North Saskatchewan River Water Quality

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Biography

Steph Neufeld was born and raised on a farm near the McLeod River where she spent many summer days and nights on her banks or navigating through her waters. She completed both her undergraduate and masters degrees at the University of Alberta. Her M.Sc. degree investigated the effects of landuse change on water quality and aquatic insect communities in Alberta streams. After graduation, Steph worked in consulting as an Aquatic Biologist for several years and currently works as a Watershed Specialist for EPCOR Water Services where her focus is on drinking water source water protection and watershed management. She presently sits on the Integrated Watershed Management Plan steering committee for the North Saskatchewan Watershed Alliance, is president of the Alberta Lake Management Society, and a board member for RiverWatch.

Abstract

Water quality in the North Saskatchewan River (NSR) in the last 60 years has undergone some substantial changes. Water quality monitoring was first initiated in the 1940s in response to pollution problems in the NSR associated with the City of Edmonton. At that time municipal wastewater, which included domestic sewage and industrial wastes, received only primary treatment. Untreated sewage was discharged directly into the river during rainfall events, garbage was disposed along the river bank, and accidental oil spills at industrial sites were not uncommon. With these pressures, it is not surprising that water quality was poor. These conditions persistent until about 1960 when waste management was improved and flow-regulation by the newly constructed Brazeau dam increased winter flows and assimilation capacity during this critical time. Although water quality conditions at the sites downstream of the City of Edmonton continue to reflect urban, industrial, and other inputs, it has improved substantially compared to the 1940s to 1960s. Improvements in water quality in recent years are largely due to wastewater plant upgrades at the Gold Bar and Alberta Capital Region Wastewater Treatment Plants. However, despite improvements, current water and watershed management initiatives call for continued improvement and/or maintenance of water quality at

reaches downstream of the City of Edmonton. Moreover, trace contaminants such as pharmaceuticals, endocrine disrupting compounds, pesticides, and metals are of increasing concern and more research is necessary to assess the risks. Peak runoff conditions from upstream also result in significant contaminant loadings from non-point sources. To maintain levels of other contaminants such that water quality degradation is avoided, management of the cumulative water quality impacts of all future development and land use changes in the region will be required. To achieve this it will be necessary to support comprehensive monitoring, watershed based planning initiatives and proposed water quality objectives and managing both point and non-point runoff. With a focused integration of land and water planning and management we can expect the NSR to meet the needs of all users, now and in the future.

Background

The North Saskatchewan Watershed in Alberta drains 80,000 km^{2} (includes Battle), which comprises just over one tenth of Alberta's land mass. The river originates at the Saskatchewan Glacier in the Columbia Icefields in Banff National Park and descends almost 900 meters in elevation over 1,000 kilometres to the Alberta/Saskatchewan border. It joins with the South Saskatchewan River in Saskatchewan east of Prince Albert, flows into Lake Winnipeg in Manitoba and eventually empties into the Hudson Bay via the Nelson River. As part of the Saskatchewan River Basin, the North Saskatchewan River is subject to the 1969 Prairie Provinces Water Board (PPWB) Master Agreement on Apportionment, which states that Alberta must pass 50% of the natural flow of rivers into Saskatchewan.

The headwaters area of the North Saskatchewan River (NSR) remains sparsely populated and largely forested; resource extraction and timber harvesting are prominent land uses in the region. As the river flows past the towns of Rocky Mountain House and Drayton Valley, agricultural land use increases and, by the time the NSR reaches Devon, the surrounding land use is predominantly agriculture. As well, oil and gas activity in the Drayton Valley area is notably high and the density of pipelines is one of the highest in Alberta, with several intersecting the North Saskatchewan River. At this point, 95% of the total flow in the river has already entered from the major tributaries of the Ram, Clearwater and Brazeau. Flow in the North Saskatchewan River is affected by two headwaters dams: the Brazeau on the Brazeau River; and the Big Horn (which forms Lake Abraham) on the mainstem near the mouth of the Big Horn River. The effect of these impoundments is to redistribute flow to a higher than natural flow in the winter time and lower than natural flow in the summer.

