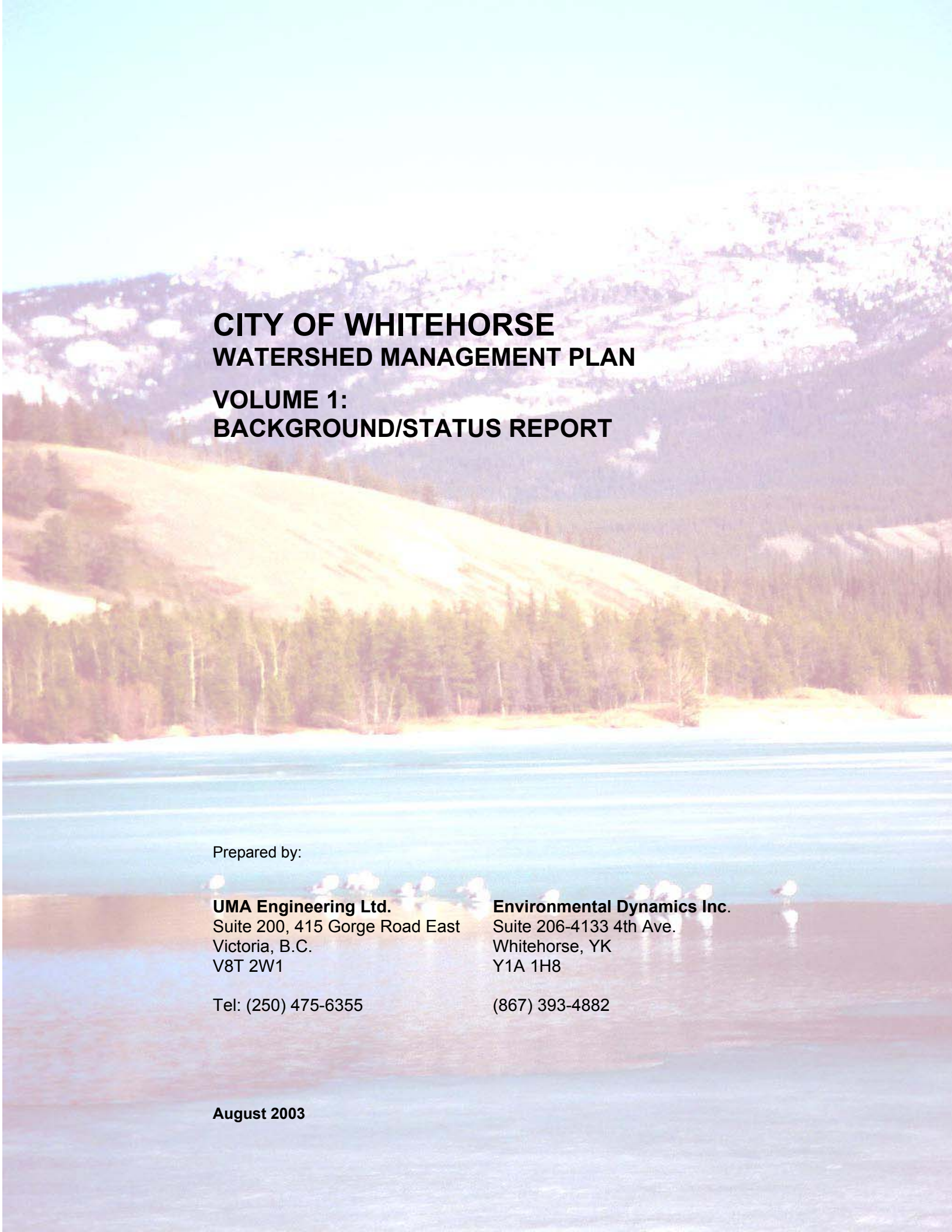




CITY OF WHITEHORSE WATERSHED MANAGEMENT PLAN VOLUME 1: BACKGROUND/STATUS REPORT

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GLOSSARY

The following list provides definitions of terms used in this report. Definitions given are in the context of this report.

alkalinity - The capacity of water to neutralize acids, expressed in milligrams per litre of equivalent calcium carbonate.

alkalinity - The acid-neutralizing capacity of water, primarily due to the presence of carbonates, bicarbonates, and hydroxides.

aquifer - An underground geologic formation capable of storing water.

anthropogenic - Man-made.

avian - Pertaining to birds.

bacteria - Single-celled micro-organisms, some of which may be disease-causing.

bathymetry - Mapping the contours of lake beds or ocean floors.

chloramination - Treating drinking water by applying chlorine before or after ammonia. This creates **chloramines**, which provide a persistent disinfectant residual.

chlorination - The addition of **chlorine** to water, for the purpose of disinfection, or the destruction of disease-causing micro-organisms.

chlorine residual - The concentration of chlorine remaining in water after disinfection.

coliform - A group of bacteria commonly found in the environment. They are rod-shaped, gram negative, and spore forming, and are an indicator of the potential contamination of water. Disinfection effectively destroys coliform bacteria. A sub-group, **fecal coliform**, may indicate the presence of human or animal fecal matter in water.

conductivity - A measurement of the ability of a water sample to conduct electricity. The higher the conductivity, the higher the concentration of dissolved matter in the sample.

contaminant - Any natural or man-made physical, chemical, biological, or radiological substance or matter in water, which is at a level that may have an adverse effect on public health, and which is known or anticipated to occur in public water systems.

Cryptosporidium - A disease-causing parasite, resistant to chlorine disinfection. It may be found in fecal matter or contaminated drinking water.

E. coli - *Escherichia coli* is a bacterium commonly found in the human intestine. For water quality analyses purposes, it is considered an indicator organism. These are considered evidence of water contamination. Indicator organisms may be accompanied by pathogens, but do not necessarily cause disease themselves.

ecosystem - A community of organisms and its physical environment.

enterovirus A virus whose presence may indicate contaminated water; a virus which may infect the gastrointestinal tract of humans.

eutrophic - Refers to a lake that is, literally, “old” in terms of its productivity of algae and other plant growth, due to the presence of nutrients required for such growth.

evapotranspiration - An approximation of the total water use of a natural area, combining evaporation and transpiration, or the use of water by plants.

filtration - A process that physically removes particles from water.

fluoridation - The addition of fluoride to water, in order to protect the enamel on human teeth.

Giardia lamblia - A pathogenic parasite which may be found in contaminated water.

glaciation - Processes related to glaciers.

glaciolacustrine - Pertaining to lakes formed by glaciers.

halogens - A group of elements that includes chlorine, fluorine, bromine, iodine, and astatine.

hardness - A measurement of the total amount of calcium and magnesium in water, expressed as calcium carbonate. The harder a water is, the more it will precipitate soap, making it more difficult to wash.

hydrocarbons - Generally pertains to petroleum products, e.g. oil, gasoline, diesel fuel.

hydrogeology - The study of groundwater.

hydrology - The study of the properties, distribution and effects of water on the earth's surface.

igneous - Pertaining to rocks formed by the solidification from a molten state.

impervious - Not allowing, or allowing only with great difficulty, the movement of water.

lacustrine - Pertaining to lakes.

limnology - The study of lakes.

microbe - Any minute, simple, single-celled form of life, especially one that causes disease.

mg/L - Milligrams per litre

mL - Millilitre

moraine - An accumulation of boulders and other debris deposited by a glacier.

nitrates - A soluble form of nitrogen found in fertilizers and sewage by-products which may leach into groundwater and other water sources. Nitrates may also occur naturally in some waters. Over time, nitrates can accumulate in aquifers and contaminate groundwater.

NTU - Nephelometric Turbidity Unit. A measure of the clarity of water.

nutrients - In the context of lakes, the main nutrients are nitrogen and phosphorous, which encourage the growth of aqueous plants and animals.

oligotrophic - Unproductive and low in nutrients. Pertaining to lakes, this means the waters are generally clear and clean.

ooocysts - Resistant cells that are one part of the life cycle of the *cryptosporidium* organism.

pathogens - A pathogen is a bacterium, virus or parasite that causes or is capable of causing disease. Pathogens may contaminate water and cause waterborne disease.

pH - A measure of the acidity of water (the negative log of the hydrogen ion concentration).

piezometer - A tube installed in a groundwater well that measures the water elevation, or *piezometric level*.

potable water - Water that is safe to drink.

protista - Single-celled organisms, including protozoans, bacteria, some algae, and other forms not classified as either plant or animal.

raw water - Water that has not been treated in any way; which is generally considered to be unsafe to drink.

riparian zone - The area of vegetation that borders rivers, streams, and wetlands, and which is transitional between terrestrial and aquatic ecosystems.

sediment - Soil particles in the water, primarily silts and clays held in suspension.

sedimentary - Pertaining to rocks formed from sediment, or from transported fragments deposited in water.

surface water - Water which is open to the atmosphere and subject to surface runoff i.e. lakes, streams, and rivers.

toxoplasmosis - A disease caused by a single-celled parasite, *toxoplasma gondii*.

treated water - Disinfected and/or filtered water served to water system customers. It must meet or surpass all drinking water standards to be considered safe to drink.

trihalomethanes (THM) - Four separate compounds including chloroform, dichlorobromomethane, dibromochloromethane, and bromoform, that may be formed during disinfection with chlorine.

turbidity - A measure of the cloudiness of water caused by suspended particles.

virus - Submicroscopic pathogens, smaller than bacteria, consisting essentially of a core of a single nucleic acid surrounded by a protein coat.

watershed - An area which drains all of its water to a particular watercourse or body of water.

water works - All of the pipes, pumps, reservoirs, dams and buildings that make up a water system.

EXECUTIVE SUMMARY

The Watershed Management Plan is intended to set the direction for managing the City of Whitehorse source water areas for the purpose of protection of source water quality. The year 2003 marks the first time that a formal process has been undertaken in recognition of the importance of the watershed of the upper Yukon River basin for producing an ample supply of safe, high quality drinking water. The Watershed Management Plan is also guided by the knowledge that the watershed fulfills many other economic, social, cultural and environmental needs.

**The City of
Whitehorse
wants to ensure
source water
quality protection**

This Background/Status Report provides information on the current status of the watershed that supplies the City's drinking water, including a preliminary source water assessment and evaluation of land uses and activities with the potential to affect source water quality. Also included is information on important components of watershed-based drinking water protection, as well as examples of approaches to watershed management planning in other communities and jurisdictions. Finally, the report documents some of the lessons learned from consultations with the public in and around Whitehorse regarding their drinking water and the watershed in which they live. This report serves as a foundation for the subsequent evaluation of risks to the drinking water supply and development of recommendations for regulations, guidelines, policies, tools, and monitoring for watershed protection.

The City of Whitehorse obtains about one third of its annual potable water needs from groundwater collected from the Selkirk Aquifer to the immediate east of the Yukon River within the Riverdale area of the city, and about two-thirds from Schwatka Lake from an intake pipe east of the hydroelectric dam.

Year-round recreational and other uses of Schwatka Lake have raised concerns about potential for introduction of various types of contaminants, and the preservation of water quality. The Yukon Department of Health and Social Services and others have expressed a desire for a watershed management plan that will facilitate some of the day-to-day decisions about activities in the portions of the Yukon River watershed that could potentially affect drinking water quality and possibly result in increased human health risks.

The responsibility for good quality source water in Canada is divided among many different parties. The protection of drinking water quality through appropriate watershed and groundwater management is a shared responsibility of all orders of government, communities, the private sector, and individual Canadians.

**Protection of
drinking water
quality is a
shared
responsibility**

The protection of source water quality is the first element of a multi-barrier approach to drinking water protection. It is an alternative to the over-reliance on treatment and compliance monitoring of drinking water quality at the tap.

Building on the City's Official Community Plan, the following draft vision statement captures the City's watershed management interests:

"The watershed of the Yukon River, its sub-watersheds and lakes in the Whitehorse region, and the groundwater aquifers they are connected to, are essential to the health of the community. Governance of these resources shall focus above all on the protection of source water quality.

In addition, watershed management strategies and initiatives shall recognize the value of the watershed for social, cultural and economic activities, as well as the integral role of these activities in sustainable communities. Strategies and initiatives shall embrace only those activities that are compatible with and enhance source water protection.

Finally, watershed management is a shared responsibility and brings with it a commitment to collaboration with all interested parties."

There are a variety of reasons why watershed management plans (WMPs) are initiated. For example, WMPs are developed to protect fisheries, enable ecosystem restoration, address flooding, or guide specific land use activities such as agriculture and forestry.

In Canada, there are only a few municipalities that have developed WMPs specifically for drinking water protection. On the other hand, there has been extensive discussion especially at the national and provincial level about the importance of a "source-to-tap" approach to drinking water protection. Eight of ten provinces (but none of the territories) have substantially re-evaluated the way in which they manage drinking water supplies and protection since 1999. Approaches vary in different provinces. Ontario intends to make the development of watershed management plans a mandatory requirement for drinking water providers. British Columbia has established dedicated Drinking Water Officers who will oversee "source-to-tap" assessments for BC communities. Both Ontario and Quebec have recognized the need for the amalgamation and integration of all legislation to more effectively deal with matters related to drinking water protection, treatment, and distribution.

The Whitehorse 2002 Official Community Plan (OCP) discusses the City's growth projections and trends. In 2001, 4.6 million m³ of water were drawn into the City's distribution system. This serves the needs of city residents and also people in surrounding areas who are served by trucked water. The overall population served by the City's distribution system was estimated at 22,649 in the Year 2001. The average per person use of potable water in 2001 was 203 m³/person/year. By 2030, the City might require 8.2 million m³ of water annually (or 8.2 billion litres).

The Yukon River Basin near Whitehorse receives very limited precipitation annually owing to its position in a rain shadow, while Yukon River headwaters lie in a wetter, more mountainous climate. The majority of streams in the study area exhibit peak flows in May, following the annual snowmelt. The Yukon River near Whitehorse has an atypical hydrograph, however, and peak flows occur later in the summer, owing mainly to the late melting of high elevation glaciers and snow fields.

The Selkirk Aquifer is hydrologically linked to the water mass in Schwatka Lake and the Chadburn Lake outwash complex. Recharge areas for this aquifer are currently relatively undeveloped, and some protection is afforded through green space provisions in the 2002 Official Community Plan.

Generally, the Schwatka Lake surface water supply for the City has exhibited good quality, with the exception of high seasonal turbidity, coliform concentrations in raw (but not treated) water, and evidence of *Giardia* cysts. The groundwater supply is of excellent quality, with low to moderate hardness, and no evidence of human-related nutrient or bacterial inputs.

Existing water
quality is good

The feedback received from early public and stakeholder consultations is presented in this report, as a pre-requisite for the further detailed evaluation of risks to the drinking water supply, and development of watershed-based management options.

