The challenge for integrated water resources management is to attempt to balance human and environmental needs within this diverse river basin. This implies a need for a more robust institutional framework to meet future challenges.

LANDSCAPE MODIFICATION

The landscape of the Saskatchewan River basin has completely changed in the last 150 years. Natural grasslands and parkland forests have given way to agricultural development, foothills forests have been disturbed by oils and gas exploration, as well as by timber harvesting, and wetlands have been drained. Expansion of urban centres and growth of transportation networks to support those centres continue to transform the natural landscape.

Landscape changes also affect the hydrologic regime of the basin, through changes in storage of surface and groundwater, and in modifications to flow patterns. Physical and hydrological changes lead to biological change, through changes in aquatic, riparian and terrestrial habitat.

Wetlands are critically important to the lifecycle of ducks, geese, swans, and other waterbirds. They also provide food and habitat for fish, shorebirds and mammals. Wetlands modify effects of hydrologic events, recharge or receive groundwater, and filter sediments and contaminants. Wetlands make up a significant portion of the land surface of the prairie and boreal lands of the basin. Landscape changes threaten the wetlands of the plains and of the boreal forest. Wetlands conservation programs are aimed at protecting critical wetlands, mapping other wetlands and related upland habitat, and identifying best management practices for resource development.

Riparian areas adjacent to wetlands, lakes and streams provide unique ecosystems and are important to landscape health. Riparian health can be affected, not only by human activity, but also by natural phenomena such as floods and droughts. Riparian health may be assessed by measuring a standard suite of physical and vegetative parameters at selected sites. Sites where 80 percent of the parameters show little impairment of riparian function are considered healthy. Sites with some impairment are considered healthy, but with problems, and sites with severe impairment are considered unhealthy.[1] In general, about one-half of the riparian areas of the basin can be considered healthy, but with problems. Many human influences have been identified, and more work is needed to present a thorough assessment of riparian health.

Agriculture

The soils of the prairies developed under grassland vegetation, which supported substantial populations of numerous animal species. At the same time, sloughs and potholes dotted the landscape, providing habitat for birds and other wildlife. Trees in river valleys also provided sanctuary. The vegetation of the region varied from short grasses in the drier sections, to tall grasses in areas of increased rainfall, to reeds and sedges in low-lying areas.

Agricultural development has irrevocably altered the natural landscape of prairie Canada, affecting both physical attributes and biological resources.
As agriculture became more intensive and farm equipment increased in size, wetlands were drained, trees removed, and grasslands cultivated. Only one percent of the tall grass prairie, 18 percent of the short-grass prairie, 25 percent of the mixed grass prairie, and 25 percent of the aspen parkland remain.[2] Over 70 percent of pre-settlement wetlands have been drained or altered to the point of no longer functioning as wetlands ecosystems. As a result, habitat for many plant and animal species has been lost to a grains and forage monoculture. Remaining areas of unaltered wildlife habitat have become progressively more fragmented, more isolated, and often too small to sustain viable populations of once abundant species.

Grazing by cattle and other domestic animals reduces plant cover and the supply of food and shelter for meadow and grassland species of mammals, birds and invertebrates. On the other hand, some forms of wildlife thrive under conditions arising from agriculture. Farm shelterbelts and abandoned farmsteads provide cover for numerous species of birds. Other species have benefited from increased feeding opportunities provided by agricultural crops.

While the area devoted to farming in the Prairie Provinces has not increased over the last two decades, land use continues to evolve. Since 1981, there has been a dramatic decrease in the practice of summer fallowing, from 20 percent to 7 percent of the area in farms in Alberta and Saskatchewan.[3] This decrease in summer fallow is almost entirely taken up by an increase in area under crops. Cropped areas now cover 52 percent of the farm area of the two provinces. Significant changes in cropping practices have also occurred during this same period, with an ever-increasing number of farmers adopting zero or minimum till. In general, current tillage practices improve soil moisture for crop growth, but lead to less runoff.

Another significant trend is that farmers increasingly rent the land they farm rather than owning it. Stewardship of agricultural land, therefore, becomes a joint responsibility of the owner and renter.

The environmental sustainability of farmed areas of the Saskatchewan River basin cannot be considered without first considering the factors that affect environmental, social and economic aspects of agricultural production. These factors include protecting quality and productivity of farmed soils; reducing soil erosion and salinity; conserving and restoring soil organic matter; protecting quality of surface and groundwater; preserving and restoring riparian zones; and maintaining or improving the quality of rangelands.[4] Careful attention to these factors will inevitably lead to a better match of land use to land capability. Enhancing the sustainability of agriculture production can, with care, improve environmental performance.

