SURFACE WATER QUALITY IN THE SOUTH SASKATCHEWAN RIVER BASIN

SEAWA Watershed Report 2009-5

SEAWA Web-based State of the Watershed Report

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Introduction

This report considers the South Saskatchewan River sub-basin. It outlines the parameters by which surface water is measured for quality as it pertains to specific uses. It serves to provide the most current and reliable information available and links to those sources.

Discussion

1). About the South Saskatchewan River Basin- The South Saskatchewan River (1392km long) is formed by the joining of the Bow and Oldman Rivers. These two rivers originate from the glaciers in Rocky Mountains on the Alberta- British Columbia border, east of the 'Continental Divide'. The South Saskatchewan River joins the North Saskatchewan River roughly 130km downstream of Saskatoon, Saskatchewan. Before the building of the Gardiner dam in 1960, roughly 100km south of Saskatoon, the South Saskatchewan River would completely freeze every winter causing brilliant, and dangerous, ice flows in the spring. At least one bridge in Saskatoon was destroyed by ice carried by the river. Due to the reduced power of the river and lower water levels produced by the dam, many permanent sand bars have formed. The water from the South Saskatchewan is ultimately carried to the Hudson Bay via the Nelson River.

The river was named 'Kisiskatchewani Sipi' by the Cree, meaning 'swift flowing river'. The modern name is a rendering of the original and was adopted in 1882.

2). Dimensions of the South Saskatchewan River Basin- The South Saskatchewan River Basin (SSRB) is comprised of four sub-basins equalling a total area of 121,095km^2; the Oldman River sub-basin (22% of total area), the Red Deer River sub-basin (41%), the Bow River sub-basin (21%) and the South Saskatchewan River sub-basin (16%) which begins where the Oldman and the Bow rivers join.

All of these rivers have their origins in the Rocky Mountains and generally flow eastward through the foothills and the prairies.[(27)] Runoff generation and hydrologic regimes vary tremendously across the SSRB. Most of the stream flow through major tributaries is not generated in the prairies but derived from snow and glacier melt in the Rocky Mountains. Roughly 90% of the total SSRB flow comes from the Rockies while the Province of Saskatchewan portion contributes only 2%. Soil moisture and runoff is largely dependent on local precipitation.[(24)]

The South Saskatchewan River sub-basin is comprised of all or parts of Cypress County, the counties of Forty Mile No. 8 and Warner No. 5, the municipality districts of Taber and Acadia No. 34, and Special Areas (2, 3, and 4). Major population centres include the City of Medicine Hat, the towns of Redcliff and Bow Island, and the village of Foremost. Parts of Canadian Forces Base - Suffield are also situated in the basin.[(26)]

The South Saskatchewan Sub-basin (SSSB)

Total watershed area of 14,000 square kilometers
Population (2001) 65,451
Population Density 5 persons per square kilometer
Average Annual Discharge 92,800,000 cubic meters
Total Annual (Check This Number)Allocation 2,858,740 cubic meters

3). A Definition of Surface Water Quality- Surface water quality encompasses a wide range of conditions and there is no single or simple measure of water quality. The water of even the healthiest rivers and lakes is not absolutely pure. All water (even if it is distilled) contains many naturally occurring substances– mainly bicarbonates, sulphates, sodium, chlorides, calcium, magnesium, and potassium. To identify the substances present in a stream or lake, scientists collect samples of the water, of living organisms, and of suspended and bottom sediments. Technicians then analyze these samples in a laboratory with specialized instruments and procedures. Certain measurements, such as: temperature, dissolved oxygen, turbidity and conductivity can be taken in the field with portable equipment.(15) Water quality measurements fall into three broad categories; physical characteristics, such as: temperature, color, suspended solids and turbidity, chemical characteristics, such as: nutrients, minerals, metals, oxygen, organic compounds and a wide range of pollutants (e.g., pesticides, hydrocarbons, pharmaceuticals, polychlorinated biphenyls [PCBs]), and biological characteristics, such as: the types and quantities of bacteria, protozoan parasites, algae, invertebrates, plants and other animals. Parameters are set for surface water quality based of the end use. (3)

The most common things water is tested for are:

pH- the balance of positive hydrogen ions (H^+) and negative hydroxide ions (OH^-). The pH scale ranges from 0 (high concentration of positive hydrogen ions, strongly acidic) to 14 (high concentration of negative hydroxide ions, strongly basic). A healthy lake or river has a pH from 5.0 to 9.0 but the optimum is considered between 6.5 and 8.2.

Alkalinity- is a total measure of the substances in water that have "acid-neutralizing" ability. pH measures the strength of an acid or base; alkalinity indicates a solution's ability to react with acid and "buffer" its pH.

Ammonia- is a strong-smelling, colorless gas. It is manufactured from nitrogen and hydrogen. In nature, ammonia is formed by the action of bacteria on proteins and urea. Ammonia makes a powerful cleaning agent when mixed with water. For this reason, it is one of the most common industrial and household chemicals. Ammonia is also rich in nitrogen, so it makes an excellent fertilizer.

Carbon Dioxide-is an odourless, colorless gas produced during the respiration cycle of animals, plants and bacteria. Carbon dioxide will bind with water molecules to form carbonic acid, and depending on other factors (pH and alkalinity) can lower the pH, unfortunately, it can make it too low for watercourses.

Chlorine- is a greenish-yellow gas that dissolves easily in water. Some people can smell it at concentrations above 0.3 parts per million. Chlorine is an excellent disinfectant and is commonly added to drinking water supplies. In parts of the world where chlorine is not added to drinking water, thousands of people die each day from waterborne diseases like typhoid and cholera. Chlorine is also used as a disinfectant in wastewater treatment plants and swimming pools. It is widely used as a bleaching agent in textile factories and paper mills, and it's an important ingredient in many laundry bleaches. Free chlorine (chlorine gas dissolved in water) is very toxic to fish and aquatic organisms. Its dangers are relatively short-lived because chlorine reacts quickly with other substances in water (and forms combined chlorine) or dissipates as a gas into the atmosphere. The free chlorine test measures only the amount of free or dissolved chlorine in water. The total chlorine test measures both free and combined forms of chlorine.

Nitrite and Nitrate- are forms of the element nitrogen, which makes up about 80 percent of the air we breathe. It is found in the cells of all living things. Organic nitrogen (nitrogen combined with carbon) is found in proteins and other compounds. Inorganic nitrogen may exist in the free state as a gas, as ammonia (when combined with hydrogen), or as nitrite or nitrate (when combined with oxygen). Nitrites and nitrates are produced naturally as part of the nitrogen cycle.