As the river makes its way towards Edmonton land use, point source inputs (defined as pollution that can be traced back to the original source – usually an industrial or municipal discharge), precipitation patterns, slope, erosion potential, and underlying geology and soil composition cumulatively affect water quality in the river. The towns of Rocky Mountain House, Drayton Valley, Devon, and other villages and towns have wastewater treatment plants and wastewater lagoons that either discharge their treated effluent directly into the NSR, or into its tributaries. Agricultural land use also contributes non-point source contaminants (defined as pollution that cannot be traced back to a single origin or source; examples are storm water runoff, overland runoff from agricultural and logged areas, seismic lines, road crossings, septic systems, etc). The movement of these types of contaminants, such as nutrients and bacterial pathogens, from the land to the NSR mainstem is largely limited to spring runoff and heavy rain events. However, the largest footprint is from the greater Edmonton area, where the majority of the population in the watershed is concentrated and where treated wastewater and storm water enters the NSR. General water use along the NSR and its tributaries includes human consumption, thermal power generation, oil and gas extraction and processing, and agricultural uses such as livestock watering and some irrigation.

History of water quality in the NSR: 1950s to 1980s

Water quality in the (NSR) and many of its tributaries has been monitored through various municipal provincial, federal, and private programs. The first water quality assessment on the NSR was conducted in the late 1940s and was fuelled by waste disposal issues associated with the two large urban centers in Alberta: Edmonton and Calgary. In 1949 the Province of Alberta instituted a stream pollution control program to address these issues. Because declines in water quality in the NSR at this time were largely limited to point source inputs from the City of Edmonton's sewage plants and from industrial inputs, monitoring was focused on the reaches downstream of Edmonton. At that time municipal wastewater, which included domestic sewage and wastes from the four large meat packing plants in Edmonton, received only primary treatment. Untreated sewage was discharged directly into the river during rainfall events, garbage was disposed along the river bank, and accidental oil spills at industrial sites were not uncommon. On top of that, the population of Edmonton almost doubled in the 1950s and many new industrial plants were constructed- bringing additional human and industrial wastes. With these pressures, it is not surprising that the first report on the water quality in 1951 noted elevated bacterial levels, extremely low dissolved oxygen levels, odour problems, visible garbage, grease deposits and oil slicks. Measurement of these basic water quality parameters resulted in pollution control orders to be issued to Edmonton by the Provincial Board of Health in the 1950's.

These conditions persistent until about 1960 when the City of Edmonton built a secondary sewage treatment plant, packing plant wastes were diverted to lagoons, and garbage disposal along the riverbank was discontinued. As well the water quality in the North Saskatchewan River improved due to flow-regulation by the newly constructed Brazeau dam which increased winter flows. Studies showed dissolved oxygen concentrations generally remaining above 5 mg/L (considered a minimum acceptable level for aquatic ecosystem health). Despite improvements, high bacterial densities, ammonia concentrations, and oil and grease levels were still observed downstream of Edmonton in the 1960s. With increasing concern about these contaminants, more systematic data collection programs were implemented and beginning in the late 1960s water quality in the NSR the Long-Term River Network (LTRN) program was established. This monitoring initiative originally included monthly sampling at Devon, and Pakan, and now includes a site at Rocky Mountain House. The program has resulted in an extensive long-term database of general water quality information for the mainstem. As well the federal government has operated three long-term water quality monitoring sites on the mainstem of the river (Whirlpool Point near Banff National Park in the headwaters, and the original PPWB site at Lea Park (near Marwayne), which was moved closer to the Alberta-Saskatchewan Border (PPWB site)) in the early 80s.

Results of this long-term monitoring and a more detailed study of the water quality in the NSR the carried out in 1982-83, were described in a comprehensive report by Alberta Environment in 1986. This report focused on differences between upstream and downstream of the City of Edmonton and noted that effluent discharge from sources within the City of Edmonton boundaries affected the river's water temperature and levels of dissolved oxygen, nutrients, algae, other water quality parameters, and the aquatic insect community structure. Again, water quality in the mainstem appeared to be largely associated with the discharge of Edmonton's municipal wastewater.

Based on these findings, in 1985 Alberta Environment initiated a series of studies to collect additional water quality data to aid in watershed planning. This work included assessing water quality along the entire mainstream from its headwaters to the Alberta-Saskatchewan border as well as in selected tributaries. It was the first of its kind to attempt to address water quality in the NSR basin at a large spatial scale and quantify contaminant loadings from tributaries as well as point sources. The 1994 report that was produced that summarized this work affirmed distinct differences in water quality upstream of Edmonton compared to downstream. Moreover, it confirmed that these differences were attributed largely to municipal wastewater from the city of Edmonton. It was also noted that discharges from storm and combined sewers contributed to increased levels of contaminants including sediment, some metals, nutrients and bacteria. At this time, diffuse sources from

agricultural and industrial land were thought to influence water quality as well, but sources had not yet been quantified. The overall urban and industrial areas of Edmonton, Strathcona County and Fort Saskatchewan noticeably impacted water quality and certain effects were still noticeable even at the Alberta-Saskatchewan Border.