Forestry

While most of the Saskatchewan River basin is agricultural land, the western and northern parts of the basin include the western boreal forest. The forests of the Saskatchewan River basin include the foothills forest in Alberta, parkland forests of the North Saskatchewan River sub-basin in Alberta and Saskatchewan, as well as the boreal forest of the lower Saskatchewan River sub-basin in Saskatchewan and Manitoba. The foothills forest of the eastern slopes of the Rocky Mountains is a unique part of the boreal forest. The conifer forest at higher elevations consists of stands of spruce, pine and fir. The mixed-wood forest at lower elevations contains hardwoods and conifers and significant wetlands.

Beyond the boundaries of the national parks and designated wilderness areas, the foothills forest is extensively logged. Harvesting old-growth forests reduces unique habitat. The oil and gas sector also has a major effect on the foothills forest by cutting seismic lines, constructing roads and pipelines, and installing extraction facilities. Construction of access roads and other linear features fragments habit. The old growth lodgepole pine stands of this region are particularly threatened by the current outbreak of mountain pine beetle. This could spread to other pines. Changes in composition and age structure of the foothills forest will alter runoff from these forests. In general, decreases in the average age of a forest will lead to increases in runoff.

The parkland forest or boreal transition forest is a mix of trees – largely poplar – shrubs and wetlands in Alberta and Saskatchewan. It is highly productive habitat for birds, mammals and plants. Over time, agricultural expansion has led to conversion of this transition forest to cropped land. In general, this has led to wetland drainage, loss of habitat, decreased biodiversity and hydrological change. The spruce and pine forests in portions of this forest are also subject to logging pressures.

While the boreal forest of the lower Saskatchewan River basin has generally been modified by forest harvesting, the forest of the Precambrian Shield portions of the lower basin in Saskatchewan and Manitoba has been relatively untouched by human activity. The principal disturbances have been road construction and mining, although there is some logging in the Manitoba portion of the shield.

Urban Development

Urban centres in the Saskatchewan River basin are growing rapidly and much of that growth is low-density, automobile-dependent, suburban development. The preference for a suburban life style comes with costs – environmental, social and economic. Loss of wildlife habitat, relatively high water use for lawn watering, and damage to receiving waters from stormwater runoff are some of the environmental costs. Other effects include loss of productive farmland, increased cost of water and transportation infrastructure, and socio-economic fragmentation. Some cities are considering Smart Growth concepts as a means of ensuring more sustainable urban growth patterns.[5]

WATER SUPPLY

In 1900, the first of many projects that would alter timing and quantity of the flows in the Saskatchewan River basin was in operation. This was the Great Irrigation Canal, used to divert water from the St. Mary River southeast of Cardston to the Lethbridge area. In 1910, a weir was constructed on the Bow River in Calgary to divert water for irrigation. A hydroelectric project at Horseshoe Falls on the Bow River in 1911 provided electricity to Calgary. These were just the first of many projects, particularly in the Oldman and Bow river basins, that store or divert water for irrigation and power generation. Today, there are over 30 such projects in the basin, the vast majority being found in the South Saskatchewan basin.

The dams and diversions of the basin make a major contribution to the economic vitality of the basin. Water supplies permit irrigation development, enable value-added agricultural processing, sustain urban centres, and promote industrial growth. They also help mitigate, to some degree, the environmental consequences of human developments.

Considering the basin as a whole, water supplies are sufficient to meet reasonable needs, if managed wisely. The management challenge differs in different parts of the basin. The quantity of water consumed in the North Saskatchewan River basin in a typical year is small. Under the terms of existing water allocations, that quantity could be double its current size. Even then, this would be small compared to the reliable water supply. Water consumption is also very small downstream on the Saskatchewan River.

The South Saskatchewan River basin is a different matter, however. About 35 percent of the naturalized flow is consumed in a median year. The Bow and Oldman sub-basins can be considered fully allocated. Alberta has placed a cap on new water licences in those sub-basins. The current water-supply situation prompts questions about water supplies under future climate scenarios, and raises concerns about environmental effects of existing and proposed dams and diversions.

Water supplies originating with the mountain-fed principal streams of the basin are much more reliable than those of the plains-fed tributaries. For these streams, reliable flow tends to be small so potential investments in water infrastructure tend not to meet economic tests. As much of the land producing plains-runoff is agricultural, land-use change alters runoff.