Nitrites are quickly converted to nitrates by bacteria. Nitrites can produce a serious illness (brown blood disease) in fish. Nitrites also react directly with hemoglobin in human blood to produce methemoglobin, which destroys the ability of blood cells to transport oxygen and causes a condition known as methemoglobinemia or "blue baby" disease in children under 3 months old.

Nitrate is a major ingredient of farm fertilizer. When it rains, varying nitrate amounts wash from farmland into nearby waterways. Nitrates also get into waterways from lawn fertilizer run-off, leaking septic tanks and cesspools, manure from farm livestock, animal wastes, and discharges from car exhausts. Nitrates stimulate the growth of plankton and water weeds that provide food for fish. This may increase the fish population, but soon oxygen levels will be reduced and fish will die.

Dissolved oxygen- or DO (dee-oh) is oxygen that is dissolved in water by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. Virtually all of the oxygen we breathe is manufactured by green plants. A total of three-fourths of the earth's oxygen supply is produced by phytoplankton in the oceans. If water is too warm, there may not be enough oxygen contained within it. Also, when there are too many bacteria or aquatic animals in the area, they may overpopulate, using up the DO.

Phosphates- The element phosphorus is necessary for plant and animal growth. Nearly all fertilizers contain phosphates (chemical compounds containing the element phosphorous). During rain events, varying amounts of phosphates wash from farm soils into nearby waterways. This encourages water plants to flourish, but it leads to low DO.

Temperature- is affected by many variables; the color of the water, the depth, amount of shade, the latitude or location, the time of year, the volume, and the temperature of effluents dumped into the water. The colder the water, the more DO it can hold in solution.

Turbidity- is defined as "the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample." [6] It basically refers to the cloudiness of the water. Turbidity affects temperature which in turn affects DO. Turbidity is measured in NTU's or Nephelometric Turbidity Units. Drinking water must have an NTU of 0.3 or lower.
(22)

It should be noted that none of the above factors of water quality stand alone. They are delicately tied to each other, and the condition of one affects the condition of all others.

4). Canadian water quality guidelines are in effect for each of the end uses of water. Environment Canada guidelines are the standards that all water is measured against. Environment Canada separates the end uses into four categories;

a). Canadian Water Quality Guidelines for the protection of **Aquatic Life** -These guidelines are based on toxicity data for the most sensitive species of plants and animals found in Canadian waters and act as science-based benchmarks for the protection of 100% of the aquatic life species in Canada, 100% of the time.[10]

This information can be found in the document “Surface Water Quality Guidelines for use in Alberta”[1] http://environment.gov.ab.ca/info/library/5713.pdf

b).Canadian Water Quality Guidelines for the protection of Agricultural Water Use

These are based on maximum irrigation rates and the sensitivity of crops to pollutants. Similarly, the Canadian Water Quality Guidelines for Livestock Water are based on how livestock are affected by their drinking water and whether certain substances, such as toxic chemicals, accumulate in the animals' bodies. [1]

This information can be found in the document “Surface Water Quality Guidelines for use in Alberta” http://environment.gov.ab.ca/info/library/5713.pdf

c). Guidelines for Canadian Drinking Water Quality

These help to protect the health of Canadians by establishing maximum acceptable concentrations for substances found in water used for drinking. To date, guidelines have been established for more than 85 physical, chemical, and biological attributes of water quality. These guidelines can be accessed through Health Canada.[20] “Guidelines for Canadian Drinking Water Quality- summary table”
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php

d). Guidelines for Recreational Water

-These guidelines deal mainly with potential health hazards such as infections transmitted by disease-causing micro-organisms, and aesthetics and nuisance conditions.

These guidelines can be accessed through Health Canada, [21] “Guidelines for Canadian Recreational Water Quality” http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/guide_water-1992-guide_eau/index-eng.php

5). <u>Water quantity</u> is affected by several factors; snow pack in the Rocky Mountains (spring run-off accounts for 75% of the river flow), precipitation, urbanization (which leads in impermeable surfaces), dams, and flow diversion.

The South Saskatchewan River sub-basin is 16%, or 14,000 km^2 of the total SSRB watershed (121,095 km^2). Average annual discharge of the South Saskatchewan River into the Province of Saskatchewan is 92,800,000 cubic meters with 2,857,840 cubic meters being allocated. Allocations for municipal use are highest in the basin. The town of Bow Island is located in the South Saskatchewan River Basin, yet it draws its water from the Oldman River (6,780 cubic meters) through the St. Mary River Irrigation District's infrastructure. The allocation for the City of Medicine Hat is larger than allocations of other cities of similar size because the City has its own power plant which draws water under the municipal licence. Municipal allocations of surface water increased substantially between 1970 and 1990 but have remained constant since then. In 2006, the South Saskatchewan River Sub-basin became one of three southern basins to be closed to new water allocations.[27]

Water allocations have grown significantly since the 1940s and 1950s, about the time when the population and industrial growth in the Province of Alberta began to increase. In the first part of the last century, water was mainly allocated to irrigation in the southern part of the Province. However, the growth of municipalities, industries, and demand for electricity have driven up total water allocations from about 2 billion cubic meters after Alberta was founded to over 9 billion cubic meters today. It is important to note that allocations do not measure actual water use - but the growth in allocations is still a reflection of an increasing demand for available water in order to support all the activities and development in the Province.[5] In general, it is most often unknown how much water is actually consumed - only that each license provides an estimate of the expected upper limit of what the losses and consumption might be. This is based on the type of activity or usage and process requirements.

The South Saskatchewan River, at the point where the Oldman and the Bow meet to where it joins the North Saskatchewan River, accounts for 4.7% of the total flow volume in the South Saskatchewan River Basin. Municipal use holds allocations for 66% of the water, Agriculture holds 3%, Irrigation holds 18%, and Industrial holds 0% and 13% is allotted for 'other'.[6]

Statistics Canada measures water in terms of intake, discharge and consumption. For example, approximately 10 to 30% of water used for irrigation and approximately 80% of water for municipal use is returned to the source. Consumption numbers represent the actual amount of water used. Tables relating to Canada's overall intake, discharge and consumption can be seen at http://www40.statcan.gc.ca/l01/cst01/envir05a-eng.htm.

6). Historically, the <u>physical characteristics</u> of water have been simply evaluated using the five senses: temperature, taste, odour, color, and turbidity.