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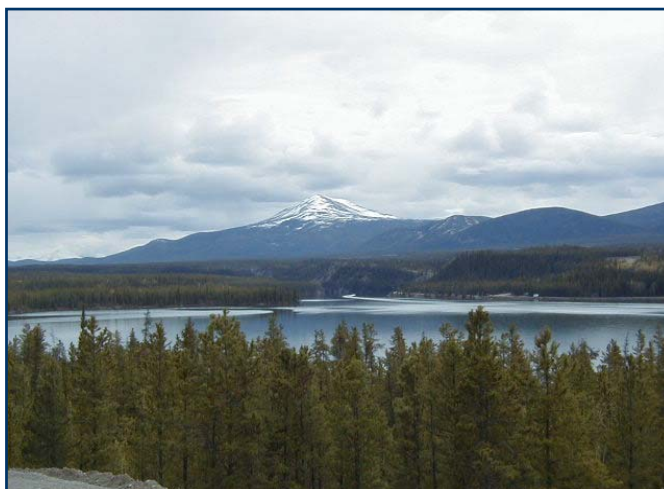


1. INTRODUCTION

1.1 Background

The City of Whitehorse has committed to preparing a **Watershed Management Plan** to help ensure continued high quality drinking water for the City. The **Plan** is intended to protect Schwatka Lake and the surrounding watershed, and to preserve, protect, and enhance water supply areas by keeping recharge areas free from incompatible development and sources of contamination.

The City derives its water from two supply sources - surface water and groundwater. Surface water is drawn from Schwatka Lake, which provides about two-thirds of the annual water used by the people of Whitehorse - a total of more than 3 million m³ per year. The lake was created by the construction of a hydroelectric dam across the Yukon River in 1959. To that point in the watershed, the Yukon River collects surface runoff from an area of approximately 22,000 km². Runoff going directly to Schwatka Lake is generated from an area of about 3,500 km².



Schwatka Lake with Golden Horn in Background

The City's
Source
Waters

Groundwater is obtained from the Selkirk well field, in the Riverdale area, which pumps about one-third of the city's water needs into the water distribution system - approximately 1.6 million m³ per year.

Groundwater is added to the surface water in the winter in order to increase the temperature of the water in the distribution system, and reduce freezing problems and heating costs. In the spring, groundwater is added in order to counter the higher levels of suspended sediments in the surface water, commonly referred to as "turbidity". Some thought has been given to the possibility that groundwater supplies close to the City could provide an expanded portion of the City's potable water needs. A preliminary study on the estimated available groundwater supply has recently been completed. This and previous studies indicate that complete reliance on a groundwater supply may be feasible.

The source water, prior to distribution and consumption, is chlorinated to disinfect it without any additional filtration or other forms of treatment. The City is considering additional treatment steps, such as water filtration and softening.

Year-round recreational and other uses of Schwatka Lake have raised concerns about potential for introduction of various types of contaminants, and the preservation of water quality. The Yukon Department of Health and Social Services and others have expressed a desire for a watershed management plan that will facilitate day-to-day decisions about activities in the portions of the Yukon River watershed that could potentially affect drinking water quality and possibly result in increased human health risks. According to Dr. Bryce Larke, the Yukon's Medical Health Officer, "the current thinking regarding safe drinking water stresses the importance of, and need for, a multi-barrier approach that begins at the watershed source, includes an appropriate water treatment plant, staffed by well-trained competent personnel, and is completed by an efficient distribution system ending at the consumer's tap".

Impetus for
concern

Recently, there has been a strong public and regulatory interest in drinking water quality throughout North America. **It is generally recognized that preventative strategies, which seek to maintain a baseline water quality in the supply prior**



A well for drinking water extraction from the Selkirk field, in the Riverdale Area.

to its treatment, will have many benefits. Protection of source water quality will minimize the necessity for more expensive treatment. Perhaps more importantly, source protection ensures that activities within the watershed are more formally evaluated against possible loss or impairment of potable water resources for the future.

The City of Whitehorse is not unique in having a drinking water supply that is also intimately tied to other aspects of lifestyle, including recreational opportunities. Within Canada and the United States, there is a broad spectrum of management strategies for community drinking water supplies, with few clear-cut

choices for the most appropriate approach based on scientific/technical issues alone. At the one end of the Canadian spectrum are the cities of Vancouver and Victoria, where the source water is protected by an almost complete prohibition of public access to the watersheds. At the other end of the spectrum are those communities drawing potable water from lakes and rivers that also serve as recreational areas, transportation corridors, and even discharge bodies for treated effluent. Examples of

communities wherein recreation occurs on surface waters that serve as a drinking water supply include Kamloops, Kelowna, Cranbrook, Calgary, and Saskatoon. In fact, the majority of Canadians obtain their drinking water from lakes and rivers while only 26% overall rely on groundwater for their major source of potable water¹. Most communities in Canada obtain their drinking water from multiple use as opposed to single use watersheds.



The Yukon Energy Corporation Dam, built in 1959, converted the historically significant White Horse Rapids into Schwatka Lake.

The drinking water intake is located at a depth of approx. 2 m below the surface, to the right of the dam in the photograph.

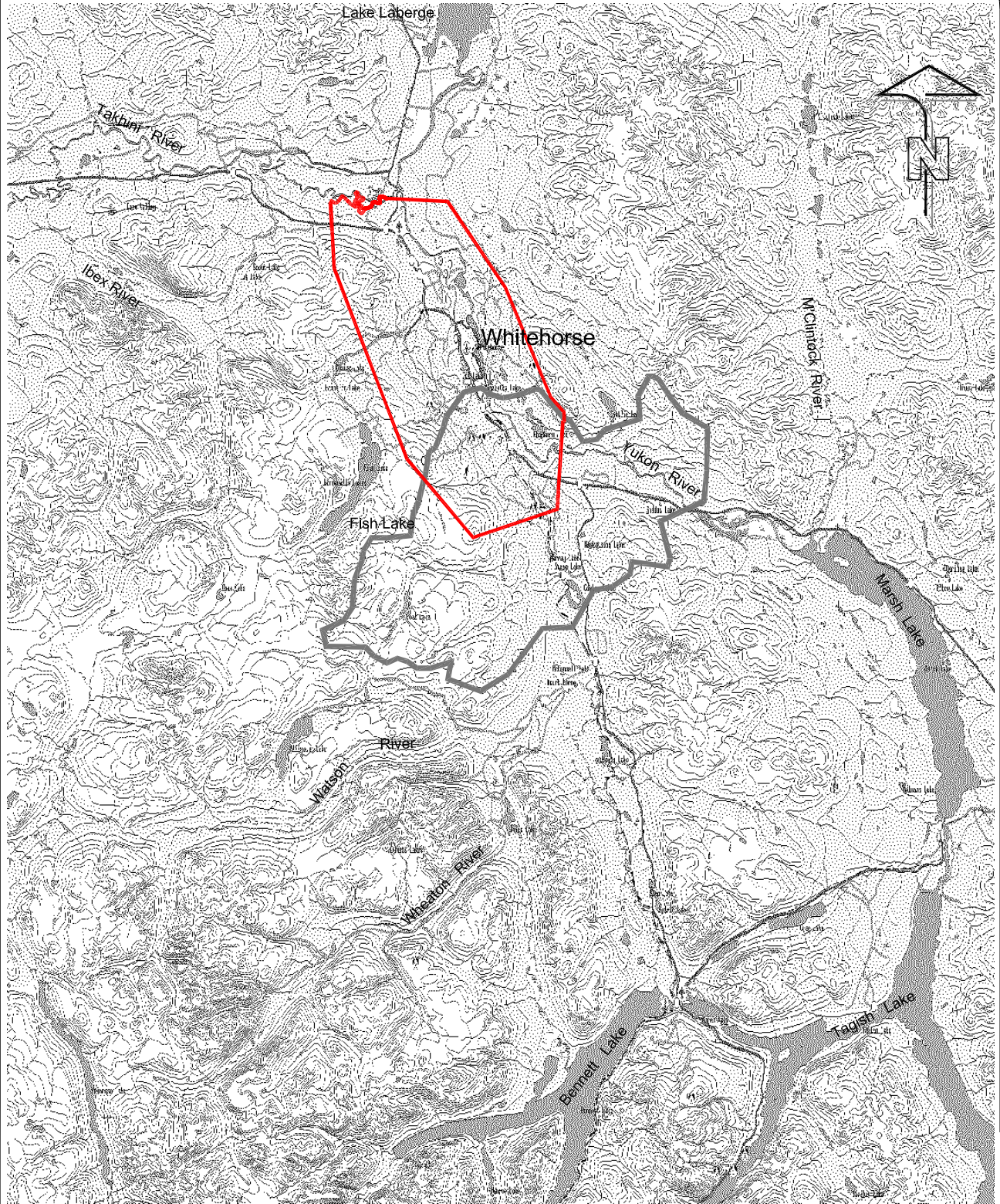
There are often complex links between surface water and/or groundwater protection and the technical challenges associated with maintaining drinking water quality. Therefore, a major aspect of watershed management plans is public education. In smaller communities, especially those established around lakes and rivers, community stewardship initiatives have arisen in the last decade as part of the solution for minimizing conflicts between watershed protection needs and various other human activities.

A role for
public
education and
community-
based
stewardship

The development of a Watershed Management Plan by the City of Whitehorse offers an excellent opportunity to examine the possibilities for safeguarding drinking water quality, in light of the best available science and in anticipation of future regulatory and other trends, and to engage Whitehorse residents in participatory planning.

This study focuses on the watershed downstream of the Yukon River bridge at Marsh Lake to the outlet from Schwatka Lake at the Yukon Energy Corporation dam, and on the sub-watersheds entering the Yukon River between that point and Schwatka Lake, as shown on Figure 1-1.

¹ Environment Canada, 2003. Water and Canada: Preserving a Legacy for People and the Environment. (available online at http://www.ec.gc.ca/water/en/info/pubs/wwf/e_contnt.htm)



LEGEND

- CITY BOUNDARY
- STUDY WATERSHED BOUNDARY

SCALE 1:500000



City of Whitehorse
Watershed Management Plan

Study Area

Figure 1-1

In addition to areas that drain directly into the Yukon River, the northern portions of Marsh Lake, or Schwatka Lake, there are five sub-watersheds that contribute to the study watershed: Yukon River east, Cowley Creek, Wolf Creek, MacRae Creek, and McLean Lakes. Also, the study and plan focus on areas near the City that can influence groundwater properties, especially in and up gradient from the Selkirk well field.

Other issues may arise in locations outside of this defined area, which are important from the perspective of source water protection for the City of Whitehorse. One example that was mentioned during public consultations was a possible influence on water quality of residential developments on Marsh Lake. Where such issues have been identified, we have attempted to accommodate them within the City of Whitehorse watershed management planning process.

1.2 A Shared Responsibility

The responsibility for good quality source water is divided among many different entities. The dependence on a large number of responsible parties, whose efforts at times may be poorly integrated, could potentially affect the ability of the City and its residents to achieve its vision, goals, and objectives for source water protection. The Canadian regulatory establishment has been publicly criticized on several occasions for the fragmented approach undertaken for drinking water protection.

Watershed protection is a shared responsibility

The Federal Government is responsible for managing boundary waters shared between Canada and the United States. The Federal Government also has responsibilities, based on the Constitution, for water on federal lands, including Canada's three territories (Northwest Territories, Yukon, and Nunavut), national parks, and First Nations communities.



Water pumps at the Selkirk pumping station

Canadian provinces have the primary jurisdiction over most areas of freshwater protection and management. Provinces may choose to delegate a portion of their authority to municipalities, regional districts, and improvement districts. Traditionally, responsibility for drinking water treatment and distribution, as well as sanitary wastewater treatment, has been delegated to the municipal level. Most water uses are licensed by the territories and provinces.

In the territories, province-like responsibilities have been progressively delegated to them by the Federal Government in recent years; however, in a few cases the jurisdictional responsibility remains unclear. The Yukon Territorial Government has recently acquired responsibility for freshwater protection as well as some aspects of human health protection.

The City of Whitehorse, like provincial municipalities, has the responsibility for the collection, treatment and distribution of drinking water. The responsibility for source water protection and watershed management has not been formally delegated to the City of Whitehorse by the Yukon Territorial Government or Indian and Northern Affairs Canada.

The watershed that supplies the City's drinking water stretches far beyond the City's formal boundaries. In addition to the jurisdictional importance of the Yukon Territorial Government and Federal Government, finalization of land-claim agreements between the Government of Canada and the Kwanlin Dun and Ta'an Kwach'an establish selected lands within the watershed under the jurisdiction of these First Nations.

The watershed
is large and
multi-
jurisdictional

The protection of the watershed that provides potable surface and groundwater for City of Whitehorse residents is a shared responsibility by all orders of government, communities, the private sector, and individuals. If there is anything to be learned from the collective Canadian experience, perhaps it is that voluntary measures for watershed protection may be at least as important as regulatory compliance instruments, and that strong collaboration is an essential part of the solution.

Cooperation as
important as
regulation

1.3 Goals and Objectives

The objective of this project is to produce a Watershed Management Plan for the water supply feeding into the City of Whitehorse's water distribution system, including the surface watershed and the groundwater aquifer.

Major subsidiary objectives include the identification of activities that might plausibly lead to risks to drinking water quality and human health, or future financial considerations based on use of alternative water supplies or higher levels of treatment beyond chlorination of an unfiltered supply.

The City of Whitehorse Watershed Management Plan includes:

- ☐ Public consultation;
- ☐ A source water assessment (for both groundwater and surface water);

- ❑ Evaluation of land uses and activities with the potential to affect source water quality and/or introduce contaminants into the watershed;
- ❑ Scientific evaluation of the possible risks for human health, based on the possible sources of contamination; and
- ❑ Guidelines and recommendations that will outline in detail the steps that should be taken to manage the risks to the source water, now and in the future

This Background/Status Report provides documentation of the first three of these five components, as a foundation for the formalized evaluation of risks and development of recommendations for regulations, guidelines, policies, tools, and monitoring for watershed protection over the short and long term.

2. EXISTING INFORMATION

The available information on the City of Whitehorse drinking water sources provides the background for the development of a watershed management plan for the City of Whitehorse. This chapter provides a catalogue of existing background information in the form of reports and other study documents. These references have been reviewed in detail, and a synthesis provided in Chapter 3. The references have been sequentially numbered in this Chapter, with brief abstracts provided for each reference. Documents are listed in chronological order, from earliest to latest. The reference numbers are cited in other sections of this report.

In addition to the technical information provided in the various reports, a list of City bylaws, policies and guidelines, and planning instruments, as well as potentially relevant Yukon and Federal legislation and guidance, is provided in Appendix A. These various management instruments have not been evaluated in detail, but will be examined in the final Watershed Management Plan report for their utility in achieving the vision, goals, and objectives of the City's finalized Watershed Management Plan.

Ref.1) Baker, S. A., Environment Canada, *An Environmental Survey of Selected Yukon River Headwaters Lakes Impacted by Communities*, November **1979**.

Biological and water chemistry data were collected from six Yukon lakes in the summer of 1977: Tagish Lake, Bennett Lake, Teslin Lake, Marsh Lake, Lake Laberge, Kluane Lake (at Burwash Landing), and Kluane Lake (at Destruction Bay). High dissolved oxygen and an absence of any significant concentrations of deleterious substances characterized the pristine waters of these oligotrophic lakes.

Marsh Lake was sampled in August and September of 1977. Measured values of phosphate and nitrate were mostly below the detection limit, and all were within acceptable levels. One turbidity value, at 12 JTU, was above the recommended limit, probably as a result of input from the McClintock River.