CLIMATE CHANGE

Climate change is a global problem that will affect the Saskatchewan River basin. The hydrological effects of climate change should be considered within the context of natural variability. There is considerable climatic and hydrological variability in the Saskatchewan River basin, both within years and between years, and basin residents and aquatic ecosystems have adapted to this variability. Water management authorities take this into account in developing programs and projects. Adaptation to the effects of climate change has to be considered in addition to adaptation to natural variability.

Recent climate change scenarios for 2050 for the mountain headwaters of the South Saskatchewan River indicate increases in annual mean temperature of 2.0°C and of 9.5 percent in total precipitation. Winters are projected to be wetter and warmer; springs, wetter and somewhat warmer; summers drier and much warmer; and autumns wetter and warmer. For 2080, equivalent annual figures indicate a temperature increase of 3.8 degrees and a precipitation increase of 15.2 percent.[6] Scenarios for the plains portion of the basin tend to show similar temperature increases, but both increases and decreases in annual precipitation. Trend analysis of temperature and precipitation from the recent past tend to show increased temperatures and no consistent trend in precipitation.

A recent review of trends in temperature and precipitation that included the plains portion of the basin indicated that from 1951 to 2004 average daily maximum temperatures increased by about one-fifth of a Celsius degree each decade, and that average daily minimum temperatures increased somewhat more than this. Over the same period, annual snowfall amounts declined throughout the basin, while annual rainfall increased. In Saskatchewan, there was an overall increase in annual precipitation, while Alberta and Manitoba showed annual decreases.[7]

A reasonable climate scenario for the Saskatchewan River basin could be based on the certainty of continued warming, the possibility of increased mountain precipitation, and the likelihood of seasonal changes in precipitation, even if annual plains precipitation remains the same. The relationship between this scenario, or any other, and future water supplies is difficult to determine. Water supplies in the basin are highly dependent on snowmelt. Increased temperatures will inevitably lead to an increased percentage of annual precipitation falling as rain rather than snow.

Projecting runoff under climate change is complicated by the fact that precipitation also recharges groundwater, which, in turn, can sustain streamflow during low flow periods. Considering the more reliable mountain runoff, there are very few current trends suggesting declining annual runoff, although spring snowmelt is occurring earlier now than in the past. Runoff from the water towers is also affected by the state of the forests on the eastern slopes of the Rockies. In general, younger forest stands yield more runoff than mature stands. Streams originating on the plains are showing decreases in spring runoff and annual runoff. These reductions could be the effect of changes in land-use practices, such as conservation tillage, as well as a response to changing climate.

Even if future average water supply conditions are within the ability of basin residents to adapt, climate change could lead to a higher probability of extreme conditions, such as floods and drought. The economic effects of the 2001-2002 drought in the basin were considerable, and potential effects of a widespread decadal drought are staggering to contemplate.

DAMS AND DIVERSIONS

Dams and weirs constructed in the basin have several important effects. First, they change the portion of the river channel where the project is constructed from a river environment to a lake environment. Reservoirs inevitably change distribution and abundance of aquatic biota. Nutrients leached from flooded soils may actually increase biological productivity, albeit for species different from the original dominant inhabitants.[8] Even when a project provides little storage, such as a run-of-the-river hydro-facility, dams and weirs fragment the natural ecosystem by providing barriers to migration of aquatic species and disrupting riparian habitat.

Reservoirs store water during the spring runoff and release it for later use. In the Saskatchewan River basin, hydroelectric stations tend to be used to meet peak load requirements, while thermal generation is used to meet base loads. Although peak power demands occur on a daily basis, hydroelectric stations tend to reverse the high and low cycles of the natural hydrograph. As overall electricity demand is greater in the winter than in the summer, river flows can be higher than natural in the winter and lower in the summer. While hydroelectric projects consume no water other than losses to evaporation, they do significantly alter the flow pattern. Because irrigation water demands are in the summer, flow conditions downstream may in some cases mimic those of the natural hydrograph when water is released from storage for use downstream. Irrigation water demands, however, are significant enough to reduce downstream flows, thus raising concerns about instream flow requirements for aquatic life.

River channels immediately downstream of a dam will tend to scour because the water discharged from the reservoir carries less sediment than the pre-project water. Further downstream, the absence of a spring peak flow (except under very high runoff conditions) reduces the natural flushing of sediments deposited in the river channel, thus changing the character of the river channel. In particular, permanent vegetation is likely to develop in areas now subject to decreased annual flooding. Conversely, riparian vegetation, such as cottonwood trees, requires periodic flooding to sustain new growth. Decreased flooding inevitably leads to loss of the riparian forest. Some aquatic species are sustained by periodic flushing of the channel.