Surface water quality monitoring has been conducted on the rivers of Alberta since the 1940s. The work focused on basic inventories to describe the state of fisheries and water resources in Alberta. During the 1950s and 1960s, problems caused by excessive nutrients (phosphorus and nitrogen) and oxygen-demanding substances entering the aquatic environment, mostly from municipal and industrial sources, were of great concern. More systematic data collection programs were implemented, beginning in the late 1960s. Long-term monitoring is essential to understand aquatic ecosystems and to determine trends over time. Following the creation of Alberta Environment and the development of provincial legislation for regulating point-source discharges in the 1970s, field studies expanded to include non-point source issues associated with logging, agriculture, mining, urban runoff and atmospheric deposition. In the 1980s and 1990s, concerns emerged about the general health of aquatic ecosystems, reflected in the presence of minute quantities of toxic substances found in various ecosystem components (water, sediments, plants and animals). The tendency for some contaminants (e.g., pesticides, metals and PCB's) to bioaccumulate in fish and wildlife and pose a risk to human and environmental health was recognized. More recently, issues have arisen regarding the presence of human pharmaceuticals, flame retardants, pathogens and new agricultural chemicals in aquatic ecosystems. Potential sources of these contaminants and toxins include large urban areas and intensive agricultural operations. Aquatic ecosystem health is now a major focus of interest and work. This involves enhanced monitoring to complete a province-wide evaluation, as well as the development of ecological indicators and guidelines to evaluate the health of aquatic ecosystems. A large component of this is the determination of in-stream flow requirements for fish and other aquatic ecosystem components.[2]

7). a). <u>Alberta Environment</u>
Alberta Environment maintains one long-term monitoring facility (station #AB0AK0020) located on the South Saskatchewan River upstream of Medicine Hat. There are several ways to access a summary of this station's quality analysis information.

i). Alberta Environment runs the 'South Saskatchewan River Basin Information Portal' and can be accessed at http://ssrb.environment.alberta.ca/.

Various data can be accessed including ‘river flows and levels’, ‘precipitation data’, and ‘water quality data’. It must be noted that the ‘water quality data’ reports solely on water level and temperatures.

ii).. The Alberta Environment ‘Alberta River Water Quality Index’ can be accessed through http://environment.alberta.ca/1777.html. The site can be accessed by scrolling down to ‘What does the index show’ to further access the different index maps. It must be noted that this site is a summary of water quality over time and is a basic tool to communicate water quality to the public. For instance, in the 2005 - 2006 reporting period, bacteria guidelines were exceeded once at the Medicine Hat monitoring site. In the 2006 - 2007 period, they were exceeded four times. Since each reporting period comprises 12 samples, this difference of three exceedances would be sufficient to drive the index results down from excellent to fair. Causes of an exceedance can be varied, but stream flow tends to be the major factor. Two of the exceedances occurred during June, when precipitation events may have contributed to surface runoff and higher bacterial concentration in the river. The other two occurred in July and August, during presumably low flows, when dilution capacity is reduced.

iii).The Alberta Environment ‘Alberta Flow Quantity Index’ can be accessed through http://www3.gov.ab.ca/env/soe/water_indicators/46_river_flow.html. This shows the difference between average natural flow and actual flow over a 10 year basis. This span is to even out any inconsistencies due to flood or droughts. The 10 year flow is examined on a two-season cycle, with summer being one season and the remaining seven months comprising the second season. The ‘Alberta Flow Quantity Index’ shows a ‘stressed’ ranking on the South Saskatchewan River, due to cumulative human impact.

iv). Complete data is inaccessible over the internet. For complete data parameters and concentrations for the Alberta Environment long-term monitoring facility (station #AB0AK0020) contact swq.requests@gov.ab.ca.

b). Environment Canada and its counterparts in provincial and territorial governments have a successful 27-year collaborative agreement on water resource monitoring and data/information within Canada. The agreement is focused on water quantity monitoring.

All jurisdictions conduct monitoring programs to assess water quality and to measure impacts of point and nonpoint sources of pollution. These programs are designed to meet the specific priorities and circumstances of individual jurisdictions. Currently, provinces, territories, and the federal government are collaborating on developing a data referencing system under the auspices of the Canadian Council of Ministers of the Environment. This will facilitate linking water quality monitoring networks across the country to provide more complete information on water quality and trends. [(14)]

i). Prairie Provinces Water Board

The Governments of Saskatchewan, Alberta, Manitoba and Canada formed the Prairie Provinces Water Board (PPWB) in 1948. Its mission was to recommend the best use of interprovincial water. In 1969, the Prairie Provinces signed the Master Agreement on Apportionment, which is still the guide to the PPWB’s activities. The Agreement on Water Quality was signed, and became Schedule E to the Master Agreement on Apportionment, in 1992. The Agreement defines the water quality mandate of the Board in interprovincial watercourses. It states that the Board shall "foster and facilitate interprovincial water quality management among the parties that encourages the protection and restoration of the aquatic environment ". The PPWB was integrated into the Transboundary Water Unit of Environment

Canada in 1995. Its three committees (hydrology, water quality, groundwater quality) are made up of both provincial and federal staff and are supported by Environment Canada. [12] The PPWB extracts its information from the stations in the Prairie Provinces. These stations are monitored by Environment Canada. Water is collected monthly, with the exception of a few sites.

Environment Canada fulfills the monitoring conditions described under the Master Agreement and provides information from 75 long term water quantity monitoring stations, 16 meteorological stations and12 water quality monitoring sites located within the Prairie Provinces. Other agencies provide information from an additional 13 water quantity monitoring stations. Five of the water quantity stations are also used for international apportionment calculations. The information collected at these stations is used to calculate natural flows and the levels of water quality parameters. [12]. In 2007, water quality guidelines were adhered to, on average, 95% of the time [23]. A list of PPWB 'Water Quality Objectives and Acceptable Limits' for the monitoring station on Highway#41is available at: http://www.mb.ec.gc.ca/water/fa01/fa01d03/fa01s20.en.html.

ii). Water Survey of Canada

The Water Survey of Canada (WSC) is the national agency responsible for the collection, interpretation and distribution of standardized water resource data and information in Canada. The Water Survey of Canada can trace its beginnings to 1908. The Water Survey of Canada's expertise in monitoring enables the public to have comprehensive data on aquatic quality, water quantity and sediment transport. The WSC manages the measurement, gathering, processing, transformation and management of environmental data. The Water Survey of Canada provides real-time, current year and historical information for a network of over 2,200 sites in Canada and maintains a database containing historic data for some 5,300 non-active sites throughout the country. [28]

iii). Water Survey- Hydrometric Portfolio

The near real-time information is received via satellite or land-line transmissions from hydrometric gauging stations owned by Environment Canada and its partners. These data are normally posted (in graphical form) within four hours of observation. This information can be accessed through http://scitech.pyr.ec.gc.ca/waterweb/fullgraph.asp .

iv). Environment Canada maintains one long term station within the South Saskatchewan River sub-basin. Station # 00AL05AK0001 is located on the border between Alberta and Saskatchewan on Highway #41. It is visited by Environment Canada staff 12 times a year and 40 quality parameters are tested. The complete data are not available over the internet. For complete data parameters and concentrations, a request must be made to Environment Canada Information at enviroinfo@ec.gc.ca.