Ref.2) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Fish Lake Water Supply Study – Working Document #1*, July **1980**.

This report assesses two potential alternatives for a drinking water supply for the City: Fish Lake and west Schwatka Lake. Both alternatives were estimated to have high capital and operating costs, although the Fish Lake alternative was more economical than developing a new supply source on west Schwatka Lake. Additional study of the existing Schwatka Lake supply source and groundwater was recommended.

- Ref.3) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Water Supply Study Working Document No. 2 – Upgrading of the Existing Schwatka/Selkirk Supply System*, June **1982**.

This second *Working Document* reviewed the existing water supply facilities, assessed deficiencies relative to meeting projected demands, investigated water quality and future treatment needs, and provided methods and costs for upgrading the existing supply system. It was foreseen that as water consumption grew, and the proportion of surface water required also grew, it would become necessary to provide filtration to reduce high turbidity in the Schwatka Lake surface water.

- Ref.4) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Water Supply Study Working Document No. 3 – Development of a Complete Groundwater System*, May **1982**.

This report examined the potential quantity and quality of groundwater to fully serve an estimated City population of 35,000 people. It was concluded that the Selkirk aquifer and Whitehorse aquifer, both in the Riverdale area, could provide the total estimated supply capacity needs of 760 L/s. Water quality was judged to be acceptable from a health standpoint, although hardness could require water softening.

- Ref.5) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Water Supply Study Working Document No. 4 - Distribution System Impact Assessment*, March **1982**.

The main objective of this document was to determine what major distribution facilities would be required for the various supply alternatives defined in the other *Working Documents*.

- Ref.6) Whitfield, P.H., McNaughton, B., and Whitley, W.G., “Indications of Ground Water Influences on Nutrient Transport Through Schwatka Lake, Yukon Territory”, *Water Resources Bulletin, American Water Resources Association, Vol. 18, No. 2*, April **1982**.

This paper describes Schwatka Lake as having a surface area of approximately 15 ha and a depth of 6 to 8 m. Samples were collected upstream and downstream of the lake, to examine the transport of nutrients. It was found that more nutrients were present in the lake outflow at the dam, than at the Marsh Lake control structure. This difference varied from less than 1% for total organic carbon to 19.8% for nitrate + nitrite. Silicate did not appreciably increase, leading to the conclusion that erosion was not likely significant within the impoundment. It was surmised that the most likely source of the elevated nutrient concentrations in the outflow was groundwater infiltration.

- Ref.7) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Water Supply Study Working Document No. 5 – Capital and Operating Costs Comparisons for the Water Supply Alternatives*, June **1982**.

Estimates were provided for five water supply alternatives: 1) Fish Lake supply; 2) Groundwater supply only without softening; 3) Groundwater supply only with softening; 4) Schwatka Lake supply without filtration; and 5) Schwatka Lake supply with filtration.

- Ref.8) Stanley Associates Engineering Ltd., for the City of Whitehorse, *Water Supply Study – Summary Document*, November **1983**.

This report reviews the findings of the five *Working Documents* listed above, and recommends upgrading of the existing Schwatka/Selkirk supply system. Due to the reduction of water wastage, major upgrading was not required at the time.

- Ref.9) Jack, M.E., Osler, T.R., and Burns, B.E., *Water Quality – Yukon River Basin*, December **1983**.

The report describes a water quality sampling program on the Yukon River and its major tributaries. Data were collected at 21 stations, 6 of which were upstream of the City of Whitehorse. The upstream station closest to Whitehorse was at the Marsh Lake control structure. This station was monitored weekly in 1980 and 1981 for air and water temperature, pH, conductance, turbidity, colour, alkalinity, hardness, nitrate, nitrite, Ca, Mg, K, Na, Cl, F, Si, and sulphate. The only parameter reported to exceed drinking water and aquatic life objectives (more than 20% of the time) was hardness, at 32 to 52 mg/L as CaCO₃.

- Ref.10) Stanley Associates Engineering Ltd., *Water and Sewer Study*, July **1990**.

This major report summarizes past water and sewer system studies and provides new input and recommendations for system upgrading. Relative to the water system, the report focuses primarily on the distribution system.

Considerable discussion is presented on demand, along with the relevance of leakage and bleeders to prevent freezing. The demand was concluded to be 195 L/s peaking to 295 L/s (maximum day).

In 1990 (as today), the surface water intake on Schwatka Lake provided water through a 550 mm diameter raw water line, running 1,350 m to the Selkirk

pumping station. Four active wells were capable of providing 150 L/s sustained, and a peak flow of 190 L/s. It was recommended that the Whitehorse aquifer be developed in addition to the Selkirk aquifer.

The report states “The security of (lake) water quality in the long term must be established. This will require that steps are taken to ensure that the use of Schwatka Lake by recreational and commercial users is environmentally acceptable.”

- Ref.11) Roach, P.D., Department of Indian and Northern Development, *Yukon Water Policy relating to Giardia and Cryptosporidium*, January 1992.

A field study was conducted in 1991 on drinking water and epidemiological studies for Dawson City and Whitehorse, to determine the prevalence of *Giardia* and *Cryptosporidium* in the surface water supplies. It was concluded that “The water supply for Whitehorse receives periodic challenges” from both micro-organisms, but that *Giardia* is much more common than *Cryptosporidium*. The paper recommended that an accurate Ct value for the Riverdale area needs to be calculated, that the concentration of trihalomethane compounds in the drinking water should be determined, and that consideration should be given to improved treatment of raw water. Limits for *Giardia* and *Cryptosporidium* were recommended for inclusion in the *Guidelines for Municipal Wastewater Discharges in the Yukon*.

- Ref.12) EBA Engineering Consultants Ltd., letter report re: “Environmental Assessment – Schwatka Lake Float Plane Base”, June 22, 1994.

The report describes the Level I and II environmental assessments done on the floatplane base. Work included aerial photograph interpretation, Land Titles Registry search, a site visit, test pit excavation and soil sampling, analysis and interpretation. The site investigated is generally that now occupied by Black Sheep Aviation.

Records indicated that there has been a long history of problems related to improper storage of petroleum products and waste oil disposal. In 1993, two large underground storage tanks were removed. EBA concluded that at least one of these tanks had been leaking, and also noted hydrocarbon staining on the surface in several locations. EBA recommended further sampling and analysis, to be followed by remediation and cleanup.

- Ref.13) Inukshuk Planning & Development et al, for the City of Whitehorse, Transport Canada, and Government of Yukon, *Schwatka Lake Aviation & Land Use Study – Final Report*, (and *Background Documentation* in a separately bound document), November 1995.

This report discusses land and water use issues affecting Schwatka Lake. The concern regarding unregulated use and potential risks to the water supply are examined, particularly in relation to the use of the lake by floatplanes. Concerns about dam operation, boats, and shore-based activities are also discussed. The report concludes that the greatest risk to water quality is bacterial contamination related to upstream development in the watershed.

The report also concludes that the floatplane activity on Schwatka Lake does not pose a sufficient risk to justify relocation, but that the floatplanes should be restricted to the west side of the lake, along Miles Canyon Road. There are detailed recommendations related to management of docks, fuel handling and storage, lack of public washrooms and garbage removal, vandalism and signage.

The *Background Documentation* contains detailed information regarding floatplane use, public consultation, water quality data (1986 to 1994), fisheries (fishway at the dam and fish populations) and archaeology, fuel storage, and docks.

- Ref.14) Mougeot Geoanalysis and Agriculture and Agri-Food Canada, for Planning Services, City of Whitehorse, *Soil, Terrain and Wetland Survey of the City of Whitehorse*, May **1997**.

This study and associated mapping describes soils, terrain, and wetlands within the City of Whitehorse. The soil survey map provides information on texture, associations, drainage, landform topography and sensitivity to development. The terrain classification is based on air photo interpretation, providing estimates of material type and stratigraphy for the upper 5 m of surficial material, permafrost, erosion and flooding risk, and landslide hazard. The wetland maps delineate 130 wetlands at 1:20,000.

Digital versions of the maps were produced using AutoCAD and processed for use with the City's GIS environment. The written report describes landform building processes, soil weathering and classification, mapping procedures, soil association descriptions, and wetland types.

- Ref.15) J.R. Paine & Associates Ltd., for the City of Whitehorse, *Environmental Site Assessment - Schwatka Lake Float Plane Base, Schwatka Lake*, September **1998**.

The study objectives were to test for contaminants at the floatplane base owned by the City, characterize the contaminants if any, determine groundwater and soil conditions, and recommend actions. The report describes test pitting, sampling, and laboratory work, and the hydrocarbon contamination that was found. Recommendations were made for drilling and monitoring.

- Ref.16) J.R. Paine & Associates Ltd, for the City of Whitehorse, *Schwatka Lake Float Plane Base - Excavation and Removal Program*, August **1999**.

The report describes the excavation and removal of hydrocarbon-contaminated soils at the City-owned floatplane base. Approximately 300 m³ of soil were excavated and removed from the site for remediation by land-farming.

- Ref.17) UMA Engineering Ltd. et al, for the City of Whitehorse, *A Planning Foundation and Vision for the City of Whitehorse*, August **2000**.

This report presents the planning foundation (demographic and physical data) and community vision underlying the *2002 Official Community Plan*. The planning foundation includes information on geology, vegetation, wildlife, and physical constraints to development. It also includes historical population growth and projections of growth to the Year 2026.

Section 5.2 of the report describes the City water system as consisting of five metered service areas: Riverdale, Valleyview, Porter Creek, Hillcrest expansion, and Copper Ridge. Map 10 shows the locations of wells, reservoirs, and pumping stations.

- Ref.18) UMA Engineering Ltd., for the City of Whitehorse, *Notes from Public Open House, Visioning Packages, and Visioning Workshops*, August **2000**.

This document is an Appendix to the *Planning Foundation* report. It contains notes on the public input to the process, on likes and dislikes, and desired improvements.

- Ref.19) Underwater Video North, *A Preliminary Underwater Waste Survey of Schwatka Lake*, November **2000**.

An underwater Remote Operated Vehicle was used to inventory waste material at selected locations in Schwatka Lake, primarily along the west side. The survey found twenty-three 200-L steel barrels, three 20-L containers, one engine block, and assorted items including tires, a rubber boot, bottles, aluminum beverage cans, metal screening, dock debris and two concrete blocks. Most of the barrels and other materials were found near the floatplane docks.

- Ref.20) Applied Ecosystem Management Ltd., for the City of Whitehorse Planning Department and YTG Department of Renewable Resources, Wildlife Viewing Program, *Defining Ecologically-Based Significant Wildlife Areas for the City of Whitehorse*, August **2000**.

The report describes important wildlife habitats within the City and provides a rating of ecological sensitivity for each area. Maps show wildlife values and environmental ratings. An Ecosystem Map was created for about 60% of the City, of which approximately 7% encompass high value wildlife units.

Ref.21) City of Whitehorse, *Annual Water License Report*, **2001**.

This annual report includes monitoring results and interpretation for raw and treated water, raw and treated sewage, and storm water. Relative to water supply, the total watershed area is approximately 22,000 km², and the area flowing directly to Schwatka Lake is approximately 3,500 km². The report describes surface water protection measures already undertaken.

In 2001, the Selkirk Pump House pumped 4,601,848 m³ of water into the distribution system, consisting of 1,597,961 m³ of groundwater and 3,003,887 m³ of surface water from Schwatka Lake. Raw water is chlorinated to achieve a residual of 0.8 mg/L. Three rechlorination facilities operate as required to achieve the objective of maintaining at least 0.2 mg/L at the system extremities. Turbidity is now continuously monitored, and if levels exceed 4 NTU surface water flows are restricted and groundwater flows increased.

The raw water supply is tested weekly for total and fecal coliforms. Of 51 tests of the surface raw water, total coliforms ranged from 0 to 59/100 mL and fecal coliforms ranged from 0 to 7/100 mL. Of 12 tests for *Giardia*, counts ranged from non-detectable to 30 cysts/100 mL. All other parameters tested were consistently below the maximum allowable concentration levels.

Ref.22) Gartner Lee Limited, *Upper Yukon River - 2000 Surface and Groundwater Inventory Project*, February **2001**.

The inventory covers the area between Marsh Lake and Lake Laberge, providing details of streams, lakes and wetlands. Map 2: South Sheet, of The Surface Water Inventory Map shows the portion of the study area that is pertinent to the preparation of the Watershed Management Plan, at a 1:20,000 scale. The Inventory shows the sub-watersheds within the study area that contribute to the Yukon River, and also provides a preliminary inventory of potential impacts, or watershed stressors, as shown on Map 3.

For groundwater, the report provides a water well database and groundwater usage study for the Wolf Creek and Pineridge subdivisions area.

- Ref.23) Gartner Lee Limited, for Energy Solutions Centre, *Vanier School Ground Source Heat Pump Project: Site Setting & Conceptual Design*, January **2002**.

The report summarizes conceptual designs for three ground source heat pump options for the Vanier School, including one that would use the Selkirk aquifer. Each option would involve heat pumps operating at up to 90 USgpm to transfer heat to the school's heating loop. The option of using the Miles Canyon Basalt Aquifer was recommended as having a reduced potential for conflict with the City's Selkirk aquifer well field, and lower operating costs.

- Ref.24) Gartner Lee Limited, for Community Development Branch, Government of Yukon, *Preliminary Groundwater Assessment of the Proposed Whitehorse Copper & Mount Sima Development Area*, December **2002**.

The report assesses the potential for local impacts to groundwater resources in the Wolf Creek and Pineridge areas, from the proposed development of 156 rural residential lots and 62 light industry lots in the Whitehorse Copper area. The new development would be served by wells and on-site sewage systems. The new development was judged not to have any significant impacts on the neighbouring areas.

- Ref.25) Gartner Lee Limited, *Upper Yukon River - 2001 Groundwater Inventory Project*. Part 1: *Long Term Monitoring Well No. 1 - Wolf Creek Subdivision*; Part 2: *Wolf Creek and Pineridge Subdivisions Groundwater Quality Assessment*; and Part 3: *Preliminary Groundwater Inventory of the City of Whitehorse*, February **2003**.

Part 1, prepared for Indian and Northern Affairs Canada, described the construction of the well, hydrogeological testing and analysis, and groundwater quality. The purpose of the well is to measure trends in water levels and quality.

Part 2, prepared for the City of Whitehorse, assessed the impact of nutrient loading by septic systems in the Wolf Creek and Pine Ridge Subdivisions, and presented analytical data for metal concentrations and general groundwater chemistry. 22 wells were sampled, consisting of 11 bedrock wells and 11 overburden wells. Some samples were found to exceed Canadian Drinking Water Quality Guidelines for total coliforms (one sample), and nitrate (one sample), probably due to septic system effluent.

Part 3, for the Community Development Branch, Government of Yukon, was completed in March **2003**. The study provides a broad overview of groundwater resources in the City and the environmental factors controlling its occurrence. Eight coloured maps are included along with a water well database.

- Ref.26) Applied Ecosystem Management Ltd., for the City of Whitehorse, *Development of a Fish and Fish Habitat Database and Restoration Plan*, April **2003**.