Reservoirs also affect the thermal regime of the river. Summer releases tend to be cooler than normal, while winter releases are warmer. Water temperatures will affect the distribution of fish species downstream of a reservoir. Changes in the winter flow regime will change ice conditions in the stream and affect the winter aquatic ecology.[9]

The physical, biogeochemical, and biological processes within the reservoir will affect water quality in the reservoir and downstream. The degree to which water quality is affected will depend on factors such as the surface-to-volume ratio and depth of the reservoir, surficial geology and soils of the catchment, sedimentation rates, magnitude and timing of flows entering the reservoir, and biological productivity of the reservoir.

MUNICIPAL WATER AND WASTEWATER

Continued urban growth and the related demand for water services such as water supply, wastewater treatment, and drainage pose a considerable challenge. All the urban centres in the basin provide treated water and some level of wastewater treatment to household, industrial, commercial, and institutional users. The cost of providing these services is recovered through water charges and municipal taxes. Two of the key challenges for the Saskatchewan River basin are providing safe drinking water and reducing effects of wastewater effluents on downstream communities and ecosystems.

Water Supply

Almost all the water used in the cities of the basin is surface water. Groundwater tends to be used only by smaller communities and farmsteads. Although urban water withdrawals are large, household water consumption in the basin is relatively small. The reason for this is that almost all the domestic water used indoors returns to the aquatic system as wastewater; only water used outdoors tends to be consumed. If one includes stormwater runoff as part of the contribution of urban centres to streamflow, most urban centres in the basin return more surface water to the natural system than they withdraw. Urban centres also tend to be net contributors to the groundwater system, as water tables in urban areas can be as much as five metres higher than those in undeveloped areas. There are several reasons for this, the most important being excessive lawn watering.[10]

The main advantage of urban water conservation, therefore, lies not so much in saving water, as in postponing the need for capital investments in water supply and wastewater treatment systems. Calgary, for example, has a goal of decreasing per capita water consumption by 30 percent in 30 years.[11] Water-use efficiency goals of this magnitude are readily achievable; Denver uses about the same quantity of water today as it did in the 1960s, despite a 65 percent increase in population. Reduced water withdrawals also benefit the aquatic health of the streams receiving municipal effluents, by enabling more effective operation of wastewater treatment systems.

Safe drinking water and public health and environmental consequences of municipal effluents are shared concerns among municipal, provincial, and federal governments. The federal government has little direct authority over drinking water supplies, except in the case of federal lands such as First Nations reserves. Provincial governments have primary jurisdiction and responsibility for drinking water quality. However, a federal/provincial/territorial government committee on drinking water standards develops and maintains *Guidelines for Drinking Water Quality*.[12] The committee takes into account health assessments (both domestic and international), treatment costs, and other economic factors. The *Guidelines* specify maximum acceptable concentrations of substances known to or suspected of causing health effects.

Public concerns about safe drinking water can be addressed through source water protection, effective water treatment, a secure distribution system, and robust operating and control systems. Larger centres have the skilled personnel and financial resources to design, build, operate, and maintain a satisfactory water supply system. This is not always the case for smaller centres and First Nations reserves. Difficulties lie not only in the need to secure resources and skills to implement a water supply system, but also in particular problems related to protecting and enhancing local source waters, including meeting the need for innovative small-scale systems.[13] In fact, rural water supplies in the basin rarely meet health and aesthetic objectives. The United States Environmental Protection Agency has observed that municipal water systems serving more than 20 000 people tend to be safer than smaller systems.

Wastewater

Municipal wastewater consists of human and other organic waste, suspended solids, nutrients, microorganisms, and various household and industrial chemicals. It may also contain stormwater runoff in centres where combined sewers are still in use. All cities in the basin treat their wastewater before discharging it to the natural system. The treatment process reduces contaminant levels of the effluent, but the sheer volume of effluents discharged annually to the environment make urban wastewater an environmental concern. Effluent suppresses oxygen levels in the stream and may contain suspended solids, nutrients, organic chemicals such as pesticides, and metals. Other contaminants may include pharmaceuticals, personal care products, endocrine-disrupting compounds, and brominated flame retardants. These effluents affect the quality of the receiving waters as well as the quality of the sediments in the stream, in turn affecting the plants and animals of the ecosystem. Effluents may also lead to human health and economic effects.[14, 15]

Generally, municipal wastewaters are treated through a progression of processes usually identified as preliminary, primary, secondary, tertiary, and quaternary. These processes incrementally remove increasing amounts of suspended solids from the effluent stream and reduce the oxygen demands of the effluent. Sewage lagoons provide a level of treatment similar to secondary treatment. Some wastewater treatment systems in the basin also include nutrient reduction. Effluents are disinfected before release to the environment. All municipal effluents in the basin receive at least secondary treatment. Banff, Calgary and Saskatoon perform advanced nutrient reduction.