Water quality in the NSR: 1990s to present

The 1980s ushered in increasing concerns regarding the general health of aquatic ecosystems, and the effects of minute quantities of pollutants found in various ecosystem components (water, sediments, plants and animals). The tendency for some contaminants (ex. pesticides, metals and PCBs) to bioaccumulate in fish and wildlife, thereby posing a risk to human and environmental health, was recognized and monitoring of these substances was increased. More recently, issues have arisen regarding the presence of pharmaceuticals, flame retardants, pathogens and new agricultural chemicals in the NSR and its tributaries. As well, with improvements in point source management, there was increased focus on non-point source pollutants. As such, since the 1980s, the broad based monitoring initiatives of the LTRN program and the federal monitoring programs have been supplemented by other monitoring programs. These programs varied in their intensity and their purpose, but have provided an enhanced assessment of sources and types of contaminants to the North Saskatchewan River. Specifically, programs have expanded with the intention of understanding non-point source contaminants, quantifying contaminant loading at finer scales, and monitoring for emerging contaminants.

In terms of emerging contaminant programs, Alberta Environment has measured pesticides in the NSR since the mid-1980's and reports on pesticide concentrations in surface waters as part of its evaluation and reporting responsibilities. In general, pesticide detections in Alberta surface waters are common and widespread. Specific to the North Saskatchewan River, industrial point sources are believed to have been associated with elevated levels of 2,4-D and lindane in the 1970s and early 2000s, respectively. Once remedial actions were taken or when suspected sources disappeared detections declined sharply or were eliminated. However, urban and agricultural use of pesticides results in noticeable patterns of pesticide contamination in selected tributaries and/or the mainstem of the NSR. Moreover, although surface water quality guidelines are exceeded infrequently in the NSR mainstem, the full implications of pesticide occurrence in surface waters remain a complex and largely unresolved issue.

On a similar vein, during the past ten to fifteen years, the presence of pharmaceuticals, hormones, and other endocrine disrupting compounds (EDCs) in

wastewater treatment plant (WWTP) effluents, receiving waters, drinking water, and groundwater has become an issue of increasing international attention and concern. Before study was initiated by Alberta Environment in 2002, sampling for pharmaceuticals and EDCs was rather limited within Alberta. The work Alberta Environment collected wastewater treatment plant (WWTP) effluents and receiving river water from numerous locations throughout the Province and analysed them for a broad range of organic wastewater contaminants. This preliminary survey has confirmed the presence of a fairly broad range of pharmaceuticals, endocrine disruptors, and other organic wastewater contaminants in wastewater treatment plant effluents and receiving rivers of Alberta, including in the North Saskatchewan River. However, a more comprehensive, longer-term study that would help assess the risk of OWCs to the aquatic environment is warranted. Currently AENV, EPCOR Utilities Inc., and the City of Edmonton continue to monitor these emerging contaminants in the NSR upstream and downstream of the City of Edmonton.

Programs that have emphasized non-point source in the last 20 years include monitoring programs by the provincial government, EPCOR Utilities Inc. and the City of Edmonton and include non-point source issues associated with logging, agriculture, mining, urban runoff and atmospheric deposition. Non-point source runoff from agricultural activities have been quantified largely through the provincial Alberta Environmentally Sustainable Agriculture (AESA) Water Quality Resource Monitoring Program, and its' predecessor the Canada Alberta Environmentally Sustainable Agriculture (CAESA) program. The AESA Stream Survey, which is part of this program, is a long-term monitoring program that tracks water quality in 23 streams in agricultural areas across Alberta, three which are in the NSR basin. Initiated in 1997, the AESA Stream Survey is operated by: Alberta Agriculture and Rural Development, Alberta Environment, Alberta Health and Wellness, and Agriculture and Agri-Food Canada.