8). Water quality monitoring reports

a). Alberta Environment

Alberta Environment tests for many organics and inorganics when determining water quality. Included below are the averaged readings for the eleven most commonly tested inorganic parameters. Twelve readings were taken between April 25th, 2007 and March 11th, 2008.

Total Alkalinity (mg/L)	Total Ammonia (mg/L)	Carbon Dioxide	Chlorine Total Recoverable (mg/L)	Dissolved Oxygen (mg/L)	pH	Dissolved Phosphates (mg/L)	Nitrate (mg/L)	Nitrite (mg/L)	Water Temperature (ºC)	Turbidity NTU (Nephelometric Turbidity Units)
158.8	0.145	/	9.62	11.33	8.30	/	0.641	0.006	9.13	19.9

b). Environment Canada

Environment Canada has been keeping records of water quality monitoring since 1968. Below are the concentrations on November 3, 2008 and December 8, 2008 for the eleven most commonly tested inorganic parameters.

November 3rd, 2008

Total Alkalinity (mg/L)	Total Ammonia (mg/L)	Carbon Dioxide	Chlorine Total Recoverable (mg/L)	Dissolved Oxygen (mg/L)	pH	Dissolved Phosphates (mg/L)	Nitrate & Nitrite Grouped (mg/L)	Water Temperature (ºC)	Turbidity-NTU (Nephelometric Turbidity Units)
140	0.28	1.155	/	11.62	8.67	0.021	0.646	7.54	7.2

December 8th, 2008

Total Alkalinity (mg/L)	Total Ammonia (mg/L)	Carbon Dioxide	Chlorine Total Recoverable (mg/L)	Dissolved Oxygen (mg/L)	pH	Dissolved Phosphates (mg/L)	Nitrate & Nitrite Grouped (mg/L)	Water Temperature (ºC)	Turbidity-NTU (Nephelometric Turbidity Units)
149	0.05	1.129	/	9.9	8.74	0.001	1.09	0	3.62

9). Pharmaceuticals in Wastewater

Pharmaceuticals have been finding their way into the environment for a long time. People and animals excrete pharmaceuticals, which then find their way into the environment through a variety of routes- wastewater, agricultural runoff, manure and biosolids that are used as fertilizers. They can also enter the environment when people simply flush them down the toilet or pour them down the drain. Pharmaceuticals represent only a small fraction of the man-made chemicals present in the environment, but even in small concentrations, they can pose a serious problem. Pharmaceuticals are specifically engineered to elicit a biological response at very low levels. [(29)]

Scientists realize that pharmaceuticals have been making their way into the water since the beginning of their development. Studies have assessed the removal of pharmaceuticals from drinking water using conventional methods and advanced methods. Conventional methods included: coagulation, flocculation, filtration and chlorination. Only chlorination proved to be effective, removing about half of the chemicals included in the study. Advanced methods, such as ozonation, activated carbon and nanofiltration, worked well, but are expensive and not generally used to treat wastewater. Wastewater treatment plants were originally designed to improve the aesthetic quality of treated sewage and to reduce incidence of disease, they were not engineered to remove synthetic substances.[(29)]

The most obvious example of pharmaceutical pollution has been the effect of estrogenic compounds on fish. In the 1990s, scientists in the United Kingdom began to notice feminization of fish downstream of a waste water treatment plant. Karen A. Kidd, a biology professor at the Canadian Rivers Institute in New Brunswick, spearheaded a research project in Canada’s Experimental Lakes Area to study the overall impact of estrogenic compounds in fish.

The Experimental Lakes Area (ELA) field station consists of a number of lakes and watersheds that have been set aside for the purpose of whole-lake manipulation studies. This facility, in existence since 1968, offers scientists and biologists a unique opportunity to do experimental research in nature instead of inside the laboratory. Entire small lakes are available to test hypotheses about freshwater ecosystems. With permanent buildings housing modern labs, living facilities and support services, the science community is able to move into residence for a field season with the potential to work on site year round.

The ELA is located on the Precambrian Shield of northwestern Ontario, approximately 250 km east of Winnipeg and 50 km east-southeast of Kenora. The ELA includes 58 small lakes (1 to 84 hectares in area) and their drainage basins, plus three additional stream segments, which have been set aside and are managed through a joint agreement between the Canadian and Ontario governments. Only research activities, or activities compatible with that research, are permitted within or adjacent to these watersheds. The ELA also has laboratories on site where a range of analytical work is carried out on samples such as water, zooplankton, and fish.[(17)]

Kidd and her team polluted a lake with ethinyl estradiol at 5 ppt (parts per trillion) which is the same concentration measured in municipal wastewaters and in river waters downstream of wastewater discharges. The team observed delayed sperm cell development in male fathead minnows. A year later, the male minnows were producing eggs and the species had largely stopped reproducing. Over a three year period the minnow population had all but disappeared. The trout population had dropped by 30%

due to the loss of food supply. In 2006, three years after the team stopped adding ethinyl estradiol to the water, the fathead minnow population had rebounded.

Studies have also shown the antidepressant fluoxetine, or Prozac, can slow the development of fish and frogs. The anticonvulsant carbamazepine affects the emergence of mosquito-like insects that are a popular food source for certain fish. Scientists also worry what the massive amounts of antibiotics used to treat livestock may be creating antibiotic-resistant microbes. The main question is whether pharmaceuticals in drinking water will have any direct impact on human health. Scientists report concentrations are far too low to be of immediate concern, but the problem is not so simple if the contaminants are causing an antibiotic resistance.

In 2003, Trent University in Peterborough Ontario analyzed samples of water for Alberta Environment taken from the Red Deer and Bow Rivers. The Bow River joins the Old Man River to create the South Saskatchewan River. Below are the mean concentrations results for 15 pharmaceuticals.