Stormwater

Prior to the 1940s, cities constructed combined sewers to convey sanitary and stormwater runoff to receiving streams. Even as wastewater treatment facilities were in development, combined sewers continued to discharge untreated sewage to receiving waters during high-runoff events. These combined sewers still exist in the central cores of some cities in the basin. Cities are modifying infrastructure to reduce overflow incidents. The City of Edmonton, for example, is increasing capture and treatment of wet weather flows in the combined sewer system from 56 to 86 percent, and reducing average annual overflow incidents from 89 to 46.

Recognizing problems associated with combined sewers, cities developed sewer systems exclusively for stormwater runoff. Early systems were aimed, primarily, at reducing property damages from flooding and allowing traffic to move during storms. Some of these systems caused physical damage to conveyance channels and to downstream properties, and little consideration was given to effects of stormwater runoff on aquatic resources or wildlife habitat.

Stormwater detention ponds were developed in the 1970s as a means of reducing physical damage from urban runoff, and as a means of enhancing environmental values. They have met with varying degrees of success. They will, in general, reduce downstream damages while maintaining reasonable quality water in the pond.

Stormwater runoff contains much lower levels of contaminants than sewage effluent, but flows of stormwater are much greater than those of sewage effluent and are often confined to pulses of flow during wet weather. These flow pulses contain contaminants from streets and parking lots. As wastewater treatment systems improve, effects of stormwater runoff on receiving waters become more apparent. Treatment of stormwater runoff will become an increasing requirement in the basin.

NATURAL HAZARDS

The Saskatchewan River basin is subject to both floods and droughts. Floods and droughts are primarily natural events, although they can be modified, both positively and negatively, by human activity. These phenomena affect natural ecosystems and human settlement. Although the effects of smaller floods and droughts can be mitigated, there is always the risk of a flood event exceeding the design capacity of the infrastructure, or of a drought exceeding the coping range of aquatic ecosystems, individual water users or infrastructure.

Floods

Many urban communities in the basin are in river valleys. During spring runoff and intense summer rainstorms, these communities can be flooded. Although loss of life is rare in Canadian floods, financial and other losses associated with flooding are significant. Entire communities may be disrupted for lengthy periods following a flood.

The traditional approach to reducing flood damages was through construction of structural measures such as dams, dikes, and diversions. These measures are costly to build and maintain, and may lead to a false sense of security for floodplain residents. They may also have significant environmental consequences. Current approaches tend to be non-structural: that is, the flood hazard in a community is determined, high risk property is identified, and zoning implemented to reduce the threat of flood damages. This often leads to floodplains being used for parks and other low-impact uses, rather than for homes and industries. Flood-risk areas have been determined for urban communities in the basin, and maps showing that risk are available from provincial authorities. Basin communities where at least some portion of the community is subject to flooding from streams or lakes are shown in Tables 12.1 and 12.2. The tables also identify communities where flood-risk areas have been mapped and zoned.

Rural areas of the Saskatchewan River basin are subject to flooding hazards, leading to losses in agricultural productivity and other economic losses. Damages can sometimes be reduced through operation of water infrastructure, but often adjustments to help upstream lands lead to flooding of downstream lands and vice versa.

Provincial governments produce flood forecasts and warnings so that emergency response personnel and the public can take appropriate action during a flood. Maintaining meteorological and hydrometric monitoring networks to support flood forecasting can be a problem.

Table 12.1. Alberta Communities Having a Flood Hazard.