In addition, enhanced tributary water quality monitoring has been funded through the AESA program and other partners in the last 15 years. For example, extensive monitoring and study of the tributaries and point sources flowing into the NSR mainstem upstream of Edmonton was completed between 1998 and 2000. The goal of the project was to identify potential major sources of waterborne parasites in the NSR. Key findings of the study were that livestock contribute peak loads of parasites (*Cryptosporidium* spp. and *Giardia* spp.) to the North Saskatchewan River. This combination of this work has shown that agricultural can degrade water quality during certain times and tributary water quality in agricultural stream in the NSR is comparatively poor in relation to headwater tributaries. Specifically, the poor water quality in many tributaries can affect mainstem water quality during high flow periods. The study also found that municipal wastewater effluent is a consistent and chronic source of *Giardia* spp. to the NSR upstream of Edmonton.

Other monitoring programs on the NSR, include the City of Edmonton's annual Environmental Monitoring Program (EMP), which has been running since 1991. This program was established in response to the "Wastewater and Collection System" Operating Approval conditions as outlined by Alberta Environment, which allows the City of Edmonton to operate its storm water and municipal wastewater treatment systems. The objective of the program is to quantify, on an annual basis, the amount of material that is released by the City of Edmonton to the NSR and to evaluate how water quality in the NSR is affected by the release of this material. Initially, the EMP was focused around the completion of annual water quality surveys of the NSR within and downstream of the city limits. Over time, the program has expanded in scope to include seasonal sampling at multiple locations as the NSR flows through Edmonton and past Fort Saskatchewan. Tributaries to the NSR and outflows from the Gold Bar and Alberta Capital Region Wastewater Treatment Plants have also been sampled in more recent years, along with several wetlands/detention ponds and the main storm sewer and combined sewer outfalls maintained by the City of Edmonton. In addition, the City of Edmonton maintains a network of continuous monitoring stations that are located at the four largest storm sewer outfalls and the two largest combined sewer outfalls.

Not surprisingly, data collected as part of the EMP program continue to illustrate a general decline in water quality in a downstream direction with nutrients, sediment, pathogens, organic material and some metals being significantly higher downstream of Edmonton and at the border, compared to at upstream reaches. Again, this pattern is not unexpected due to inputs from storm sewers and wastewater treatment plants, which have continued to affect water quality in the NSR. Also, effects from the wastewater plants are most predominant during dry weather conditions when dilution is lower and background levels are lower.

Despite the difference between upstream water quality compared to downstream shown in recent EMP reports, water quality downstream of Edmonton is, in general, remarkably better than in the 50s and 60s. Trend analysis report produced by Alberta Environment for the LTRN data (1977 to 2002) showed that total phosphorus, total dissolved phosphorus, total nitrogen, total coliform bacteria, and fecal coliform bacteria, have shown significant decreases downstream of Edmonton at Pakan. These reductions, thought to be a result of upgrades to the Gold Bar Wastewater Treatment Plant in Edmonton, are indicative of marked improvements in river water quality. Recent changes to the Capital Region WWTP have also contributed to improvements in downstream water quality. For example, at the Pakan monitoring site, values for more recent nutrient data show decreases of approximately 70% for phosphorus and 30% for nitrogen.

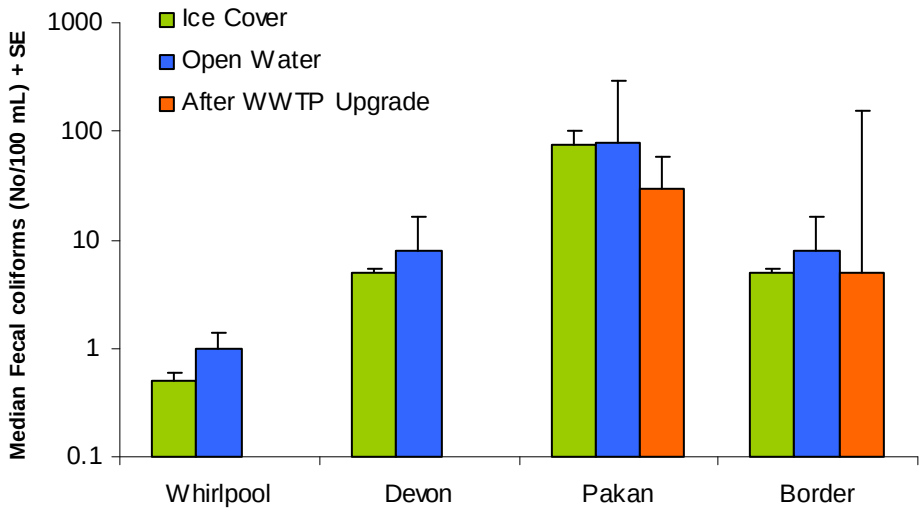

Figure 1. Fecal coliform numbers at long term monitoring sites on the North Saskatchewan River from 1988 to 2006.