Table 1. Acidic drugs

Sample ID No.	**Red Deer River**	**Old Man River**
Bezafibrate	ND	0.010
Clofibric acid	ND	ND
Diclofenac	ND	0.021
Fenoprofen	ND	ND
Gemfibrozil	0.004	0.023
Ibuprofen	ND	0.023
Indomethacin	ND	0.020
Ketoprofen	ND	ND
Naproxen	ND	0.059

Table 2. Neutral drugs

Sample ID No.	**Red Deer River**	**Old Man River**
Fluoxetine	ND	ND
Norfuoxetine	ND	ND
Trimethoprim	ND	0.018
Pentoxifylline	ND	0.015
Cyclophosphamide	ND	ND
Carbamazepine	0.095	0.094
Caffeine	0.054	0.064
Cotinine	ND	0.007

Table 3. Quinolone antibiotics

Sample ID No.	**Red Deer River**	**Old Man River**
Ciprofloxacin	ND	ND
Enrofloxacin	ND	ND
Norfloxacin	ND	ND
Ofloxacin	ND	ND
Oxolinic acid	ND	ND
Pipemidic acid	ND	ND

Table 4. Sulfonamide antibiotics

Sample ID No.	**Red Deer River**	**Old Man River**
Sulfapyridine	ND	0.015
Sulfamethoxazole	ND	0.048
Sulfacetamide	ND	ND
Sulfamethazine	ND	ND
Sulfisoxazole	ND	ND

Table 5. Tetracycline antibiotics

Sample ID No.	**Red Deer River**	**Old Man River**
Chlorotetracycline	ND	ND
Doxycycline	ND	ND
Oxytetracycline	ND	ND
Tetracycline	ND	ND

ND – not detected

10). Phthalate esters in Wastewater

Phthalate esters are esters of phthalic acid and are mainly used as plasticizers. These esters increase the flexibility, transparency, durability and longevity in plastics.

Phthalates are being phased-out of many products in the United States and Europe over health concerns. Canada is reported to use approximately 70,000 tonnes of phthalate esters a year and there is a provision in the 'UNECE Protocol on Long Range Atmospheric Transport of Persistent Organic Pollutants' for banning industrial chemicals from use and production if these chemicals are persistent or bioaccumulative. The Canadian Department of Fisheries and Oceans conducted a two year research project spanning from 1999 - 2001 to investigate the extent of accumulation of phthalate esters in marine organisms and in their predators. The study concluded that only the esters with a higher molecular weight tended to appear in the tissues of only some organisms, fish excluded. [18]

Regardless of the threat, Phthalate esters end up in the environment. When plastics break down, the esters leech into the groundwater and river systems. Below are the results of water tested for Phthalate Esters on behalf of Alberta Environment in the South Saskatchewan River at Medicine Hat and in the effluent from the Water Treatment Plant.

	South Saskatchewan River @ Medicine Hat -River Water	Medicine Hat Waste Water Treatment Plant -Effluent
	Conc (ng/L)	Conc (ng/L)
DMP- Dimethyl phthalate	1.6	0.8
DEP- Diethyl phthalate	33.2	28.3
DIBP- Diisobutyl phthalate	5.1	30.6
DBP- Di-n-propyl phthalate	77.2	63.0
BBP- Butyl benzyl phthalate	10.3	16.3
DEHP- Di(2-ethylhexyl) phthalate	2060.3	3041.5
DnOP- Di(n-octyl) phthalate	3.08	11.3
DNP- Di-n-pentyl phthalate	5.61	31.5

11). Artificial Sweeteners in Wastewater

Artificial sweeteners are used in a remarkable amount of foods and beverages, but are also present in pharmaceutical drugs and sanitary products. They pass through the human body largely unmotablized and end up in wastewater. Scientists have found that testing surface and groundwater for artificial sweeteners is an excellent way to find if natural waters are being contaminated by domestic wastewater. Water samples were collected from the Water Supply Authority, Zurich, Switzerland and the Waterworks Appital, Wadenswil, Switzerland. Tap water samples were collected from several public places in the lower Glatt valley.

The four sweeteners chosen for the study were acesulfame, cyclamate, saccharin and sucralose. Sulfoamide sweeteners; (acesulfame, cyclamate and saccharin), are compounds which have a pH typical of natural water and, therefore, are expected to be quite mobile in the natural environment. [16] In Canada, cyclamate and saccharin sweeteners may be sold for consumer use only in pharmacies [9]In Europe and many other countries they are registered for normal use. Sucralose was chosen for the study because it had recently been shown to be persistent in wastewater. Aspartame, another very common artificial sweetener, was left out of the study because it biodegrades quite quickly in wastewater treatment plants.

The sweetener Acesulfame was consistently detected in treated wastewater at rates of 12 to 46 micrograms per litre, in most surface waters, in 65% of tested groundwater and even in several tap water samples up to 2.6 micrograms per litre . The highest concentrations of Acesulfame were found in groundwater with direct river infiltration, directly downstream from wastewater treatment plants at 4.7 micrograms per litre. Cyclamate was detected in the influent at rates from 10 to 65 micrograms per litre and effluent from ND (non detection) to 0.82micrograms per litre. Saccharin was detected in influent at rates from 3.9 to 18 micrograms per litre and in effluent at rates from ND to 3.2 micrograms per litre. Lastly, sucralose was detected in influent at rates of 2 to 9.1 micrograms per litre and in effluent at rates from 2 to 8.8 micrograms per litre.[16]

In a related German study, all surface water analyzed yielded similar results pertaining to acesulfame, saccharin, cyclamate and sucralose. [8] There was also a direct correlation between population, location of test sites and concentrations.

Cyclamate and saccharin have been accused of causing bladder cancer in lab rats. Acesulfame is commercially used as potassium salt and no health problems related to it have been reported in the scientific literature. However, in 2008, a study was published reporting DNA damage due to acesulfame exposure. Sucralose has been discussed as a migraine headache trigger. [8]

12). The SSRB and Climate Change

Findings below have been extracted directly from the SSRB final technical report titled "Climate Change and Water".

Climate change has the potential to impact various aspects of water resources the world over. The impacts have consequences for both water availability and water use. This is important in Canada and especially the SSRB considering that this region receives low annual precipitation. The potential for changes in precipitation, warmer temperatures with increased evapotranspiration, and greater frequencies of extreme events will affect both water quality and quantity. Impacts on the environmental system would also affect the economic and social systems that depend on water resources within the SSRB.

Under climate change, the impact of a change in water availability on the socioeconomic system will depend on the type of water use, the quality and quantity of water for a given use, and the institutions in place for governing water use for each specific activity.

The SSRB final technical report titled "Climate Change and Water" summarizes the work and results of a study entitled "Assessment of the Vulnerability of Key Water Use Sectors in the South Saskatchewan River Basin (Alberta and Saskatchewan) to Changes in the Water Supply Resulting from Climate Change". It classifies the SSRB as one of Canada's largest and most vulnerable interprovincial watersheds. The study built upon prior research on the potential impacts of climate change in the Canadian Prairies, by Natural Resources Canada, in 2002. The major end to this project was to link the physical hydrological and socioeconomic aspects in an 'end-to-end' framework. This means that the reports goal was to lay a foundation for future analysis of the impacts of climate change on the physical and social dimensions of the basin.