The study mapped the Yukon River channel and tributaries, within the City of Whitehorse. Tributaries mapped were the Takhini River, Nine Mile Creek, MacAuley Creek, Croucher Creek, McIntyre Creek, Marwell Creek, Spook Creek, Basalt Creek, MacRae Creek, Wolf Creek, and Cowley Creek. The Restoration Plan recommended the additional study of species distribution and habitat mapping, collection of baseline water quality information, and assessment and removal of barriers to fish passage.

- Ref.27) Gartner Lee Limited, letter report to the City of Whitehorse, Re: "Desktop Assessment of Potential for a Groundwater Supplied Municipal Water System", February 27, **2003**.

The report assesses the potential for groundwater to meet the current and future City demands. The current demand is on average 13,340 m³/d with a maximum of 26,680 m³/d. Future average daily demand is estimated at 27,070 m³/d. The modelling results show that future water supply requirements could be met with groundwater from the Selkirk well field, however this conclusion needs to be confirmed by monitoring, pump testing, and other recommended hydrogeological investigations.

- Ref.28) Pearson, F.K., Hart, C.J.R., and Tower, M., *Distribution of Miles Canyon Basalt in the Whitehorse Area and Implications for Groundwater Resources*, Yukon Exploration and Geology **2000**, pp.235 - 245.

This paper describes the basalt that hosts the City of Whitehorse's significant groundwater resource. Miles Canyon basalts have high hydraulic conductivity. The paper summarizes the occurrence of the basalt, outcrop observations, water well data, and a seismic survey.

Additional references are contained in Appendix A. These additional references are primarily Bylaws and other regulatory, planning, and governance documents.



3. WATERSHED STATUS

3.1 Drinking Water Needs

The White of Whitehorse 2002 Official Community Plan (OCP) (Ref 28) discussed the City's growth projections and trends. The City's population was 17,853 in 1991, 19,157 in 1996, and 19,058 in 2001, according to census records. The decline in population of about 0.5% between 1996 and 2001 might be due in part to declining mineral prices and the closing of the Faro mine. Population growth may well rebound owing to the cyclical nature of economic activities in and around the City.

The 2002 OCP provides estimates for the City's population in the year 2026 based on three hypothetical growth scenarios.

Table 3-1				
Possible Rates of Population Growth (from Ref 28)				
Growth Rate	Population Estimate		Net Growth	Estimated Annual Drinking Water Needs¹ (m³/yr)
	2001	2026		
High (2%/yr)	19,058	31,267	12,209	6.3 million
Medium (1.2%/yr)	19,058	25,680	6,622	5.2 million
Low (0.5%/yr)	19,058	21,589	2,531	4.4 million

¹ Excluding residents in outlying areas

Any growth projection is speculative, however the City's population grew from 11,217 in 1971 to 19,058 in 2002, or about 260 people/year over the last three decades. This represents a rate of growth in the range of 1.4% to 2.3% per year over 30 years.

In 2001, 4.6 million m³ of water was drawn into the City's distribution system. This served the needs of city residents and also people in surrounding areas who are served by trucked water. The overall population served by the City's distribution system, therefore, was estimated at 22,649 in 2001 and 22,545 in 2002. The average per person use of potable water in 2001 was about 203 m³/person/year, or about 560 L/d.

The average use of water is about 560 litres per person per day.

The City of Whitehorse has initiated a Water Conservation Education Program. Nevertheless, assuming: 1) a need to serve the city's population and outlying residents, 2) no appreciable decrease in per capita water use, and 3) a 2% annual population increase, the total annual demand for drinking water could rise from a current 4.6 million m³ (or 12,600 m³/d on average) to 8.2 million m³ (or **22,500 m³/d** on average) by the year 2030 – a total increase of about 78% over three decades.

By 2030, the City might require an average of 22.5 million litres of water per day.

There are slight variations in the estimates of current and future water demand that have been used as part of various planning exercises. For example, in 1979, Associated Engineering Services Ltd. provided a report to the City of Whitehorse outlining possible water requirements for an 'ultimate' future population of 35,000 (as reported in Ref 8). They estimated an ultimate average daily water demand of 32,800 m³/d and **maximum daily demand of 65,700 m³/d**.

Stanley and Associates (Ref 8) revised these estimates in 1983, based on discussions with city staff to an ultimate average daily water demand of 27,300 m³/d and an ultimate **maximum daily demand of 42,300 m³/d**.

Gartner Lee in 2003 (Ref 27) used a figure as provided by the City for current water demand of 13,340 m³/d on average, with a maximum daily demand of 26,680 m³/d. They stated a "predicted future demand" (no date provided) of 27,070 m³/d on average and a **maximum daily demand of 54,140 m³/d**.

From the perspective of assessing adequate water quantity, reference to the average daily demand does not account for the inevitable times of above-average use; for example, during peak water use periods during the day (morning and evening) or with seasons. The Average Daily Demand (ADD) represents the total volume of water consumed in a year divided by 365 days. The Maximum Daily Demand (MDD) is usually calculated by using the Average Daily Demand as a baseline and multiplying by a peaking factor for increased usage during high consumption days. According to Stanley and Associates (Ref 8), a peaking factor of 2.0 was used in 1979 to estimate the MDD. The actual system measurements recorded over the last half of the 1970s suggested an actual peaking factor for the City of about 1.55.

In addition to this, the ability of a water supply system to meet "fire flow criteria" is often assessed according to whether the system has the capability of delivering the required fire flow volume and pressure during a period when the system is experiencing peak usage (Ref 8). Stanley and Associates (Ref 8) summarized modelling analyses wherein a simulated maximum 266 L/s fire flow (potentially required for fire control at a framed warehouse facility) was drawn from various locations around the City, with the system already operating at maximum daily demand conditions (MDD). The Stanley and Associates estimates of future water needs accounted for these modelling results.

According to Gartner Lee (Ref 22), Environment Canada has estimated for the Whitehorse region an average annual precipitation rate of 266 mm, of which about 241 mm is lost to evapotranspiration, leaving an annual water surplus of 25 mm that will either run off or infiltrate into the ground. Building on the previously described estimates of possible future water needs for the City of Whitehorse of 8.3 million m³ per year, the land area required in light of the annual water surplus can be roughly calculated.

An estimated 184 km² of land area is required to serve the City's needs without leaving any portion of the annual water surplus for other important ecological functions.

It is estimated that approximately 330 km² of land area is required to collect sufficient water to serve the City's future needs, independent of the need for that land to also collect water that sustains vegetation, fish, and many other aspects of natural ecosystems. An estimated 184 km² of land area is required to serve the City's current needs without leaving any portion of the annual surplus for other important functions.

These simple calculations serve to reinforce the overall importance of the watershed for not only determining source water quality, but also the available quantity.

3.2 Watershed Description

The City of Whitehorse draws surface water from Schwatka Lake, an impoundment on the Yukon River. The approximate area of the overall watershed is 22,000 km². An area of approximately 3,000 km² drains directly to Schwatka Lake as opposed to the upriver portion of the Yukon River.

The watersheds and sub-watersheds within the area of influence of the City's drinking water supply are shown on Figure 3-1. In addition to areas that drain directly into the Yukon River, the northern portions of Marsh Lake, or Schwatka Lake, there are five sub-watersheds that contribute to the study watershed: Yukon River East, Cowley Creek, Wolf Creek, MacRae Creek, and McLean Lakes.

3.2.1 Surface Water

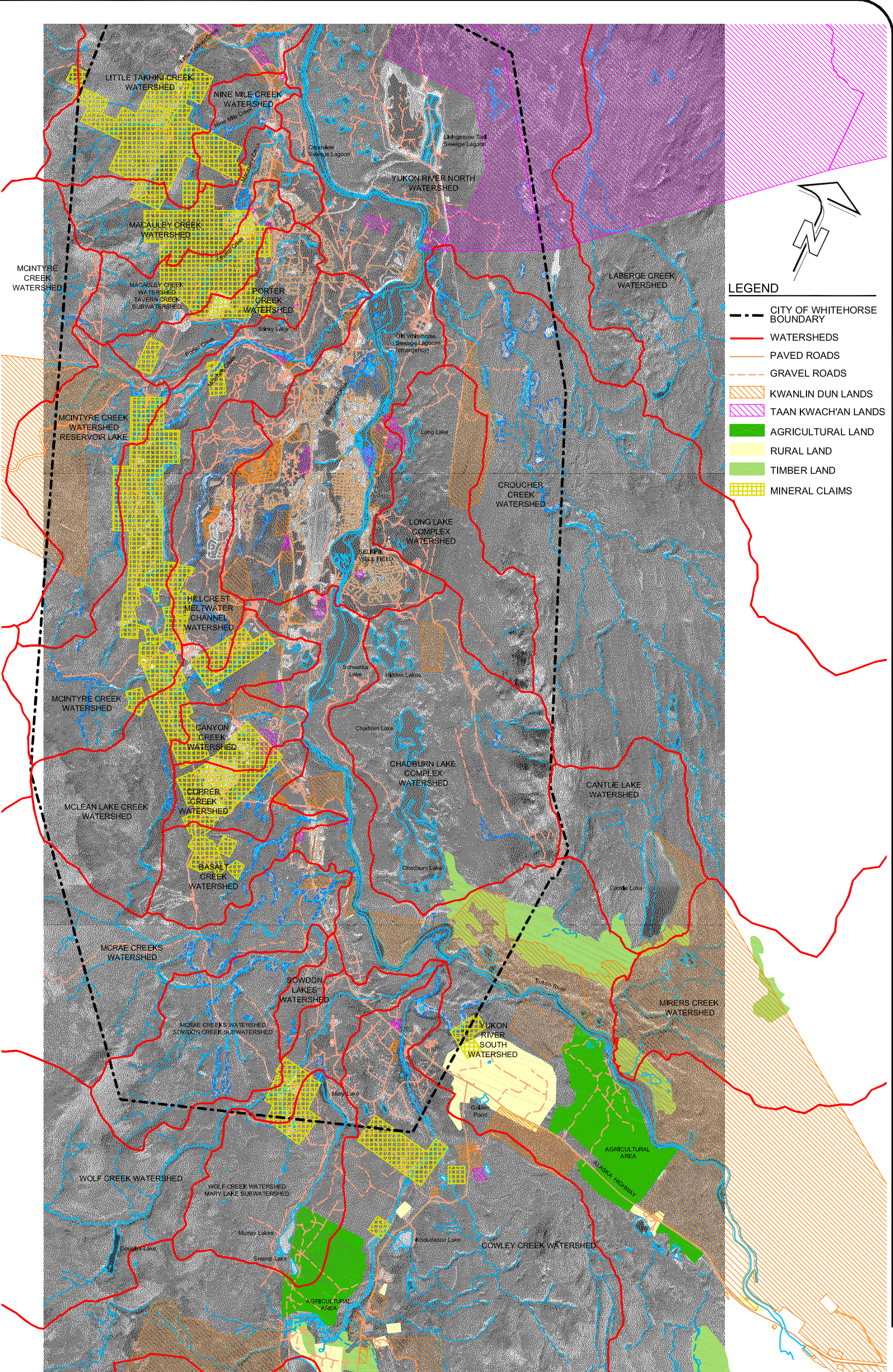
This section presents a general description of the hydrology of the Whitehorse area. Following a summary description of the climate and hydrological regime, we provide a description of the local runoff for the watersheds in the study area around Schwatka Lake.

Climate:

The southern Yukon has a boreal climate with very cold winters and moderate but short summers. Precipitation is typically low over much of the southern central Yukon with annual amounts less than 500 mm. Precipitation is higher in the Pelly, Cassiar and Mackenzie Mountains to the east of the Yukon River and much higher in the St. Elias Mountains and the Coast Mountains in the southwestern corner of the Yukon.

Precipitation is low over much of the central Yukon.

Whitehorse has a mean annual temperature of -0.7°C (Figure 3-2). Maximum daily temperatures at Whitehorse peak in July at 20.5°C with daily minimums of 7.7°C.



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0 1000 2000 3000 m

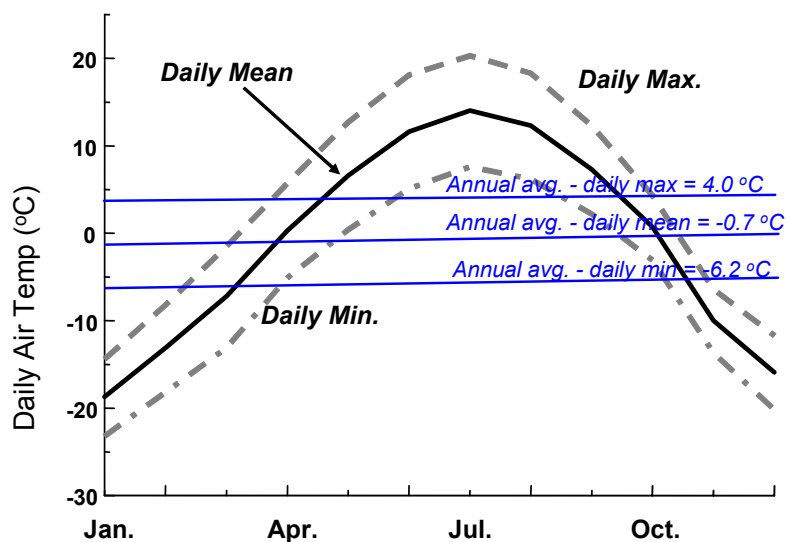


City of Whitehorse
Watershed Management Plan

Watersheds

Figure 3-1

**Figure 3-2:
Whitehorse Air
Temperatures¹**



Whitehorse has an annual precipitation of only about 267.4 mm. This is typical of much of the area along the southern portion of the Yukon River, which is in the rain shadow of the St. Elias and Coast mountains. However, the headwaters of the Yukon River are in Bennett, Tagish and Atlin Lakes. These watersheds are in the mountains and receive much higher precipitation. As shown in Table 3-2 below, the precipitation at Whitehorse is highest in the summer months of June, July, August and September with monthly amounts of 30 to 40 mm that fall mainly as rain. The lowest precipitation occurs from January through May when monthly amounts (as snow, primarily) are near or below 15 mm.

Table 3-2 Study Area Precipitation			
Precipitation	Rainfall-mm	Snowfall-cm	Total-mm
Jan.	0.2	23.7	16.7
Feb.	0.1	16.8	11.4
Mar.	0.0	14.9	10.4
Apr.	1.3	8.0	7.0
May	13.0	2.4	15.2
Jun.	29.7	0.5	30.3
Jul.	41.4	0.0	41.4
Aug.	38.5	1.0	39.4
Sept.	29.3	5.1	34.1
Oct.	8.8	18.9	23.8
Nov.	0.7	27.3	19.2
Dec.	0.3	26.4	18.5
Annual	163.1	145.0	267.4

This low winter precipitation is a result of the Arctic airstream that controls the winter climate^{2,3}. However, in late spring, summer, and early fall, the climate of the southern Yukon is generally controlled by the westerly airstreams from the Pacific. For example, the average temperature and precipitation of 0.9°C and 7.0 mm in April increases to 6.9°C and 15.2 mm in May.