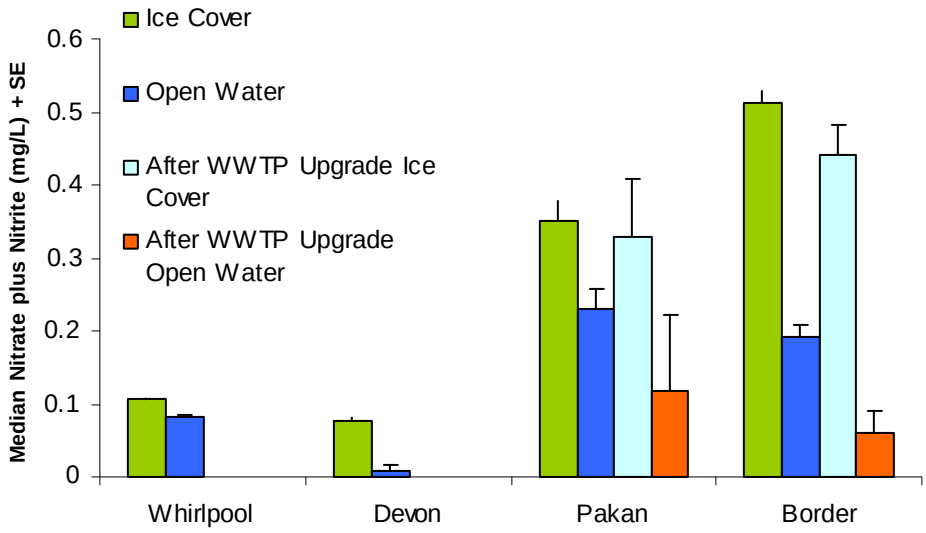

Figure 2. Nitrate plus nitrite concentrations at long term monitoring sites on the North Saskatchewan River from 1988 to 2006.

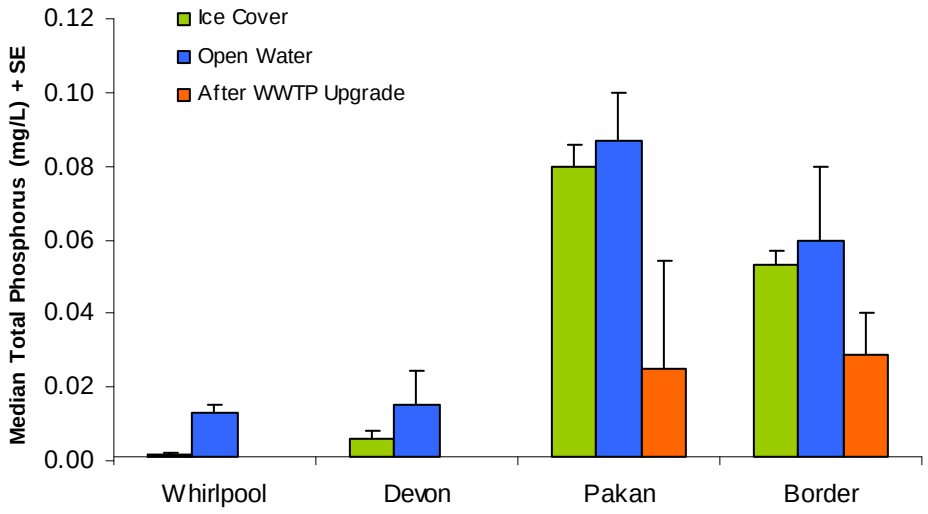

Figure 3. Total phosphorus concentrations at long term monitoring sites on the North Saskatchewan River from 1988 to 2006.