This integrated analysis was achieved by having two separate teams, (one focused on the physical aspects and one focused on the social aspects), working in cooperation. The physical team used down-scaled climate scenarios from selected general circulation models (GCM's) that were calibrated to actual 1961-1990 hydrological data to project 'naturalized' surface water supplies in the SSRB without the impacts of flow regulation and withdrawals. The socioeconomic team built upon its own application of geographical information systems (GIS) and a summary of the physical geography to analyze the impact of the physical team's results.

Central in the interpretation of the physical results of the whole SSRB region was the recognition that climate change will drive a more active precipitation cycle that builds on existing patterns. These patterns include: spring snowmelt in the Rockies which provides most of the surface water supply; heavy spring and early summer rains which recharge soil moisture and ground water reserves; and glacier melt which contributes to instream flows. These combined observations suggest that streamflows across the full basin will not be uniformly impacted.

Because of distinct sub-basins within the SSRB, it was found worthwhile to do streamflow forecasts, displaying sub-basins as envelopes, and constructing their own hydrological models. Regionally, the potential changes anticipated include: changes in annual streamflow, possibly large declines in summer streamflow; increased likelihood of severe drought, and increasing aridity in semiarid zones; and increases or decreases in water availability and irrigation demand.

The key findings of the SSRB study were:

- The selected GCM's showed a modest average increase of 3.6%, with a range of -3.8% to +11.5%. The GCM's also predicted a 1.5ºC to 2.8ºC temperature increase by 2050.

- The downscaled instream flow impacts suggest a risk of significant decrease in surface water availability, with an average decrease of 8.4% across all basins. These projected impacts have considerable variation across the SSRB sub-basins. The instream flow decrease could be highest in the Red Deer basin at -13%, followed by the Bow River basin at -10%, the South Saskatchewan basin at -8.5% and the Oldman basin at -4%.

- The SSRB population could easily double from 1.5 million to 3.1 million, with the strongest growth being in the Bow River basin.

- By 2046, irrigation consumption (withdrawls minus return flow) could increase by 23%

- Climate change is likely to reduce water availability by approximately 546 million cubic meters between 1996 and 2046, while the rise in consumption from irrigation could be 440 million cubic meters under a medium growth scenario.

- The SSRB will continue as a pivotal agricultural region, with irrigation capacity and efficiency already achieved in Alberta.

- The share of surface water used for agriculture across Canada is only 9%, it is almost 50% in the Prairie Provinces, and 86% in the SSRB.

- Growth in irrigation is most likely to put most pressure on the SSRB surface water supplies due to its high water consumption and scale of water use.

- Thermal industrial sectors have the potential to impact significantly on water quality (including temperature) as well as increase water use, retention and demand in response to an expanding economy.

- Changes in timing of return flows may prove critical in balancing actual water consumption.

- The SSRB is highly vulnerable to climate change as stakeholders face increasing temperatures, accelerated evaporation and a more active precipitation cycle. Agricultural users are particularly vulnerable to abrupt changes. Adaptive challenges due to the gradually shifting conditions will likely be exacerbated by more frequent extreme events such as flooding, drought, hail and windstorms.

- Critical ecological (instream flow) needs plus baseline human consumptive need operate within overall water availability, leaving the unallocated portion of water available (essentially, a “buffer”) to absorb all additional demands, including consumptive growth and climate change as well as the uncertainty and variability associated with both.

There are results for the hydrological models under six climate change scenarios by sub-basin in the SSRB. Included in this report are the results for only the South Saskatchewan River sub-basin. The data is an average of the monthly flow in cubic meters per second converted to million cubic meters (MCM) per year.

The top part of Table 1 shows the annual naturalized flow of water through each hydrometric station located within the sub-basin. The first row is the current yearly naturalized flow calculated for the base period 1961- 1990. This flow accounts for all human withdrawls and diversions. It should be noted that flows at station HG001 are lower than the station AJ001 upstream of Medicine Hat. This is due to the large amount of evapotranspiration at Lake Diefenbaker. Naturalized flows do not account for this dimension.

The second row provides the modeled flow for the 1961-90 calibration period. These differ from the calculated naturalized flows since a perfect calibration is not possible.

Following these are the anticipated flows from the six future climate scenarios. These were calculated by inflating (or deflating) the current naturalized flows by the percent change in modeled flow. In general, the ECHA scenarios lead to the driest outcomes and the NCARA lead to the wettest. What are ECHA and NCARA?The South Saskatchewan, as the downstream collector, gets an average of these results with a potential rise of 7 percent under the wet scenario and a decrease of 14 percent under the dry.

As a measure of dispersion, the difference between the wettest and driest scenarios was reported as a ratio to the average scenario. For the South Saskatchewan the dispersion is around 30 percent, with the Red Deer at 50 percent and the Oldman and Bow rivers at about 20 to 25 percent. The large differences show two things. First, the climate scenarios, that are the basis for the hydrological modeling, are quite different in their implications for temperature and precipitation. Second, the hydrological implications at the basin level are sensitive to the choice of scenario: change the scenario and the outcome changes dramatically. This uncertainty makes predicting future flows difficult and, as such, these outcomes are to be viewed as guides. Although the scenarios cannot predict catastrophic changes in the SSRB, they do point to a risk of significant reductions in water.

	South Saskatchewan River			
	AJ001	**HD036**	**HG001**	**HH001**
Naturalized Flows (1961-90)	**7099**	**32**	**6445**	**6264**
Modeled Flows	**7857**	**102**	**11382**	**11524**
Climate Scenario				
echa21a	5906	26	5026	4877
echb21b	5987	27	5204	5049
hada21a	6941	32	6114	5930
hadb21b	6486	29	5555	5391
ncara21a	7521	35	6985	6777
ncarb21b	7164	32	6513	6329
Climate Scenarios				
Average	**6667**	**30**	**5900**	**5726**
(max-min)/avg	0.24	0.30	0.33	0.33
Avg/current	0.94	0.96	0.92	0.91
Gain/Loss*				
Ave. Gain/Loss	**-431**	**-1**	**-546**	**-538**
as a fraction of natural flow	-0.06	-0.04	-0.08	-0.09
Maximum Flow	**423**	**4**	**540**	**513**
as a fraction of natural flow	0.06	0.12	0.08	0.08
Minimum Flow	**-1192**	**-5**	**-1420**	**-1386**
as a fraction of natural flow	-0.17	-0.17	-0.22	-0.22

Table 1- Annual Water Flow (AWF) by climate scenario for South Saskatchewan River sub-basin
**Gain/Loss calculated as (Flow in scenario – Natural Flow)*

Table 2 accounts for all precipitation, evaporation, and net transfers into groundwater. Whatever is unused flows downstream. The Basin Water Supply (BWS) provides a measure of the available water that can be used. As with the flow data, all basins see a net decrease in available water with the exception of the South Saskatchewan River sub-basin where the BWS may actually rise a small amount. Again, there is much variability across the scenarios. It must be noted that most of the water originates from areas closer to the mountains with only a small contribution from the prairies. This is consistent with the view that the prairies are a dry climate. This table suggests that total basin water supply may rise by 8 percent or fall by 22 percent.