Hydrologic Regime:

With minimum temperatures rising above 0°C in May, the snowmelt begins and streams begin to rise. Figure 3-3 shows hydrographs of flow per unit area for creeks in the southern Yukon. The peak of the spring freshet usually occurs in mid to late June with the warmer temperatures and the onset of summer rains.

This pattern is typical of streams in the southern Yukon. The area around Whitehorse is in the centre of the rain shadow effect from the mountains to the west. The hydrographs^{20,4} for the Ibex River, Tagish Creek and Watson River reflect this. The McClintock River is on the eastern side of the Yukon valley and has a higher peak as a result of increased precipitation in its headwaters. The plot for the Wheaton River shows much higher flows than the other creeks and rivers, a result of higher precipitation in the mountains to the west. The westerly parts of its watershed are not in the rain shadow affecting the central part of the southern Yukon and thus the Wheaton is in a higher runoff zone than the streams around Whitehorse.

The
Whitehorse
area is in the
rain shadow of
the mountains
to the west

Yukon River – The plot for the Yukon River at Whitehorse on Figure 3-4 is different than for most other rivers, with a high peak, reflecting the high precipitation in its headwaters in the Coast Mountains. The peak is typically delayed into mid-August although it can occur from late July to early September. A peak this late in the summer is very unusual and is partly the result of the large amount of natural and regulated storage on the southern lakes. However, the main reason for the late peak is the melting of high-elevation glaciers and snow fields later in the summer. Yukon Energy's Lewes Dam controls the storage in Marsh Lake⁵. Although Bennett, Tagish and Atlin Lakes are all natural lakes, they contribute significant natural storage. The outflows from these three lakes into Marsh Lake normally peak in July. The peak outflow from Marsh Lake does not occur until August. The gates at Lewes Dam must be open from July 15 to August 15, as specified in the Water Licence⁶. The effect is to allow Marsh Lake to rise naturally through May, June, July and the first half of August. After August 15th the outflow is restricted and the stored water is released

² Environment Canada, "Hydrological Atlas of Canada", 1974.

³ Hare and Thomas, "Climate Canada", Second edition, 1979.

⁴ Environment Canada. Water Survey of Canada, "Historical Streamflow Summary – Yukon".

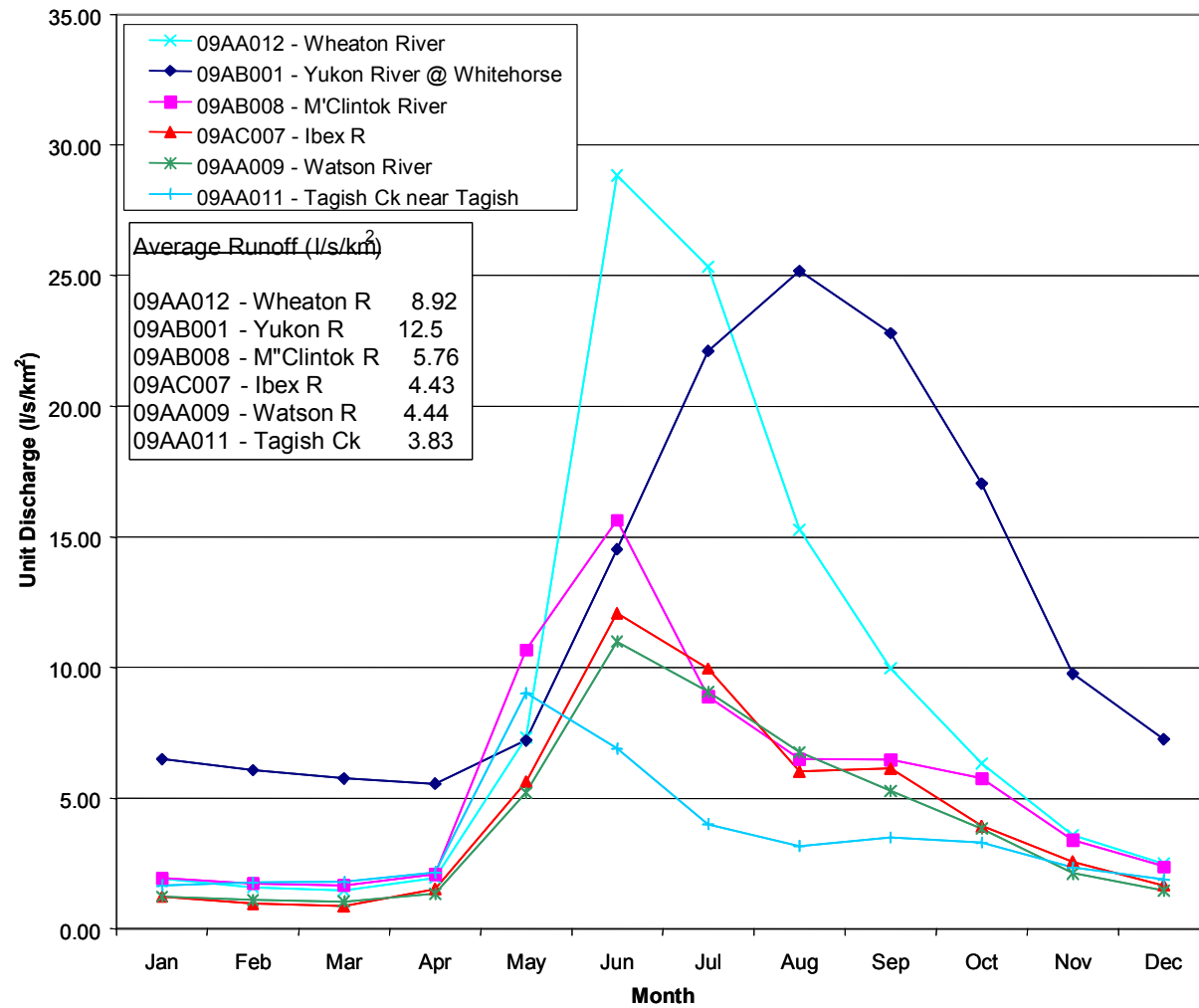
⁵ Yukon Energy Corporation, reference information on Schwatka Lake, Whitehorse Rapids Generating Station, Lewes Dam and Yukon River operations in communications with D. E. Cass, UMA Engineering Ltd., June 2003.

gradually through the fall, winter and early spring. This keeps the winter low flows at Whitehorse well above what the local runoff would provide and is why the Yukon River is such a unique and important asset to the Yukon in terms of water supply and fisheries resources.

Local Watersheds – The local runoff regime around Whitehorse was discussed above and is shown on Figure 3-2. The average runoff for the local watersheds has been taken to be the average of the Ibex River, McClintock River, Watson River and Tagish Creek. Using drainage areas from the earlier April 2001 report “Whitehorse Surface Water Inventory – User’s Guide”⁶, the average runoff has been estimated as shown on Table 3-3 for the local drainages around Schwatka Lake (Map 1-1). The Fish Lake and Cantlie watersheds have been discussed in previous studies as potential water supply sources. The drainage areas quoted in the 2001 study have been used here.

⁶ Gartner Lee Limited; “Whitehorse Surface Water Inventory – Users Guide”, Prepared for City of Whitehorse and DIAND Water Resources – April/2001.

CITY OF WHITEHORSE - WATERSHED MANAGEMENT PLAN
REGIONAL HYDROGRAPHS
FIGURE 3.3



CITY OF WHITEHORSE - WATERSHED MANAGEMENT PLAN
WHITEHORSE REGIONAL HYDROGRAPHS
FIGURE 3-4

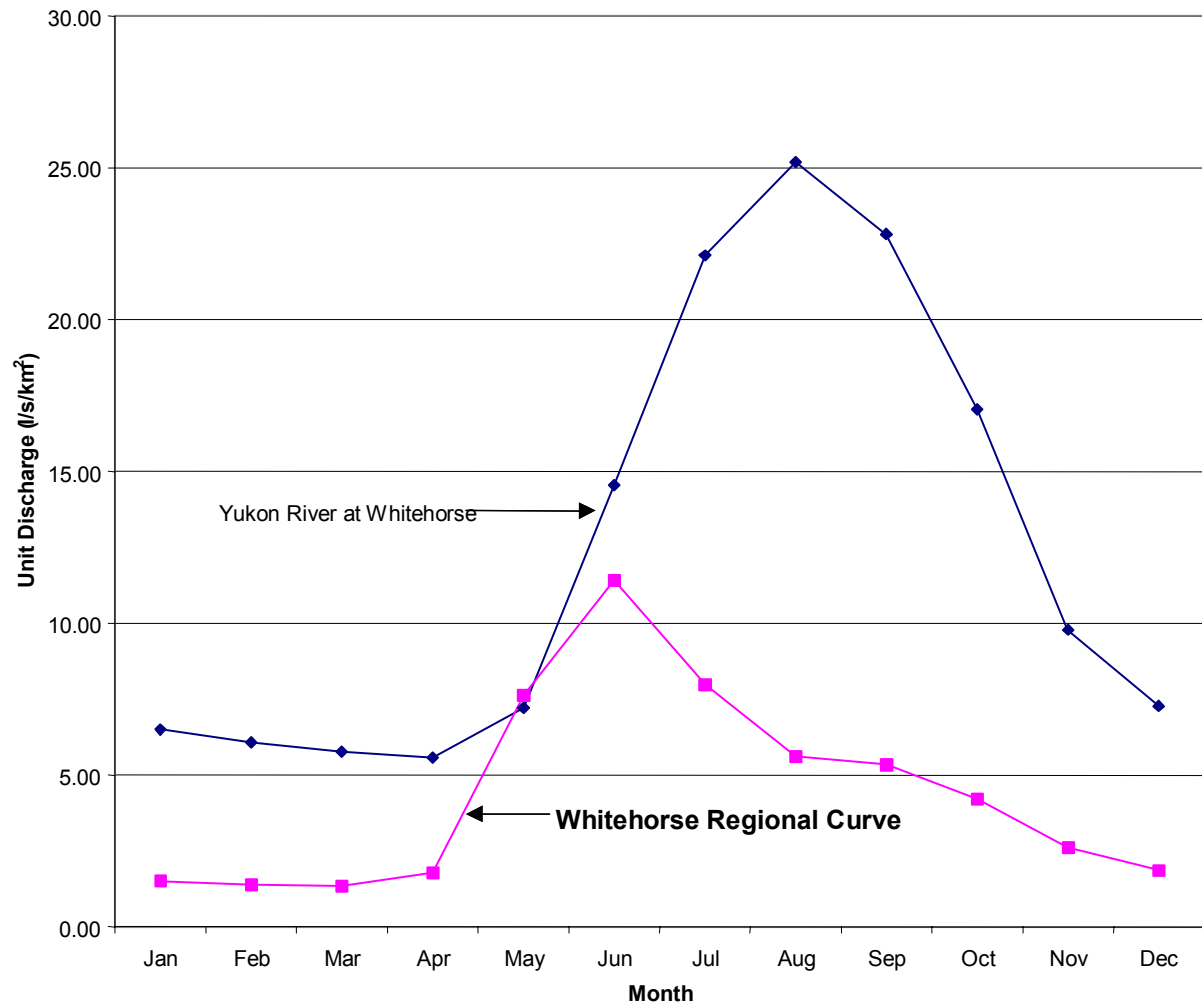


Table 3-3: Summary of Hydrological Conditions

Watershed ID Watershed Name Subwatershed Name			Area (ha)	Whitehorse Region Average Unit Runoff (L//km ²)												
				Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				4.670	1.612	1.489	1.444	1.925	8.447	11.541	7.620	5.228	5.368	4.329	2.773	1.981
				Average Discharge in m ³ /s												
				Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	Yukon River South		N/A													
B	Cowley Creek		17,246	0.81	0.28	0.26	0.25	0.33	1.46	1.99	1.31	0.90	0.93	0.75	0.48	0.34
B	Cowley Creek	Cowley Lakes	4,024	0.19	0.06	0.06	0.06	0.08	0.34	0.46	0.31	0.21	0.22	0.17	0.11	0.08
C	Mirers Creek		4,641	0.22	0.07	0.07	0.07	0.09	0.39	0.54	0.35	0.24	0.25	0.20	0.13	0.09
D	Wolf Creek		16,311	0.76	0.26	0.24	0.24	0.31	1.38	1.88	1.24	0.85	0.88	0.71	0.45	0.32
D	Wolf Creek	Mary Lake	1,821	0.09	0.03	0.03	0.03	0.04	0.15	0.21	0.14	0.10	0.10	0.08	0.05	0.04
E	Cantlie Lake		1,684	0.08	0.03	0.03	0.02	0.03	0.14	0.19	0.13	0.09	0.09	0.07	0.05	0.03
F	Yukon River South	Sowdon Lakes	229	0.01	0.00	0.00	0.00	0.00	0.02	0.03	0.02	0.01	0.01	0.01	0.01	0.00
F	MacRae Creeks		4,328	0.20	0.07	0.06	0.06	0.08	0.37	0.50	0.33	0.23	0.23	0.19	0.12	0.09
G	MacRae Creeks	Sowdon Creek	1,784	0.08	0.03	0.03	0.03	0.03	0.15	0.21	0.14	0.09	0.10	0.08	0.05	0.04
H	Basalt Creek		853	0.04	0.01	0.01	0.01	0.02	0.07	0.10	0.06	0.04	0.05	0.04	0.02	0.02
I	Chadburn Lake Complex		3,691	0.17	0.06	0.05	0.05	0.07	0.31	0.43	0.28	0.19	0.20	0.16	0.10	0.07
J	Copper Creek		605	0.03	0.01	0.01	0.01	0.01	0.05	0.07	0.05	0.03	0.03	0.03	0.02	0.01
K	Canyon Creek		561	0.03	0.01	0.01	0.01	0.01	0.05	0.06	0.04	0.03	0.03	0.02	0.02	0.01
L	McLean Lake Creek		2,108	0.10	0.03	0.03	0.03	0.04	0.18	0.24	0.16	0.11	0.11	0.09	0.06	0.04
M	Yukon River North		N/A													
N	Hillcrest Meltwater Channel		1,108	0.05	0.02	0.02	0.02	0.02	0.09	0.13	0.08	0.06	0.06	0.05	0.03	0.02
O	Long Lake Complex		1,929	0.09	0.03	0.03	0.03	0.04	0.16	0.22	0.15	0.10	0.10	0.08	0.05	0.04
P	Croucher Creek		11,199	0.52	0.18	0.17	0.16	0.22	0.95	1.29	0.85	0.59	0.60	0.48	0.31	0.22
Q	McIntyre Creek		3,208	0.15	0.05	0.05	0.05	0.06	0.27	0.37	0.24	0.17	0.17	0.14	0.09	0.06
Q	McIntyre Creek	Reservoir Lake	2,003	0.09	0.03	0.03	0.03	0.04	0.17	0.23	0.15	0.10	0.11	0.09	0.06	0.04
Q	McIntyre Creek	Upper Intake	7,412	0.35	0.12	0.11	0.11	0.14	0.63	0.86	0.56	0.39	0.40	0.32	0.21	0.15
R	Porter Creek		943	0.04	0.02	0.01	0.01	0.02	0.08	0.11	0.07	0.05	0.05	0.04	0.03	0.02

Table 3-3: Continued																
Watershed ID Watershed Name		Subwatershed Name	Area (ha)	Whitehorse Region Average Unit Runoff (L/s/km ²)												
				Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				4.670	1.612	1.489	1.444	1.925	8.447	11.541	7.620	5.228	5.368	4.329	2.773	1.981
		Subwatershed Name	Area (ha)	Average Discharge in m ³ /s												
ID	Watershed Name			Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
S	Laberge Creek		N/A													
T	MacCauley Creek		1,297	0.06	0.02	0.02	0.02	0.02	0.11	0.15	0.10	0.07	0.07	0.06	0.04	0.03
T	MacCauley Creek	Tavern Creek	960	0.04	0.02	0.01	0.01	0.02	0.08	0.11	0.07	0.05	0.05	0.04	0.03	0.02
U	Nine Mile Creek		496	0.02	0.01	0.01	0.01	0.01	0.04	0.06	0.04	0.03	0.03	0.02	0.01	0.01
V	Little Takhini Creek		2,575	0.12	0.04	0.04	0.04	0.05	0.22	0.30	0.20	0.13	0.14	0.11	0.07	0.05
X	Takhini River		N/A													
Z	Fish Lake		16,918	0.790	0.27	0.25	0.24	0.33	1.43	1.95	1.29	0.88	0.91	0.73	0.47	0.34

Surface Water Sources:

Schwatka Lake - Yukon River - Schwatka Lake on the Yukon River is the primary source of drinking water for the City of Whitehorse. It is a small reservoir on the Yukon River created by the construction of the Whitehorse Rapids dam. The dam is 18 to 20 m high and was constructed by the Northern Canada Power Commission at the head of a set of rapids. As the reservoir is only about 3 km long, the lake bottom rises rapidly making the reservoir relatively shallow. The active storage in Schwatka Lake is small relative to the size of the Yukon River and thus the dam has been designed and operated as a run-of-river plant with a nearly constant headpool level. The water licence allows a fluctuation of 1.07 m (3.5 ft) but the daily fluctuations are reported to be typically in the order of 0.3 to 0.35 m.