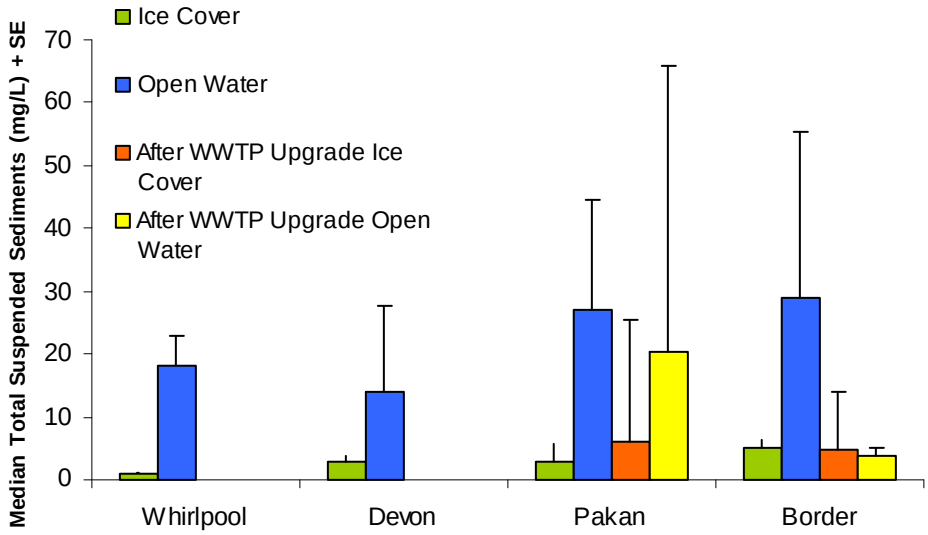

Figure 4. Total suspended sediment concentrations at long term monitoring sites on the North Saskatchewan River from 1988 to 2006.

These recent upgrades have resulted in current values for nutrients are in accordance with water quality objectives recently proposed (2010) by the North Saskatchewan Watershed Alliance (NSWA). They are also below CCME and Alberta surface water quality guidelines for the protection of aquatic life, and below water quality objectives outlined by the Prairie Provinces Water Board. However phosphorus levels

are approaching 70% of the NSWA's objective values and increased loadings must be managed accordingly. Similarly, pathogens numbers have shown decreases in recent years, but values are still above NSWA's proposed water quality objectives and established guidelines for irrigation and recreation. Total suspended sediment values have not shown marked decreases in recent years, largely because the majority of the suspended sediment load originates from upstream non-point sources, or from City of Edmonton storm sewers. Stemming from the EMP program, recent work has shown that during precipitation and snowmelt events storm sewers are a significant source of non-point sediment loads to the NSR within the City of Edmonton's boundaries, as well as a source of other contaminants.

On the whole, data collected from the NSR mainstem reflect good water quality, a consequence of having both a good natural supply of water from the east slopes of the Rocky Mountains, and much progress in pollution abatement over the decades. Inputs from non-point source agricultural runoff do affect water quality at certain times although, at a mainstem scale, the largest footprint remains from wastewater and storm water runoff within the Alberta Capital Region. Additional monitoring, which includes Alberta Environment's re-visitation of its 1980s basin-wide synoptic survey work in 2008, wherein a plug of water was followed as it moved from the NSR headwaters down to the border with Saskatchewan, will continue to shed light on how and why water quality changes as the NSR flows though Alberta.

Watershed and Water Quality Management

Watershed management is complex, particularly when multiple stakeholders affect land use and when there are various landscape planning initiatives occurring at different levels of government. At a provincial level, watershed and water management is guided by Alberta Environment's Water for Life (WFL) Strategy which has three main goals: 1) safe, secure drinking water, 2) healthy aquatic ecosystems; and 3) reliable, quality water supplies for a sustainable economy. Recognizing that partnerships and watershed planning are key to managing water resources in Alberta, regional partnerships were established with Watershed Planning and Advisory Councils (WPACs), who are the designated leaders in watershed assessment and planning. The North Saskatchewan Watershed Alliance (NSWA) is the WPAC for the basin, and is mandated under WFL to complete State of Watershed reporting and to develop an Integrated Watershed Management Plan for the basin. It is a collaborative of stakeholders, including the City of Edmonton, EPCOR Utilities Inc., and Alberta Environment, who are committed to a shared vision of maintaining and protecting water quality in the river. To date, the North Saskatchewan Watershed Alliance (NSWA) completed a "State of the North Saskatchewan Watershed" (2005) as well as a "Municipal Resource Guide" for communities in this watershed.