Community	Stream	Mapped	Designated	Zoned
Airdrie	Nose Creek	✓		
Alix	Parlby Creek			
Birchwood Village Greens	Buck Lake			
	Modeste Creek			
Black Diamond/Turner Valley	Sheep River	✓	1996	✓
Bragg Creek	Elbow River	✓		
Calgary	Bow River	✓	1996	✓
	Elbow River	✓		
	Nose Creek	Draft, under review		
Camrose	Camrose Creek	✓	1995	✓
Canmore	Bow River	✓	1994	✓
Carbon	Kneehills Creek	✓		
Cardston	Lee Creek	✓	1994	✓
Cochrane	Bow River	✓	1991	✓
Coleman/Blairmore	Crowsnest River	✓		
Didsbury	Rosebud River	✓		
Drayton Valley	West Creek			
Drumheller	Red Deer River	✓		
Eckville	Medicine River	✓		
Edmonton	North Sask. River	✓		
Fort Macleod	Oldman River	✓	1992	✓
High River	Highwood River	✓		
Lacombe	Wolf Creek	✓	1998	✓
Lamont	Lamont Creek	✓		
Lethbridge	Oldman River	✓		
Markerville	Medicine River	✓		
Medicine Hat	South Saskatchewan River	✓	1991	✓
Millet	Pipestone Creek	✓		
M.D. of Bighorn	Bow River	✓	1998	✓
M.D. of Rockyview	Elbow River	✓		
Okotoks	Sheep River	✓	2000	✓
Penhold	Waskasoo Creek	Draft, under review		
Pincher Creek	Pincher Creek	✓	1994	✓
	Kettles Creek	✓	1994	✓
Ponoka	Battle River	✓	1994	✓
Priddis	Fish Creek	✓		
Radway	Namepi Creek			
Red Deer	Red Deer River	✓	1996	✓
	Waskasoo Creek	✓	1995	✓
Rochester	Tawatinaw River	✓		
Rocky Mountain House	North Saskatchewan River	Draft, under review		
Rosebud	Rosebud River			
St. Albert	Sturgeon River	✓	1991	✓
Stettler	Red Willow Creek	✓		
Sundre	Red Deer River	✓	2003	✓
Thorsby	Weed Creek	underway		
Two Hills	Vermilion River	Draft, under review		
Vegreville	Vermilion River	✓	1997	✓

Table 12.2. Saskatchewan and Manitoba Communities Having a Flood Hazard.

Community	Stream	Mapped	Designated	Zoned
Aborfield	Burntout Brook			
Battleford/North Battleford	North Saskatchewan River, Battle River	✓	1990	✓
Carrot River	Emmons Creek	✓		
Cumberland House	Saskatchewan River	partial		
Martensville	Opimihaw Creek tributary			
Melfort	Melfort Creek	✓	1988	✓
Prince Albert	North Saskatchewan River	✓		
Rosthern	Rosthern Creek			
Saskatoon	South Saskatchewan River	✓		✓
Swift Current	Swift Current Creek	✓		
Tisdale	Doghide River	✓	1989	✓
Zenon Park	Burntout Brook tributary			
RMs of Corman Park, Vanscoy Dundurn, Montrose	South Saskatchewan River	partial		
The Pas, Manitoba	Saskatchewan River	partial		

Drought

Unlike other natural hazards that can affect the basin, drought is a slow-onset phenomenon. In fact, definitions of drought vary considerably and the precise beginning and end of a drought period may be difficult to determine. All droughts begin with a deficiency in precipitation extending over a significant length of time, known as a climatological drought. If this deficiency leads to lack of availability of soil water to support agricultural activities, an agricultural drought exists. With continuing precipitation deficits, streamflows, lakes, reservoirs, and aquifers may become depleted, leading to hydrological drought. Finally, effects of meteorological, agricultural and hydrological droughts on human activity may affect human activity so significantly that we can speak of a socioeconomic drought.[16] The economic impact of the 2001-2002 nation-wide drought in Canada, if taken as one event, would constitute the largest natural disaster in Canadian history.[17]

Defining a drought requires consideration of three elements: intensity, duration and spatial coverage. In North America, the Palmer Drought Severity Index (PDSI) is frequently used to indicate the extent and severity of drought, and reconstructed PDSIs have been produced for many severe events over many decades. PDSI maps do not take into account water storage and supply factors and are, therefore, a better indication of climatological rather than hydrological drought. Efforts have been made to produce indices of surface water availability based on precipitation, streamflow, reservoir storage, and so on. While useful, different drought indices will provide different results. In terms of informing the public and water users, a consistent approach is probably more important than a 'right' approach. Products from the Prairie Farm Rehabilitation Administration's Drought Watch are good examples of this consistent approach.