The volume of water in Schwatka Lake is replaced up to 3.5 times per day during maximum flow, or about 0.67 times per day during low flow.

According to Whitfield *et al.* (Ref. 6) Schwatka Lake has a surface area of approximately 15 ha, and an average depth of only 6 to 8 m. During the period of maximum daily inflow (46 million m³/d) the volume of the lake is replaced 3 to 3.5 times/day. Under minimum daily flows (5 million m³/d) the detention time of the reservoir is 1.5 days.

Although Schwatka Lake has a small storage capacity, the Yukon River at Whitehorse is highly regulated by a combination of natural and regulated storage in Marsh Lake and natural storage in Tagish, Bennett and Atlin Lakes. These are large bodies of water and the effectiveness of this storage is illustrated on Figure 3-2 and 3-3 by the delay in the flood peak on the Yukon River at Whitehorse compared to the peak of the local runoff around Whitehorse.

Waters released from Marsh Lake arrives at Schwatka Lake in about 6 hours.

The active storage available in Schwatka Lake is about 8 to 13 million m³, much smaller than the volume of Marsh Lake. Thus, the effective storage for the Whitehorse Rapids plant and the adjoining City of Whitehorse water supply is in Marsh Lake and the other southern lakes. Water released from Marsh Lake arrives at Schwatka Lake in about 6 hours.

Discussions with plant staff at Yukon Energy indicated that in winter, fluctuations of the water surface are kept to a minimum to ensure a stable ice cover for recreational purposes.

No information was located on vertical characteristics of Schwatka Lake during either open water or under-ice periods, or of vertical or horizontal current regimes in the lake. In the absence of any detailed limnological observations, it is assumed that the lake does not undergo any vertical stratification, but rather is very well mixed throughout the year from top to bottom, owing to the shallow depth and long, narrow configuration. It is generally assumed, therefore, that Schwatka Lake behaves more as a riverine than lacustrine (lake) system in terms of its physical water characteristics – especially water movement.

Table 3-4 Flows in Schwatka Lake	
Month	Flow (m³/s)
Jan.	126.0
Feb.	117.9
Mar.	111.7
Apr.	108.0
May	139.9
Jun.	282.0
Jul.	428.8
Aug.	488.4
Sept.	442.4
Oct.	330.6
Nov.	189.6
Dec.	140.9
Average	242.1

The City of Whitehorse Water Intake:

The intake for the City of Whitehorse is on the east side of the main dam and spillway at a depth of 1.8 to 2.4 m below the spillway crest (depth varies depending on the water level).

Circulation patterns in the head pond to the east of the spillway are not known in detail. In general, there is a complex circulation in this area during the summer as the spillway is used for prolonged periods and induces strong currents. The circulation pattern changes in winter and is significantly less intense as the main flows are less and are directed down the west shore of Schwatka Lake into the power canal feeding units 1, 2 and 3 at the Whitehorse Rapids plant.

Sources and Transportation of Suspended Sediment:

Given the large amount of storage in the southern lakes, the outflows from Marsh Lake should contain little sediment load. There are only minor local catchments between Marsh Lake and Schwatka Lake and these tributaries are at most minor contributors to the volume of the southern Yukon River and Schwatka Lake. As discussed further in Section 3.5, however, the local catchments may have contribution to sediment load that is disproportionately large relative to volume contributions.

The McClintock River drainage, which enters Marsh Lake very close to its outflow into the Yukon River section that feeds Schwatka Lake, is a naturally turbid watershed.

We are not aware of any studies that have been completed to estimate the contribution of suspended sediments from this watershed into water that flows into Schwatka Lake. The contribution during the spring and summer is probably appreciable (Ref. 1).

Applied Ecosystem Management Ltd. (Ref 26), as further discussed in the *Yukon River Corridor Plan* (Appendix A - Ref. 29), described the landforms and terrain of the Yukon River Corridor through Whitehorse.

Between Marsh Lake and Schwatka Lake, the Yukon River traverses the scenic Miles Canyon, with massive columnar basalts that rise up above the river to 50 m in height, forcing the river into a narrow, turbulent passage. The volcanic origin basalts that formed Miles Canyon and the Whitehorse Rapids underlying and immediately down-river from Schwatka Lake are not conducive to either the depositing of suspended sediments or scouring and resuspension of materials, and should not contribute to turbidity. The Yukon River channel, where it is carved through bedrock, serves as a conduit for water and suspended sediments, wherein the deposited sediments are in dynamic equilibrium - being temporarily deposited and resuspended in various parts of the river depending on changes in water speed, but having an overall sediment supply that remains relatively constant.



Miles Canyon

The banks of the Yukon River in several stretches between Marsh Lake and Schwatka Lake are carved into either glacial outwash deposits (see section 3.2.2) or old lakebed and floodplain sediment deposits. The visually obvious cliffs along the river, or west of

the downtown section of Whitehorse, are made up of fine sand and silt, with a limited amount of finer clays. The thickness of these glaciolacustrine deposits, with their often alternating layers of finer and coarser materials, varies in the Yukon River valley from about 20 to 60 m. Most of this overburden was deposited during the end of the last glaciation in a large lake called Glacial Lake Champagne.

Glacial Lake Champagne, before it receded, drained towards the north through the Yukon River Valley and Lake Laberge. In any lake (lacustrine) system, inflow rivers and streams tend to drop their coarser, higher density sediment load near their point of entry, with a progressive deposition of increasingly finer sediment fractions farther down the lake. The glaciolacustrine deposits around Whitehorse typically consist of fine sands and silts with only low clay content. Glaciolacustrine sediments originally deposited closer to present day Lake Laberge would be expected to have a higher

proportion of the finer silt-clay sediment fraction than near Whitehorse, since the area is farther removed from where the historic inflow point into the lake was, and the finer sediment fractions would have had a longer period of time in which to settle out.

Over the last 5,000 years, surface runoff and river flows have worked the local landscape. As the energy of flowing water increases, it picks up first the finest particles from sediment deposits and then progressively more coarse sediment fractions. Finer silt-clay sediments and soils within the watershed have gradually been removed where they are or historically have been in contact with active hydrological flows. In many cases, the coarser fluvial deposits that remain are expected to be less prone to re-suspension and movement into Schwatka Lake.

On the other hand, natural and human activities that disturb new silt-containing glaciolacustrine overburden that has not recently been re-worked by water, can lead to short-term increases in suspended sediment load and turbidity. There is no information that would allow estimation of how much turbidity in Schwatka Lake is contributed from natural processes as opposed to human activities.

Sediment in
Schwatka Lake
originates from
natural
processes and
human activities.

The eastern shore of Schwatka Lake is carved out of glacial outwash deposits - gravel, sand and silt left behind in a flowing water (fluvial) environment, as the toe of the glacier retreated. In Schwatka Lake, the low magnitude of reservoir fluctuation and the presence of gravels in the deposits around the lake suggest that bank erosion is not a major ongoing source of fine sediments that could remain in suspension in the reservoir. This is further supported by anecdotal reports indicating that wind driven sediment plumes have not been observed in the lake (Yukon Energy personnel; personal communications).

There appears to be little massive shoreline erosion, or re-suspension of fine sediments near the shoreline of Schwatka Lake during the open water period. The presence of a stable ice cover prevents wind and wave action in the winter and erosion by ice would be minimal as the reservoir fluctuation is small. However, the possible importance of minor amounts of erosion during the open water season, and trace amounts of fine silts in shoreline deposits, causing the observed turbidity of the drinking water supply, should not be discounted without a more detailed examination.

Most tributaries to the Yukon River have been colonized by beavers (Appendix A - Ref. 29), resulting in secondary small-scale flooding, vegetation changes, and the deposition of fine, organic-rich sediments. The organic and silt-rich sediments in these low-lying areas around Whitehorse may also encourage development of localized permafrost, making such microhabitats particularly vulnerable to physical disturbance.

Limited numbers of wetland sites in the study area occur as organic-rich deposits, referred to as muck deposits or peat bogs. These have important water holding capacity, as well as the ability to retain sediments.

3.2.2 Groundwater

The quality and quantity of various groundwater sources is related to the overall physiography of the Whitehorse area, and the geological forces that shaped the surface and subsurface landscape. The major landforms are a legacy of the last ice age, occurring between around 35,000 and 14,000 years ago. Groundwater is found in permeable and fractured geological strata. The Whitehorse area is typical of landforms created by glaciation-deglaciation in mountainous terrain.

The Yukon Valley, in the vicinity of Whitehorse, is a broad, terraced landscape of low relief primarily glacial, riverine (fluvial) deposits and relict lake (lacustrine) sediments, dissected by the current path of the Yukon River. Toward the end of the last deglaciation, the receding glaciers dropped their massive loads of scoured and eroded boulders and gravel. The massive runoff shaped and scoured the landscape, creating frequently shifting channels, which eventually dried out as the meltwater decreased in volume. Meltwaters often create temporary lakes in topographic lows, creating the conditions for the settling out of finer sand and silt deposits. In the case of the Yukon River Corridor, much of the unconsolidated soil properties to the north of Whitehorse are a reflection of the past location of Glacial Lake Champagne.

Groundwater is a major part of the Whitehorse municipal water supply as well as numerous commercial, industrial and residential supplies. While there have been numerous studies that have examined the nature and occurrence of groundwater in the Whitehorse area, the 2003 report issued by Gartner Lee Limited entitled *Preliminary Groundwater Inventory of the City of Whitehorse* (Ref 25) is the most current and complete. It describes the geology of the region and the various aquifers that are present, as well as the extent and location of groundwater usage. While this is the most complete assemblage of groundwater information, the authors acknowledge that there are significant information gaps.

Groundwater
is an important
part of
Whitehorse's
water supply

The unconsolidated deposits (or overburden) are unevenly distributed throughout the Yukon Valley, both horizontally and with depth. As indicated on Map 8 of the 2003 Gartner Lee report (Ref. 25), there are many private residential wells, some small communal well systems and a variety of industrial and commercial well systems. Some wells are completed within granular sections of the overburden while others are completed within the bedrock. Of the bedrock systems, the Miles Canyon basalt represents the most consistent producer based on its porosity and permeability (Ref.29). But wells are also completed within the various sedimentary, metasedimentary and igneous units underlying the region. Unfortunately yields are not consistent and wells are expensive to install.

Local wells
exist in a
variety of
geological
formations

The City obtains groundwater from four wells in the Riverdale area of Whitehorse. Well 6 contributes 2/3 of the estimated annual groundwater yield of 1,600,000 m³

(2001 estimate), with wells 1 and 4 contributing the remainder. The wells are 12 to 26 m deep and are completed in the Selkirk Aquifer. This aquifer is an unconfined aquifer (not constrained within an enclosed pocket of bedrock) within the Chadburn Lake outwash deposits of sand and gravel.

Typically, groundwater is used by the City from November to June to augment the Schwatka Lake supply, specifically to prevent freezing. Since the early 1980s, the City has attempted to maintain the water temperature at the initial distribution point at a consistent 3.3°C. This, along with increased vigilance regarding vulnerable parts of the distribution system, has minimized problems with heating as well as energy expenditures for heating. It has also allowed for improvements in water conservation over the winter months relative to historical practices of maintaining flows to prevent freezing.

The Chadburn Lake complex includes coarse sand and gravel deposits left as a result of glacial retreat. This complex also includes numerous kettle lakes and small depressions. These lakes have no surface inflow or outflow, but the water in them is closely linked to the upper most groundwater in the Chadburn Lake outwash deposits, and in fact represent the same body of water as the Selkirk Aquifer. Kettle lakes in outwash deposits are created by ice blocks that persist in the gravelly outwash deposits after the edge of the glacier retreats. Their subsequent melting leaves kettle-shaped depressions in the surrounding moraine.

The general direction of flow of groundwater is to the north along the Yukon River valley. The elevations of Schwatka Lake and the numerous kettle lakes within the Chadburn Lake complex are slightly higher than the water table within the Selkirk Aquifer beneath Riverdale, indicating that locally these features recharge the Selkirk Aquifer. The close hydrological link between kettle lakes in the Chadburn Lake outwash deposit and the Yukon River is demonstrated by the fact that water levels rose in Hidden, Chadden, and Chadburn Lakes after the completion in 1959 of the Whitehorse Rapids Hydroelectric project and creation of Schwatka Lake (Ref. 22).

Net recharge of the Selkirk Aquifer from direct rainwater is limited due to the low annual precipitation, and takes place primarily in April and May. However, the hydraulic connection of the Selkirk Aquifer to abundant surface water features ensures an abundant groundwater supply.

Historically, expanding the yield from the Selkirk Aquifer through use of the underlying Whitehorse Aquifer has been studied. While additional yield appears possible, the hardness of the water, if used as the only source, would dictate the need for a water treatment plant according to Stanley and Associates (Ref 8), who compared the costs and benefits of different alternate drinking water supplies in the period 1979 to 1983 (see Section 3.4, below).

Beyond the groundwater use by the City, the significant residential areas with a reliance on individual wells are:

- Wolf Creek/Pineridge area, which is about 50:50 on overburden and bedrock wells,
- Mary Lake and Cowley Creek areas;
- Spruce Hill subdivision, and
- MacPherson and Hidden Valley subdivisions.