In late 2005, the NSWA began developing the Integrated Watershed Management Plan for the basin, which was intended to set land use, water quantity, and water quality objectives. Throughout the IWMP development, knowledge and data gaps were identified and a series of reports were completed to augment objective setting for the basin. As a key part of the IWMP development, a NSWA Technical Advisory Committee developed mainstem water quality objectives for the NSR in 2009. A draft report, entitled: "Proposed Site-Specific Objectives for the Mainstem of the North Saskatchewan River" (2010), is now complete. Although the report and objectives are currently undergoing stakeholder and public consultations, the document suggests a policy of "no further degradation in water quality" in the NSR. In areas, downstream of Edmonton, the document proposes improvements in water quality for some parameters such as total organic material, sediment, and bacterial pathogens. Others, such as phosphorus are approaching guidelines values, and may require detailed management plans.

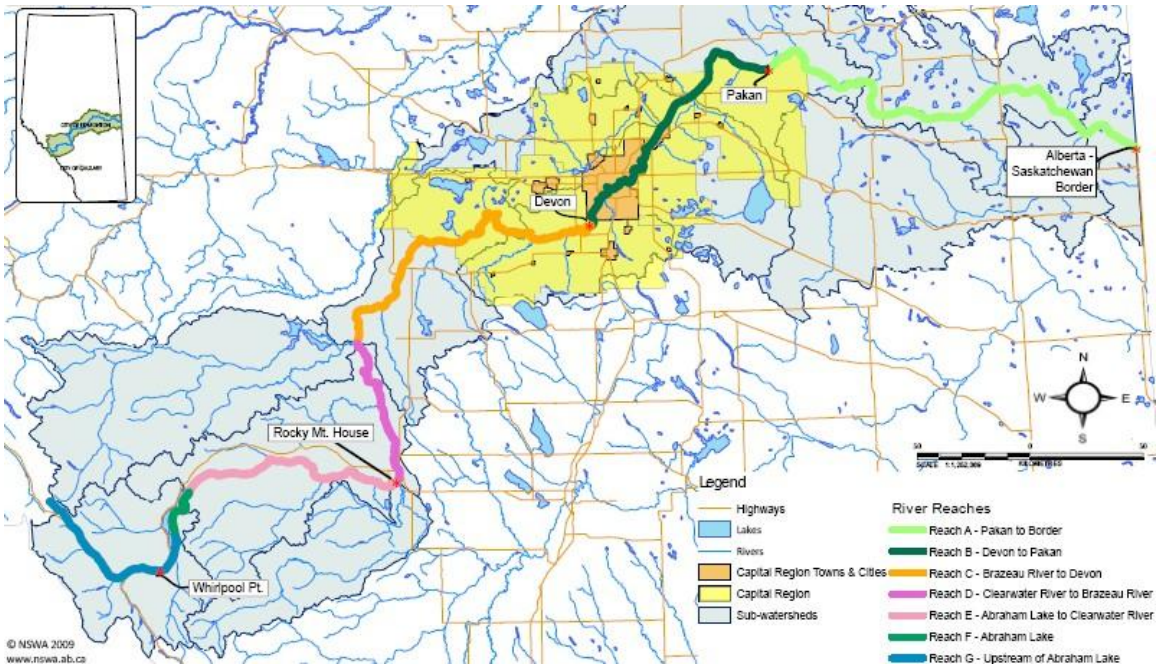

Figure 1. The North Saskatchewan River reaches for which site specific water quality objectives have been proposed.

Other watershed management initiatives in the basin include EPCOR's Watershed Protection Program (WPP), which has historically focused on source water protection for drinking water. The program has more recently expanded more recently to include downstream water quality issues as the result of its increasing number of wastewater treatment facilities it now operates, including the Gold Bar Wastewater Treatment Plant in Edmonton. This program works within the existing

watershed management and source water frameworks, at both the federal and provincial level. The program is designed to efficiently manage source water quality and quantity through integration with existing programs and resources. Although these focus areas are interrelated, in general, the core of EPCOR's WPP entails developing watershed planning documents, supporting the outcomes of those plans though implementation programs, developing and supporting monitoring and research programs to measure changes in selected metrics, and garnering support from watershed stakeholders. As such, EPCOR Utilities Inc. is heavily involved with water quality monitoring and management in the NSR basin, including working closely with the NSWA. Similarly, the City of Edmonton is involved in maintaining water quality in the North Saskatchewan River through its Environmental Monitoring Program, involvement with the NSWA, and development with contaminant loadings plans as part of its approval process.