The 20th century was climatologically benign compared to other recent centuries.[18] While significant droughts have taken place, for example in the 1930s, they may not have been as severe as those of previous centuries. Examination of proxy climate data using tree ring reconstruction indicates, for example, that droughts of varying intensity may have persisted in the Cypress Hills (Alberta and Saskatchewan) for almost the entire 1688-1692, 1792-1804, and 1887-1896 periods. Considering the

South Saskatchewan River, low-flow periods in the 1560s to 1570s, the first two decades of the 1700s, and the mid-1800s have been identified.[19] (Captain John Palliser's expedition of 1857-59 during this last drought is famous for declaring the southern prairies as not suitable for agricultural settlement.) Hudson's Bay Company traders at Edmonton House on the North Saskatchewan River observed that in the spring of 1796 there was 'no water in the river.'[20]

Nonetheless, the 20th century featured three major prairie drought events. The first was during the period 1917-1926, the second during the 1930s, and the third during the 1980s. The 2001-02 drought was unusual for its broad spatial coverage and intensity. Farm income on the prairies was negative or zero for the first time in 25 years.[21]

A return to the more extreme climates of previous centuries may raise the prospect of decadal droughts. Planning for a decadal drought in the entire Saskatchewan River basin is very conservative. Consider, for example that in 1981, a very dry year in southern Saskatchewan, there was a significant flood threat on the North Saskatchewan River and flows in the Saskatchewan basin as a whole were well above normal. A simplistic account of the spatial coverage of low-flow years in western Canada can be seen in Table 12.3. The table compares the low-flow years for two mountain-fed streams, one stream originating in the Cypress Hills, and two prairie streams. The Souris River record did not start until 1930, but the others start in 1912 or shortly after. The scatter in the low-flow years is very evident; the only frequently occurring years are 1931, 1977, and 1988.

Drought preparedness can be a difficult task because of the slow-onset nature of the problem and the lack of agreement on drought definitions and preparedness methodologies. Current approaches use risk management approaches to define the problem and to determine the public-policy response.
A drought-preparedness plan is much preferred to taking a crisis-management approach to drought response. Alberta's Drought Risk Management Plan is an example of drought-preparedness planning.

INVASIVE SPECIES

Invasive species are animals, plants or micro-organisms originating in other countries, or from other ecosystems outside the basin. They are characterized by an ability to reproduce and spread rapidly, as well as by having negative attributes that affect natural systems, crops and people. They often have no natural enemies to limit their reproduction, and spread where they are introduced. Invasive species threaten the environment by causing habitat loss for native species or by out-competing them. They threaten the

Table 12.3. Comparison of Low Flow Years in Prairie Canada.

Rank	South Saskatchewan*	North Saskatchewan*	Battle River*	Battle Creek*	Souris River*	Red River
1	2001	1942	1930	1949	1988	1934
2	1941	1941	1961	1931	1937	1931
3	1931	1975	2004	2001	1931	1935
4	1977	2001	1931	1984	1940	1939
5	1984	1988	1977	2000	1932	1933
6	1988	2002	1929	1977	1961	1937
7	1944	1929	1945	1961	1945	1977
8	2000	1984	1942	1992	1935	1936
9	1949	1919	1941	1989	1977	1940
10	1936	1937	2001	1988	1973	1961

** naturalized flows at international or interprovincial boundary* economy through pest control costs and economic losses. As well, they threaten social values by altering the natural landscape, decreasing property values, or affecting our health. Some introductions, the European starling and the house sparrow, have been deliberate, while others such as the Norwegian rat were accidental. (Alberta has a program aimed at keeping rats out of the province.) Recent examples of invasive species in the basin include the mountain pine beetle and purple loosestrife.

The mountain pine beetle is a small flying insect that has a native range extending from Mexico to central British Columbia, with an eastern extent near the Alberta boundary. The beetles preferentially attack mature pine trees, leading to stands of trees with reddish needles that eventually turn grey. The lodgepole pine is the primary host for the mountain pine beetle in Alberta. There are concerns that the infestation may spread to jack pine or non-pine species such as spruce.

The infestation is having a significant effect on parts of the Saskatchewan River basin headwaters. The death of the trees or the preventive cutting being conducted on licensed Forest Management Areas will change the habitat and hydrology of involved areas.

Severe winter temperatures tend to kill the beetle larvae but several days of temperatures below -30°C are required. The mild winters of recent years, combined with the relatively mature Alberta forests, are considered important factors in the current infestation.

Purple loosestrife is an herbaceous wetland perennial introduced into eastern North America from Europe in the early 1800s, but its first occurrence in Alberta was at Medicine Hat in 1990. It is believed that purple loosestrife arrived in the ballast of cargo ships, or perhaps through deliberate introduction by horticulturalists. Purple Loosestrife has square, woody stalks over one metre in height and pink/purple flowering spikes. It is classified as a noxious weed in the basin and nursery owners have stopped selling it.