There are also many areas for potential community or individual household well development based on the site geology. Gartner Lee (Ref 25) estimated that municipal and communal groundwater use presently (2001) accounts for about 33% of the groundwater use. Hatcheries account for 64%, with private wells using 2% and commercial wells at 1%.

Groundwater use in the Wolf Creek and Pineridge Subdivisions has been examined in great detail (Ref 22). The 2000 Gartner Lee study includes hydrogeological characterization, baseflow analysis of Wolf Creek, a set of climate and surplus water balance calculations, and assessment of groundwater recharge rates in comparison with current utilization rates. Gartner Lee attempted to determine if groundwater extraction in the Wolf Creek subdivision was occurring at a rate that has reduced baseflows in Wolf Creek or result in long-term depletion of aquifer storage; however, the absence of long-term monitoring data for levels in either the creek or local aquifer precluded any assessment.

Few if any major groundwater quality concerns have been identified, other than the fact that the Selkirk Aquifer groundwater is sometimes harder than the Schwatka Lake surface source, and the Whitehorse Aquifer, in turn appears to have groundwater that is harder than the Selkirk Aquifer.

Gartner Lee (Ref 22) estimate that approximately 20% of the water introduced into the aquifer within the recharge area represented by the Wolf Creek and Pineridge subdivisions is being re-introduced via septic tile fields. They note that “This discharge of nutrient loaded water to the aquifers could effect groundwater quality, but no assessment of groundwater quality, and nutrient loading in particular, has been conducted as part of this study.”

Locally, impacts from on-site septic systems are a risk for bacteriological and nitrate contamination. There is a land use plan for the Chadburn Lakes area, which is an important recharge area for the Selkirk Aquifer. It should be noted, however, that a portion of this area has also been identified as part of the Kwanlin Dun land selection process, so land use planning and recharge area protection may need to be collaboratively revisited.

The area upgradient of the Riverdale well field is largely uninhabited, as well, which limits the threats to the groundwater. The surface water features, primarily Schwatka Lake, are likely at greater risk of contamination, which might eventually impact the groundwater quality since the Yukon River, including Schwatka Lake, and lower portions of the Selkirk Aquifer are intimately linked.

Some risk to the aquifer may be associated with the use in Riverdale of fertilizers, herbicides and pesticides. Riverdale (formerly referred to as “hamburger heights”) arose as a military neighbourhood. Homes built before 1979 used underground oil tanks, for which good records do not exist. (Storage Tanks Regulation does not apply to low volume tanks).

Problems have been found in the Maritimes, primarily Newfoundland, with polycyclic aromatic hydrocarbon (PHC) releases from residential oil tanks. There is no evidence of problems in the Riverdale area, probably because of the dry soils. Even so, because of these issues, insurance companies are generally compelling Riverdale residents, through insurance approvals, to replace household underground storage tanks with more modern above ground tanks. There is a Yukon Housing Home Repair program that provides low interest loans to householders for tank replacement.

There is also some concern that the snow dump area above Riverdale may have accepted contaminants during the military era of occupation. If there were leachable contaminants below the snow dump, they could affect groundwater down gradient from the current drinking water extraction points. Finally, there is some concern about the Super A gasoline station in Riverdale.

Gartner Lee (Ref 25) recommended that a more comprehensive program of monitoring water use and quality, especially at the Selkirk well field, is very important. We agree completely. A long term monitoring well has been completed in the Wolf Creek subdivision to observe trends in quality and aquifer water levels. This type of proactive and sustained observation needs to be applied to all groundwater development operations. Water quality compliance data has routinely been collected at the wellhead.

Security has been installed at the production wells, but adequate source water protection will hinge on the careful examination of any development proposal within the aquifer watershed. Wellhead protection must include all areas within the aquifer that could be exposed to inappropriate land use activities. This will elevate public awareness and go a long way to avoiding threats to the quality of the groundwater.

3.3 Overview of Drinking Water System

In 2001, the City used 4,601,848 m³ of water, consisting of 3,003,887 m³ of surface water and 1,597,961 m³ of groundwater.

Water is extracted from Schwatka Lake via an intake pipe located to the east of the Yukon Energy Corporation dam and spillway. The intake is 1.8 to 2.4 m below the water surface, depending on the lake level. The lake water flows by gravity through a 550 mm diameter raw water line, running 1,350 m to the Selkirk pumping station. The total Schwatka Lake watershed area is approximately 22,000 km², and the area flowing directly to the lake is approximately 3,500 km² (Section 3.2.1).

Groundwater is supplied from the Selkirk Aquifer by four active wells, capable of providing a flow of 150 L/s sustained, and a peak flow of 190 L/s (Section 3.2.2).

The raw surface water is chlorinated at the Selkirk pumping station to achieve a residual chlorine concentration of 0.8 mg/L and is pumped into the multi-pressure zone distribution system. In the distribution system, three re-chlorination facilities operate as required to achieve the objective of maintaining at least 0.2 mg/L at the system extremities. Turbidity is continuously monitored, and if levels exceed 4 NTU surface water flows are restricted and groundwater flows increased.

The raw water supply is tested weekly for total and fecal coliforms. Of 51 tests of the surface raw water performed in 2001, total coliforms ranged from 0 to 59/100 ml and fecal coliforms ranged from 0 to 7/100 ml. Of 12 tests for *Giardia*, counts ranged from non-detectable to 30 cysts/100 ml. This does not contravene any standard, since no standard has been set by the Federal-Provincial-Territorial Task Force for *Giardia* cysts. Although of concern, better information is required on determining viability of cysts in order to assess risk. All other parameters tested were consistently below the maximum allowable concentration levels.

Existing City of Whitehorse water quality is good.

The system is well managed and thoroughly monitored

The City of Whitehorse in 2001 continued its fine-tuning of changes to the chlorination treatment and distribution system to achieve a four order magnitude (Log₁₀ 4) inactivation of viruses during low temperature periods (when water temperatures approach 2°C.; Ref. 21). In addition, the City in 2001 increased the number of secondary chlorination treatment sites within the distribution network from 9 to 13, with added routine testing for chlorine residual at these sites.

3.4 Alternative Source Supplies

The City has investigated alternative drinking water sources over the last few decades (see Refs 2, 4, 5, 7, 8, 25, 25, 27). Previously investigated alternatives include:

- **Fish Lake,**
- **West Schwatka Lake,**
- Supplementation of the Selkirk Aquifer groundwater source with groundwater from the **Whitehorse Aquifer,** and
- Expanded groundwater use from the **Selkirk Aquifer.**

The primary impetus for investigating drinking water alternatives, beginning in 1979, was the perceived need to increase the drinking water supply for the Hillcrest and Valleyview expansion areas.

Fish Lake is located about 15 km southwest of Whitehorse in the Boundary Ranges of the Coast Mountains. The lake has a surface area of approximately 1,250 ha (12.5 km²; about 11 km in length by 1 km in width), confined within a steep-walled valley. Mount McIntyre is situated between the lake and the City of Whitehorse. Yukon Energy Corporation Ltd (YECL) uses the watershed for two power stations.

YECL maintains an earth-filled dam at the lake's outlet, providing maximum water storage of about 3.5 million m³. The water passing the dam enters Fish Creek which flows into two very small lakes, Franklin Lake and Louise Lake, before emerging as McIntyre Creek. For Fish Lake, the contributing drainage area to the proposed point of collection at the confluence of the Porter and McIntyre Drainages (Ref. 2) is approximately 165 km², as shown in Table 3-5.

Preliminary evaluations in 1979 by Stanley Associates Engineering Ltd. suggested that there is sufficient water volume in McIntyre Creek immediately below the YECL Power Station No. 2 (about 9 km below Fish Lake) to be considered an alternative water source for the city. Subsequent hydrological evaluation of the watershed produced the following estimates:

Table 3-5		
Estimated Flows for the Fish Lake/McIntyre Creek Watershed - 1980		
Location	Watershed Area (km²)	Annual Flow (m³/s)
Watershed above Fish Lake Outlet	165	0.93
Watershed below Fish Lake and above Power Stn No. 2 on McIntyre Creek	73	0.41
Total Watershed area above Power Stn. No. 2	238	1.34
McIntyre Creek above Power Stn. No. 2	37	0.21
McIntyre Creek below Power Stn. No. 2	275	1.55

Hydrometric flow data from YECL Power Stn. No. 2 records are provided in Ref. 2. Suggested requirements for use of the water in McIntyre Creek (and Fish Lake) for a potable water supply including the construction of a series of ditches, a penstock, a small dam on McIntyre Creek, pump house, 400 mm diameter water supply line and possible reconfiguration of some of the YECL works farther up the catchment.

Stanley and Associates Ltd. (Ref 2) concluded that the Fish Lake Water Supply would provide sufficient, good quality water (after treating for phenols) to supply a projected population of 22,400.

In the early 1980s the situation changed when the Water Board approved YECL's McIntyre Creek power project, giving the power corporation sole rights to the use and regulation of all water emanating from the Fish Lake watershed. The power company stated in their application that they required all of the available flows from the watershed in order for the hydroelectric project to be viable.

Fish Lake water supply not viable due to conflict with needs of Yukon Energy Corporation

The West Schwatka Water Supply (Ref 2) was investigated in 1979-1980. The proposed new supply would be drawn via a siphon intake from the west side of the YECL spillway (as opposed to the current intake on the east side). It was noted that the water would likely require heating, since "warm water wells of the needed quantity for mixing purposes are not available on the west side of Schwatka Lake." The conceptual design also included a treatment plant that involved high rate filtration, followed by chlorination and then fluoridation. The water would then be piped to the Valleyview area over a distance of approximately 3,700 m using a 550 mm diameter pipe, 915 m of 450 mm diameter pipe, and 975 m of 300 mm pipe.

The overall intent was to feed the Valleyview reservoir and provide sufficient anticipated flows for fire response in the Marwell area. This would also eliminate the need for the Two Mile Hill booster station. This option was subsequently ruled out, apparently because it offered few if any advantages over an expanded intake volume from the existing Schwatka Lake intake to the east of the dam, and provided some challenges from a design perspective.

West Schwatka option ruled out as presenting design problems and having no significant advantages

Use of Groundwater from the Whitehorse Aquifer: According to Stanley and Associates (Ref. 6), the Whitehorse aquifer is located to the east of the Yukon River at a position deeper than the Selkirk Aquifer, extending through the middle of the Riverdale area and north past the east side of the Hospital. The most promising test well was established in an undeveloped area east of the hospital, and pump tests suggested that the Whitehorse Aquifer is capable of supplying the entire ultimate needs of the City. However, Stanley and Associates reported that the groundwater in the deeper aquifer has a much higher hardness than that of the currently exploited Selkirk Aquifer, potentially requiring softening treatment prior to distribution.

Whitehorse Aquifer rejected due to hardness and consequent need for costly treatment

Total Groundwater Supply from the Selkirk Aquifer: Gartner Lee in 2003 (Ref 25) provided an update to previous modeled estimates (Ref 21) aimed at assessing whether an expanded use of the groundwater supply in the Selkirk Aquifer is possible, with extraction volumes that could meet all of the City's potable water needs. The city has a current maximum groundwater extraction capability between currently existing wells 1, 4, 5 and 6 to provide about 15,200 m³/d of drinking water. It is anticipated that the future *average* daily demand will rise to 27,100 m³/d. Preliminary modeling indicates that a total municipal supply from the Selkirk Aquifer is possible.

The Selkirk Aquifer may be able to supply all of the City's needs.

Other supplies that have been considered from time to time as possible source supplies include **Chadburn Lake** and **Cantlie Lake**.

The Cantlie Lake watershed (1,680 ha or 1.6 km²) is a small closed watershed on the east side of Grey Mountain, to the east of the Yukon River valley and the City of Whitehorse. The lake has no surface outlet. It is stocked with Arctic Char by the Government of Yukon in support of a popular sports fishery. Cantlie Lake has an elevation at its surface of approximately 870 m ASL, which is about 200 m higher in elevation than the Chadburn Lake Complex and Schwatka Lake, with a surface elevation of approximately 650 m ASL. Cantlie Lake has not been evaluated in detail as a possible drinking water source, in part, because of the possibility for conflicts between recreational and drinking water uses, and in part because of the small watershed area relative to the City's needs.

Cantlie Lake probably not practical due to conflicts with fisheries and recreation values.

The Chadburn Lake Complex, a major feature of the previously described Chadburn Lake outwash complex, occupies an area of about 4,070 ha (4.07 km²). The watershed, in fact, represents the area contributing to the Selkirk Aquifer, which already supplies drinking water for the City. Chadburn Lake, therefore, is not considered to be an alternate supply.

Chadburn Lake rejected as alternate supply source.

The decisions since 1979 regarding water supplies for the City of Whitehorse have been shaped by decisions based on assumed treatment needs, supply availability, and capital and operational costs, which were the best available at the time. Stanley and Associates in 1983 (Ref. 8) compared the costs of three alternatives. Costs of the Fish Lake Alternative, the Whitehorse Aquifer supply, and upgrading of the existing Schwatka Lake/Selkirk supply system are shown in Table 3-6.

Overall, Stanley and Associates (Ref. 8) recommended in 1983 that:

“due to recent reductions in water wastage there is no need for any major upgrading programs in the near future.”

**Table 3-6
Comparison of Alternative Drinking Water Supplies**

Issue	Fish Lake Supply	Whitehorse Aquifer	Upgrade to Schwatka Lake/Selkirk Aquifer System
Description	McIntyre Creek below Power Stn. No. 2: 26,000 m³/d	1) Whitehorse Aquifer near Selkirk field (depth of 30 m) -flows $\geq$ 100 L/s (or 8,600 m³/d); 2) Whitehorse Aquifer farther north (E. of hospital; depth of 85 m) -flows $\geq$ 700 L/s (or 60,000 m³/d).	1) Selkirk Aquifer - Estimated peak flow potential est. at 190 L/s (or 16,400 m³/d); 2) Schwatka Lake intake – gravity flow is available of 740 L/s (64,000 m ³ /d)
Assumed Configuration	Water pumping station below YECL Powerhouse No. 2; Pump house with chlorination, fluoridation, heating; Water main; Treatment (with ammonia) to remove excess phenols	Softening treatment required	Replace existing Selkirk Aquifer pumphouse; Assumed filtration not necessary
Est. Capital Costs over 20 years ¹	\$4.3 million	\$4.7 million + \$4 million (softening)	\$5.7 million + \$1.2 million (filtration plant, if required)
Est. Operating Costs over 20 years ¹	\$6.6 million	\$6.1 million	\$5.4 million
Total Est. Costs	\$10.9 million	\$10.8 million	\$11.1 million

1) in 1983 dollars

From the perspective of developing a watershed management plan, we note that several Canadian municipalities have adopted source water protection strategies not just for their active supply, but also for possible future and/or back-up supplies. In this context, it may be appropriate to explore the Cantlie Lake and Fish Lake watersheds as emergency back-up drinking water sources, along with the area's abundant groundwater sources even if they may not be the most viable and cost-effective primary resource over the shorter term.