As noted above, the scenarios suggest that all river systems may see a rise in availability under the wettest scenarios. However, the scenarios suggest that the South Saskatchewan River would see a nominal increase in BWS even under the driest scenarios. Nonetheless, the net decrease in the other sub-basins leads to a net decrease in the SSRB overall.

	South Saskatchewan River			
	AJ001	**HD036**	**HG001**	**HH001**
Naturalized Flows (1961-90)	**-34**	**32**	**-2350**	**-182**
Modeled Flows	**-233**	**102**	**409**	**142**
Climate Scenario				
echa21a	-20	26	-2038	-148
echb21b	-1	27	-2056	-155
hada21a	113	32	-2312	-185
hadb21b	17	29	-2208	-164
ncara21a	94	35	-2450	-208
ncarb21b	100	32	-2398	-184
Climate Scenarios				
Average	**50**	**30**	**-2244**	**-174**
(max-min)/avg	2.62	0.30	-0.18	-0.34
Avg/current	-.022	0.30	-5.49	-1.22
Gain/Loss*				
Ave. Gain/Loss	**85**	**-1**	**107**	**7**
as a fraction of base bws	-2.48	-0.04	-0.05	-0.04
Maximum Flow	**147**	**4**	**313**	**33**
as a fraction of base bws	-4.29	0.12	-0.13	-0.18
Minimum Flow	**15**	**-5**	**-100**	**-27**
as a fraction of base bws	-0.43	-0.17	0.04	0.15

Table 2- Basin Water Supply (BWS) by climate scenario for South Saskatchewan River sub-basin

Net Water Supply (MCM)	Red Deer River	Bow River	Old Man	South Saskatchewan River	SSRB
Natural BWS (1961-90)	**1665**	**3841**	**3292**	**-2535**	**6264**
Climate Scenario					
echa21a	1131	3094	2832	-2179	4877
echb21b	1247	3143	2845	-2185	5049
hada21a	1454	3545	3283	-2353	5930
hadb21b	1248	3337	3131	-2325	5391
ncara21a	1878	3896	3532	-2529	6777
ncarb21b	1715	3760	3304	-2451	6329
Avg. Climate Scenario	**1446**	**3462**	**3155**	**-2337**	**5726**
as a fraction of base BWS	0.87	0.90	0.96	0.92	0.91
Driest scenario	**1878**	**3896**	**3532**	**-2179**	**6777**
as a fraction of base BWS	1.13	1.01	1.07	0.86	1.08
Wettest scenario	**1131**	**3094**	**2832**	**-2529**	**4877**
as a fraction of base BWS	0.68	0.81	0.86	1.00	0.78
Avg. gain/loss	**-220**	**-378**	**-137**	**198**	**-538**
as a fraction of base BWS	-0.13	-0.10	-0.04	0.08	-0.09
Max. gain	**213**	**55**	**240**	**355**	**513**
as a fraction of base BWS	0.13	0.01	0.07	0.14	0.08
Min. gain	**-535**	**-747**	**-460**	**5**	**-1386**
as a fraction of base BWS	-0.32	-0.19	-0.14	0.00	-0.22

Table 3- Gains/Losses due to climate change by major sub-basin

Current water withdrawls and consumption can be mapped into each major sub-basin. In 1996, total non-irrigation withdrawls were 514 MCM, constituting 8.2 percent of total water supply. Non-irrigation consumption was estimated at 155 MCM which is only 2.5 percent of basin supply.

In 1996, irrigation withdrawls in the SSRB were 2,522 MCM. Irrigation diversions constitute about 40 percent of total basin supply. Table 4 outlines current natural flows after accounting for consumption at each point in the river. It is done by taking the flow at a point and subtracting all upstream consumption which outlines how much water is left in the river. The average of water loss from all six climate change scenarios is considered 'consumption'.

Overall, the climate change effect of 538 MCM is about one quarter of the human demand for water.

	Red Deer River	**Bow River**	**Old Man River**	**South Saskatechewan River**
Current Natural Flow (1961-90)	**1665**	**3841**	**3292**	**6264**
Upstream Consumption	**462**	**831**	**369**	**2083**
as a share of natural flow	0.28	0.22	0.11	0.33
Flow adjusted for irrigation and non-irrigation demands	**1203**	**3009**	**2923**	**4180**
as a share of natural flow	0.72	0.78	0.89	0.67
AVG Climate Change Net Gain/Loss	**-220**	**-378**	**-137**	**-538**
as a share of natural flow	-0.13	-0.10	-0.04	-0.09
Flow adjusted for irrigation and non-irrigation consumption and climate change	**983**	**2631**	**2786**	**3642**
as a share of natural flow	0.59	0.68	0.84	0.58

Table 4- Adjusted Flow by major sub-basin

The difference between human consumption and loss due to climate change suggests that mitigation of climate change is possible. In the SSRB, human consumption is four times as much as anticipated climate 'consumption'.

Human demands could be reduced to absorb climate change losses and maintain current flows; however, the costs of reducing demand may not be worth the reduction and impact of reduced water flows. For example, if irrigators were to absorb the water loss by reducing their consumption one-for-one. The cost of reducing water withdrawls by irrigators is estimated to be $0.11/cubic meter or $110,000 per MCM. If we 'replace' the lost 538 MCM by reducing irrigation consumption, then the direct cost to irrigators in terms of lost net revenues is about $78 million.

Finally, a ‘worst case scenario’ for year 2046 was formulated in the SSRB final technical report. Climate scenario ‘echa21a’ reduces available water flows by 1386 MCM or 22 percent for the basin as a whole as shown in Table 5.