Purple loosestrife invades wetlands, reducing the size and diversity of natural plant communities. Once purple loosestrife invades an area and eliminates native flora, the wildlife that once depended upon the native flora are displaced and those that cannot move into new areas are lost. What remains is a biological desert, devoid of native plant and wildlife species. Purple loosestrife has no natural predators in North America. There are three options for control: chemical, mechanical and biological. Chemical control is difficult because herbicides should not be used in water bodies and should be used with care near water bodies.

Invasive species can be introduced through movement of goods or people, natural dispersal using winds or water movement, or by climate change effects on habitat. There are many potential threats to the aquatic systems of the basin, including zebra mussels and whirling disease, an infectious disease affecting trout.

INSTITUTIONAL DEVELOPMENT

Governments at all levels have developed a sophisticated web of legislation and programs that apply to various aspects of water management in the Saskatchewan River basin. The *Water for Life Strategy* in Alberta, *Long-term Safe Drinking Water Strategy* in Saskatchewan and *The Manitoba Water Strategy* are examples. At the same time municipal governments, agricultural producers, industries, and other organizations have developed, over time, their own programs in response to legislation, regulation and other perceived needs. Contemporary water management seeks to engage basin interests and the general public in meeting the needs of society, without degrading the natural environment. There is an underlying concept of shared governance, at least as it pertains to water planning.

Traditional water management emphasized problem solving, but the solution to one problem was often accompanied by unintended consequences. There is every expectation that water management will grow more complex as the ever-increasing population of the Saskatchewan River basin faces the vulnerabilities and threats identified earlier in this chapter. The water resources of the basin are finite. Meeting future challenges will depend not only on better scientific understanding and technological improvements, but also on institutional development that encourages integrated and adaptive approaches to water management. These approaches require legislative and policy support, appropriate science, monitoring and data, and a basin or sub-basin scale institutional framework that accommodates various interests.

Integrated water resources management cannot be achieved quickly or without difficulty. There is certainly no operations manual for engaging in integrated water resources management. Drawing a circle around water-related activity in a basin will inevitably result in a series of intersecting circles around water and other factors, such as land management, energy, wildlife, fisheries, and so on. Natural resources agencies and organizations tend to be organized along sectoral lines; thus, the challenge lies in integrating water resources activity across those sectors.

Turning to the Saskatchewan River basin, there is a significant body of legislation and policy relating to water management in this basin. Chapter Three of this report considers these matters in some depth.

As regards science, monitoring and data, while there are significant programs in operation in the basin, there are many knowledge gaps related to matters such as climate change effects on hydrology, hydrological processes themselves, sources and pathways of contaminants, aquatic and riparian habitat, and water conservation. Data gaps are also evident. Although there are excellent data available on water allocation, there are little data on actual water diversion or consumption, or on groundwater quantity or quality. Even when data are collected, they are sometimes difficult to obtain. The Alberta Water Portal is a recent example of water data made more accessible to the public. There is also a need to continue to build capacity in the various regional planning organizations in the Saskatchewan River basin. The Water Planning and Advisory Councils, Water Advisory Committees, or Conservation Districts of the basin need to be nurtured and supported so that they can reach a common understanding of key vulnerabilities and threats, and explore possibilities for effective measures to meet those challenges.

At present, there are only two multi-interest organizations with a mandate that covers the entire Canadian portion of the Saskatchewan River basin: the Prairie Provinces Water Board and the Partners FOR the Saskatchewan River basin. One is a federal-provincial board and the other a water stewardship organization. As organizations in the basin grapple with increasingly more difficult issues, not the least of which will be the deteriorating state of Lake Winnipeg, an enhanced state of institutional readiness will be needed. There will be an increasing need to engage governments at all levels, including First Nations, in determining a sustainable way forward for the basin.

This State of the Saskatchewan River Basin Report was based on existing information. It identifies water-related concerns that occur in all or in parts of the Saskatchewan River basin. Some of the challenges facing water managers and institutions at various levels throughout the basin in the future may include:

- Reaching consensus on key vulnerabilities
- Identifying notable knowledge and information gaps
- Integrating IWMP with land use planning
- Sharing available information across jurisdictions and between orders of government
- Integrating First Nations and Métis governments into IWMP initiatives
- Creating a sense of a Saskatchewan River basin community around the water management discussion
- Accommodating increasing complexity, while also broadening the base of decision-making related to watershed management

- Adapting institutions and management to accommodate new information
- Adapting policies and programs to enable decisions to be made more quickly, but with more rigour than may currently be the practice

This report should be taken, not as an end in itself, but as one step on the path to sustainable water management for the basin.

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