As part of the Government of Alberta (GoA)'s mandate for addressing the cumulative effects of development on the environment, the GoA has also established several pilot projects in which to test its Cumulative Effects Management Framework - including the Industrial Heartland region within the North Saskatchewan watershed. The Industrial Heartland project provides strategies and targets to sustain the quality of the Alberta Capital Region's environment, outlines specific environmental outcomes for the region, and sets targets for sustainability and regional strategies for the tracking and management of air, water and land. The Water Management Framework for the Industrial Heartland and Alberta Capital Region Report is the result of consultation, collaboration and planning for growth by Alberta Environment, industry, municipalities, NSWA and representatives from municipal water and wastewater treatment facilities. Key strategic objectives from the plan are to make Alberta a world leader in water and water reclamation technology and to minimize the impact or "footprint" on the NSR by improving the quality of the water and ensuring water conservation practices are in effect. Once developed, the model will improve the quality of the NSR and meet targets including those described by existing policies related to pollution prevention and water quality limits. It will also be used to manage water quantity to ensure that sufficient water remains in the river to maintain aquatic life, support current and proposed industrial development and attain water quantity and quality targets, and consider wastewater reclamation options to prevent further degradation to the water quality in the NSR as the City and surrounding capital region grow.

The Government of Alberta further enabled cumulative effects management on a landscape level with the release of the Land-use Framework (LUF) in December 2008, followed by the Alberta Land Stewardship Act (ALSA) in spring 2009. The Land Use Framework and ALSA divide the province into seven regions and commit the province to taking a cumulative effects approach to environment management.

Regional Advisory Councils (RACs) will be established to set landscape level objectives as regional plans are developed. The intention is for WPACs to be involved in the development of watershed and water related objectives as a member of the RAC.

Summary and Future Trends in Water Quality in NSR

Water quality conditions at the sites downstream of the City of Edmonton reflect urban, industrial and other impacts. Specifically, water quality declines in a downstream direction due to increased loading of contaminants from non-point source runoff and effluent discharges. However, water quality in the North Saskatchewan River, as a whole is good and downstream of the City of Edmonton water quality has improved substantially in the last 50 years. The days where floating debris and anoxic conditions were commonalities are well behind us and our understanding and management of water quality in the NSR has improved substantially. Despite improvements in recent years, current water and watershed management initiatives call for continued improvement and/or maintenance of water quality at reaches downstream of the City of Edmonton.

Upstream of the City of Edmonton, water quality is generally high, although agricultural and other land uses have been shown to degrade water quality during certain times. Specifically, the poor water quality in many tributaries can affect mainstem water quality during high flow periods. The Watershed Planning and Advisory Council for the basin (NSWA) has suggested that future water quality degradation upstream of Edmonton be avoided and the relatively good current quality conditions observed at those sites be maintained. This philosophy simply means that future human activities (e.g., industrial, municipal, land use patterns, flow regulation, etc.) should not degrade water quality compared to that currently observed. Proposing to maintain water quality, and in a few cases improve, current water quality has inherent implications for the future management of the river and activities within the watershed. Upstream of Devon, the proposed objectives imply that future additional discharges, development or land use changes in the upper area of the watershed should not have a measurable impact on water quality and growth must be managed accordingly.

Downstream of Devon, reducing point source and non-point sources of total suspended solids, bacteria and total organic carbon will be needed to meet the proposed objectives. The City of Edmonton in partnership with other stakeholders will be challenged to cumulatively manage these parameters. To maintain levels of other contaminants such that they align with proposed water quality objectives, management of the cumulative water quality impacts of all future development and

land use changes in the region will be required. Further, objectives for parameters not yet addressed but of some concern (ex. trace metals, pesticides) require development.

In addition, the effects of climate change, and associated hydrological changes, on water quality are unknown. For example, lower summer flows could mean reduced assimilation capacity of the NSR and required further reductions of inputs. More research and monitoring that focus on understanding the linkages between water flow, land use, and water quality, and the effects of climate change on these relationships, is necessary. An integral part of this is the development of a comprehensive and focused water quality monitoring program that characterises tributary water quality monitoring in the NSR, from headwaters to the border. Current monitoring provides a good metric to assess water quality changes over a long time scale, but is not designed to address the effectiveness of land management strategies, or to identify specific pollution sources. Work in this area is being undertaken, in part, by the NSWA who is determining the minimal flows in the NSR required to maintain water quality and aquatic ecosystem health. Overall, with a focused integration on land and water planning and management we can expect the NSR to meet the needs of all users, now and in the future.