	Red Deer River	**Bow River**	**Old Man River**	**South Saskatehcewan River**	**SSRB**
Current Natural Flow (1961-90)	**1665**	**3841**	**3292**	**6264**	**6264**
Current 1996 Consumption	**462**	**831**	**369**	**420**	**2082**
Human Consumption as a fraction of base flow	0.278	0.216	0.112	0.067	0.332
Driest Climate Scenario	**1131**	**3094**	**2832**	**4877**	**4877**
Gain/Loss	-535	-747	-460	-1386	-1386
Driest Scenario as a fraction of base flow	-0.32	-0.19	-0.14	-0.22	-0.22
Combined Human Consumption (1996) and Driest Climate Scenario	**997**	**1579**	**829**	**1807**	**3468**
as a fraction of 1961-90 flow	0.599	0.411	0.252	0.288	0.533

Combined Demand Growth and Climate Change					
2046 low growth	**1026**	**1612**	**839**	**1837**	**3572**
as a fraction of 1961-90 flow	0.616	0.420	0.255	0.293	0.570
Human consumption as a fraction of base flow	0.295	0.0.225	0.115	0.072	0.349
2046 medium growth	**1160**	**1782**	**941**	**1926**	**4068**
as a fraction of 1961-90 flow	0.696	0.464	0.286	0.308	0.649
Human consumption as a fraction of base flow	0.375	0.270	0.146	0.086	0.428
2046 high growth	**1214**	**1903**	**980**	**1984**	**4340**
as a fraction of 1961-90 flow	0.729	0.496	0.298	0.317	0.693
Human consumption as a fraction of base flow	0.408	0.301	0.158	0.095	0.472

Table 5- Worst Case Scenarios by Major sub-basin: Instream Flows (2046)

The SSRB final technical report concludes that, on average, the scenarios point to a drier climate with significant drying in the Prairies which will reduce both net basin supply and annual streamflows. It must be noted that annual flow charts may hide critical data. Monthly variations in streamflow and consumption show the possibility that summer flows can be significantly lower than current natural flows. This is partly because consumption demands are concentrated in the summer, as are supply loses.

Most of consumption growth is expected to come from irrigation. There is no anticipated increase in the licensed allocations, but rather, the higher irrigation demand will result from a more intensive use of licenses as operators battle lower precipitation and higher evapotranspiration. Also, the growth in irrigation demand will most likely emerge in the summer months where stresses are already occurring. Irrigation demand will remain the dominant consumption despite the fact that non-irrigation demands are expected to double within the next 40 years.

The data does not predict ecological collapse or an unsustainable growth of population and economics; rather, the data suggests that we will face a serious problem. If human consumption does not change to accommodate a fall in water supplies, and consumption nears ecological limits, then there will be extreme water stresses and the potential for ecological collapses.

One possible solution presented by the SSRB technical report, is the building of reservoirs to preserve instream flows. These reservoirs may be able to ‘transfer’ winter flows to meet late summer irrigation needs. However, under the driest scenarios, there may be too little water for sufficient ‘transfers’.

Given the current understanding of the effects of climate change and the anticipated growth in water demand, nothing is inevitable. This analysis describes the need to consider both climate change and human demands as potential problems as society moves into the future. [24]

Glossary

Allocation- The systematic distribution of a limited quantity resource

Bioaccumulation- The accumulation of a substance, such as a toxic chemical, in various tissues of a living organism. Bioaccumulation takes place within an organism when an organism eats several smaller organisms contaminated with a toxic substance. This substance remains within the larger organism. The rate of intake of a substance is greater than the rate of excretion or metabolic transformation of that substance

Coagulation- To cause transformation of a liquid or solids into a soft, semisolid, or solid mass

Flocculation- To cause the cloudy material in water to form fluffy masses

Non-point Source Pollution- Associated with runoff and erosion from construction, agricultural areas, forestry operations, industry and even city streets. These sources are difficult to identify in terms of quantity, time of discharge and content.

Organic Compounds- Materials that contain carbon and hydrogen and usually other elements such as nitrogen, sulphur and oxygen. "Organic" means that it is carbon based.

Point Source Pollution- Direct discharge of polluted effluent into lakes and rivers. i.e., sewage and industrial waste

PCB’s (polychlorinated biphenyl) - A class of organic compounds. PCB's were widely used for many applications, especially as dielectric fluids in transformers and capacitors and coolants. Due to PCB's toxicity and classification as persistent organic pollutants, PCB production was banned by the United States in 1976 and by the Stockholm Convention on Persistent Organic Pollutants in 2001.

Turbidity- refers to suspended particles in water. Turbidity directly relates to the color and clearness of water.

Interesting Facts

Developing nations are less fortunate: 80% of their diseases are water-related [(15)]
In all regions except Europe and North America, agriculture is by far the biggest user of water, accounting worldwide for about 69% of all withdrawals. [(15)]

Water quantity monitoring in Alberta dates as far back as 1894.

The oldest sites with continuous water measurements are the Bow River at Calgary and the Bow River at Banff, which have both been recording water flows since 1904.

State-of-the-art analytical instruments can detect down to one part per trillion of some substances. This is comparable to tracing one thousandth of a teaspoon of salt dissolved in an Olympic-size swimming pool.

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The **South East Alberta Watershed Alliance (SEAWA)** was formed in 2007 and incorporated as a non-profit society in 2008. SEAWA is the designated WPAC (Watershed Policy and Advisory Council) for South East Alberta. SEAWA Members include interested individuals throughout the watershed along with our communities, ranchers, farmers, industries, companies, governments, conservation groups and educational institutions.

SEAWA Vision: *A healthy watershed that provides balance between social, environmental and economic benefits.*

SEAWA Mission: *South East Alberta Watershed Alliance brings together diverse partners to plan and facilitate the sustainable use of the South Saskatchewan River Watershed for present and future needs.*

SEAWA has over two hundred members and encourages new individual and community sector members. We are proud to include the following among our founding members:

Government Sector: Alberta Government, City of Medicine Hat, Government of Canada, Cypress County, Palliser Health Region, Town of Redcliff, Town of Bow Island, and Special Areas Board.

Land Resource - Industry and Agriculture Sectors: St Mary River Irrigation District, Murray Lake Ranching, GG Bruins Farms, Short Grass Ranches, Canadian Fertilizers Limited, Redcliff Technology Enterprise Centre, Box Springs Business Park, and Canadian Centre for Unmanned Vehicles.

Academic, Research and Non-Governmental Organizations Sectors: Medicine Hat College, Alberta Research Institute, Red Deer Watershed Alliance, and Hyperion Research.

Tourism and Conservation Sectors: Grasslands Naturalists, Canadian Badlands, and Medicine Hat Interpretive Program.

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