3.5 Source Water Quality

3.5.1 Schwatka Lake

The Schwatka Lake supply is seasonally variable, with under-ice delivery of cold, relatively clear water during the winter months and delivery of warmer, more turbid surface water during peak temperature summer months, as shown in Figure 3-5. The City of Whitehorse continuously monitors the temperature of the Schwatka Lake water immediately following its intake.

Some stakeholders have expressed a concern that climate change could impinge on water quality in the Yukon River Basin. It is interesting, therefore, that the seasonal trends in Schwatka Lake water temperature, and average or extremes in variation have remained similar over a time span of 12 years.

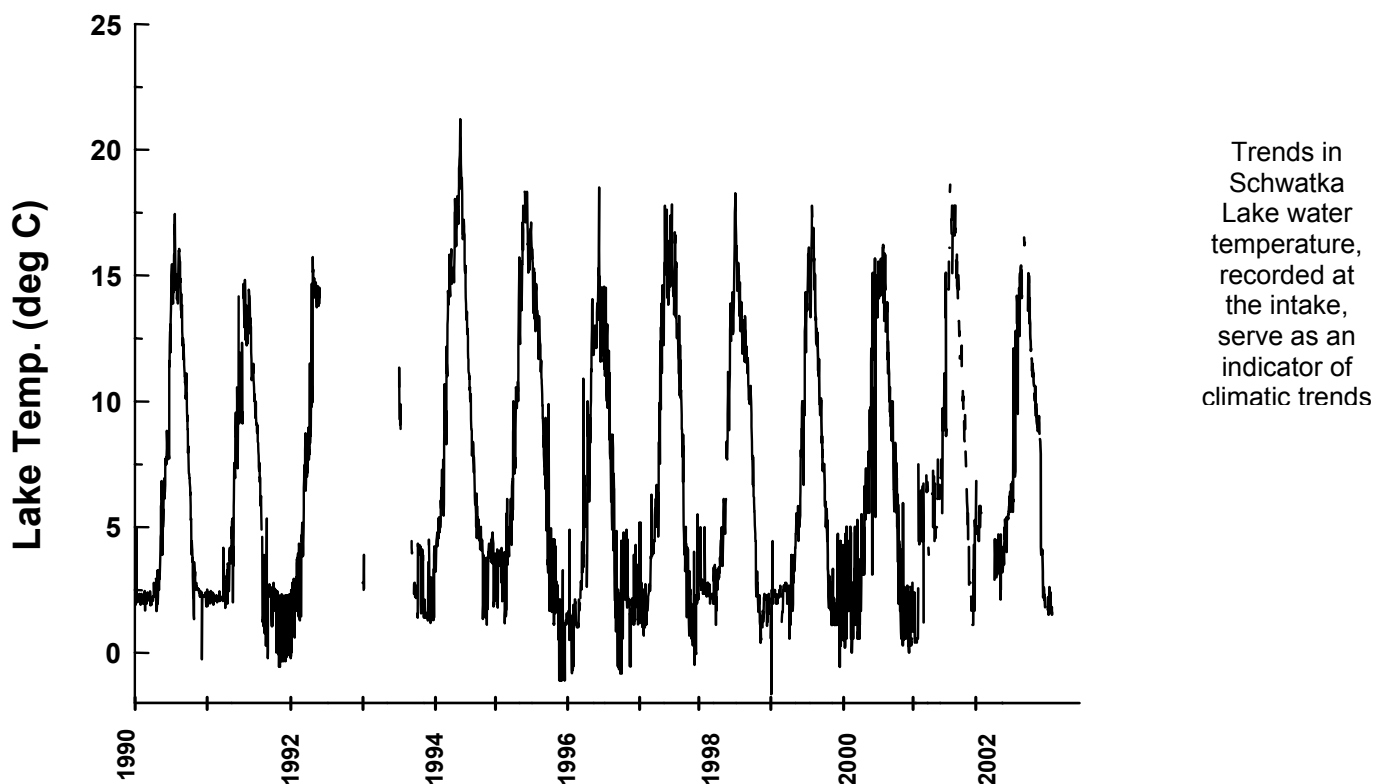


Figure 3-5: Trends in Schwatka Lake Water Temperature

The strong seasonal variation associated with freeze-up, spring melting, and runoff directly or indirectly influences many other watershed properties as well, many of which have a direct bearing on source water quality.

Turbidity:

Turbidity is a measure of the relative clarity of water, based in particular on the presence of very fine to medium sized particulates and colloidal materials that limit transparency. Materials that can contribute to turbidity include clay and silt, finely divided inorganic and organic matter, and living organisms such as bacteria, protozoans, and algae.

“Turbidity” is a measurement of the amount of solid particles in the water

Turbid surface waters often contain fine particles originating from surface soils in the watershed as well as eroded and remobilized fine sediments in from watershed tributaries, wetlands, and depositional zones. Inorganic particles are often dominated by fine silica, clay-sized iron, or aluminum oxide minerals. Turbidity is a surrogate measure for a broad range of substances, each of which potentially have different implications for risks to human health based on water consumption, or for the efficacy of various drinking water treatment regimes (Table 3-7).

Turbidity is based on water transparency, and was first measured by measuring the relative intensity of light transmission using a “Jackson Candle Turbidimeter”. Older water turbidity data, therefore, are often expressed in units of JTU, short for Jackson Turbidity Units. Alternatively, some old data are presented as FTU’s, or Formazin Turbidity Units, which are comparable to JTU’s. Turbidity measures in more recent years have almost invariably been assessed using more modern technology based on light back-scattering intensity, as Nephelometric Turbidity Units (NTU).

According to the Federal-Provincial-Territorial Subcommittee on Drinking Water⁷, levels of turbidity in raw water can range from less than 1.0 NTU to greater than 1000 NTU. Some of the potential problems associated with elevated turbidity are summarized in Table 3-7, excerpted from the Health Canada document²⁶.

⁷ Health Canada (Federal-Provincial-Territorial Subcommittee on Drinking Water), Nov. 2001. Turbidity in Drinking Water: Public Comment Document. 36 pages.

Table 3-7
Turbidity and Implications for Water Quality and Treatment

Source of Turbidity	Possible Water Quality/Chemistry Implications	Treatment Implications
Inorganic particles (silt, clay, natural precipitants, e.g., CaCO ₃ , MnO ₂ , Fe ₂ O ₃ , etc.)	● raise/lower pH and alkalinity ● source of micronutrients ● affect zeta potential ● source of metals and metal oxides ● cloudy/turbid appearance ● affect taste	● major influence on coagulation, ● flocculation and sedimentation design ● harbour/protect microorganisms
Organic particles (decomposed plant and animal debris, humic substances)	● source of energy and nutrients for microorganisms ● cause colour	● high disinfectant demand ● potential to form chlorinated organics ● potential to form ozonation byproducts ● high coagulant dose ● reduce clarifier overflow rates ● increase flocculation/sedimentation times ● harbour/protect microorganisms ● reduce filter runs ● can compete with pollutant compounds for adsorption sites in activated carbon adsorption, and ● can precipitate in the distribution systems
Biological organisms (algae, zooplankton, filamentous or macro bacterial growth)	● impart taste and odour ● serve as precursors for the formation of chlorinated or ozonated compounds ● possess ion exchange and complexing properties that include association with toxic elements and micropollutants ● affect pH ● affect zeta potential ● impart taste and odour ● potential source of toxin (microcystin-LR) ● disease transmission ● corrode tanks, pipes, etc. ● stain fixtures ● cause aesthetic problems due to sloughing of growths from tanks, filters, reservoirs and distribution system	● plug filters ● high disinfectant demand ● need multiple barriers to ensure effective microbial inactivation ● flotation may be more effective than sedimentation ● microbial inactivation required

Health Canada, and the Federal-Provincial-Territorial Subcommittee on Drinking Water, has recommended that, for unfiltered drinking water systems:

- Average daily source water turbidity levels measured at equal intervals (at least every four hours) immediately prior to where the disinfectant is applied do not exceed 5.0 NTU for more than two days in a 12-month period.
- A watershed control program (e.g., protection and controlled discharges) is maintained that minimizes the potential for fecal contamination in the source water.
- Prior to the point where the disinfectant is applied, the source water *E.coli* concentration does not exceed 20/100 mL, or the total coliform concentration does not exceed 100/100 mL, in at least 90% of the weekly samples from the previous six months.
- Disinfection reliably achieves at least a 99.9% (3-log) reduction of *Giardia lamblia* cysts and *Cryptosporidium* oocysts and a 99.99% (4-log) reduction of viruses. Overall inactivation must be met using a minimum of two disinfectants.
- More than a 99.9% (3-log) reduction of *Giardia lamblia* cysts and *Cryptosporidium* oocysts must be achieved if source water cyst/oocyst levels are greater than 1/100 L. Background levels for *Giardia lamblia* cysts and *Cryptosporidium* oocysts in the source water must be established by monitoring every quarter or more frequently during the periods of expected highest levels (e.g., during spring runoff or after heavy rainfall).

In addition, Health Canada has proposed more stringent limits for turbidity levels following filtration treatment.

The City of Whitehorse installed continuous automated turbidity monitors on its Schwatka Lake intake line in 2001. Figure 3-6 summarizes the turbidity data recorded in 2002, based on daily average turbidity levels and two-week running average turbidity levels. Prior to this, the City has monitoring data for turbidity in the Schwatka Lake water immediately after its intake, collected at approximately 3 to 6 month intervals from 1986 to the present time.

WH3 (drinking water supply) Lake Water Supply - 2002

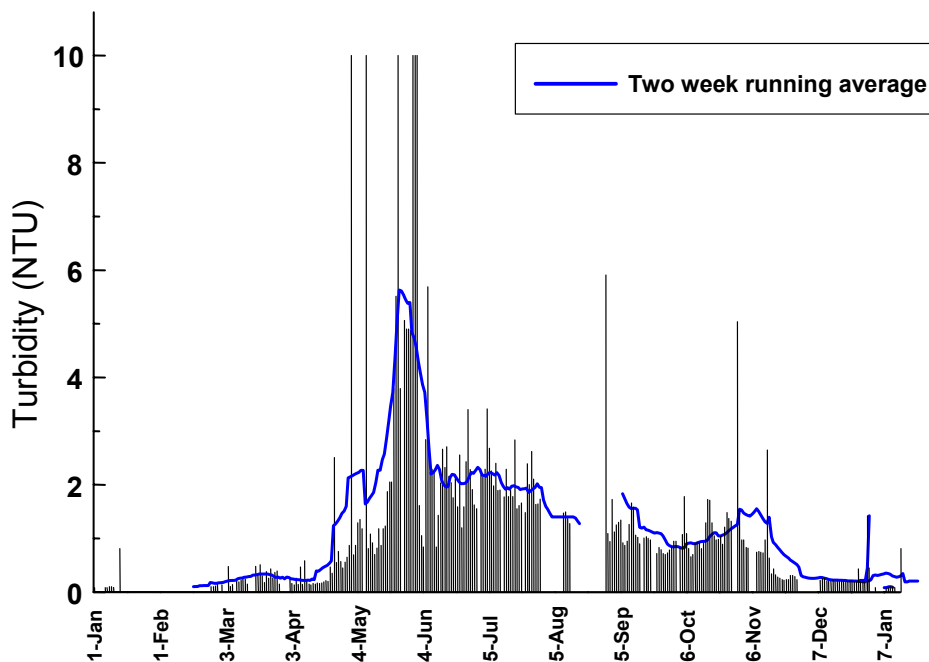


Figure 3-6: Trends in the Turbidity of Schwatka Lake (2002)

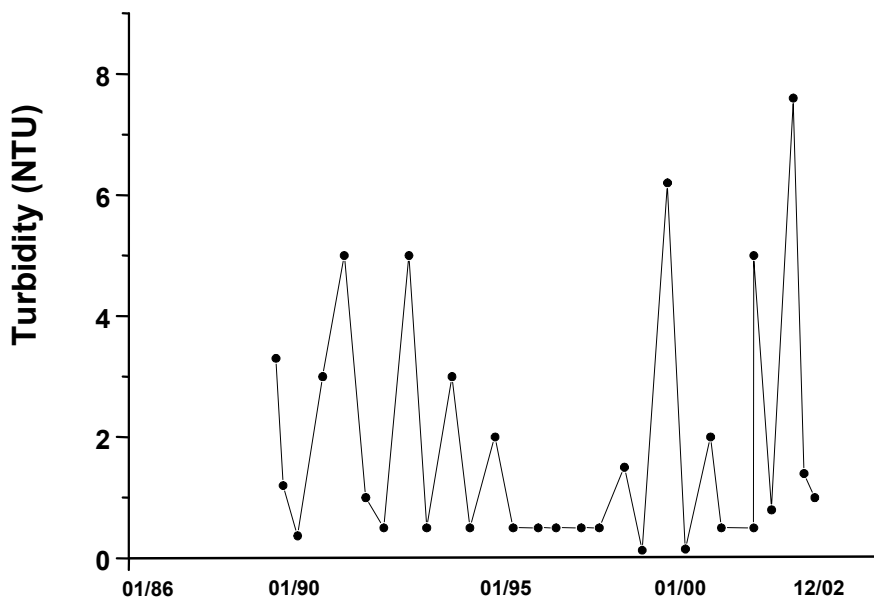


Figure 3-7: Long-Term Trends in Turbidity at WH1 (Schwatka Lake Supply)

While the turbidity data for Schwatka Lake source water were not specifically collected for the purpose of examining watershed-scale influences on source water quality, Figure 3-6 provides important clues about the source of turbidity to the water supply.

There is clearly a seasonal component to lake water turbidity. As might be expected, under-ice turbidity levels (November through April) in 2002 were consistently lower than 1.0 NTU, with only minor exceptions. This is likely a result of isolation of the source water in the Yukon River and Schwatka Lake from surface runoff in tributaries, and from the overall watershed, as well as the lower energy flow conditions in the lake under the ice.

Turbidity would be expected to be higher during the ice-free season. Recall from Section 3.2.1, however, that seasonal water flows in the upper Yukon River basin and Schwatka Lake system are atypical due to late melting glaciers and snow fields and to managed and natural water storage capacity in Marsh Lake and other large lakes up river. Also, it is important to note that the major volume of water delivered to the Yukon River at the YECL dam on Schwatka Lake originates in the watershed channelled through Marsh Lake and upriver sections, as opposed to the smaller watersheds draining to the stretch of river between the Marsh Lake outflow and Schwatka Lake outflow.

The turbidity of Schwatka Lake source water, as recorded in 2002 (Figure 3-6), parallels the hydrograph for smaller drainage systems that feed the Yukon River downriver from Marsh Lake (Figure 3-4): Whitehorse Regional Curve; Figure 3-3), much more so than the hydrograph for the Yukon River at Whitehorse, itself (Figure 3-4). Note, in particular, that the peak in turbidity levels occurred in mid- to late May of 2002, coincident with the peak water flows for hydrographs of smaller watershed systems feeding into the Yukon River, but not of the Yukon River itself.

The overall shape of the two-week averaged turbidity values for Schwatka Lake source water bears a remarkable resemblance to the Whitehorse regional hydrographic curve. This provides compelling evidence for the role of smaller, local watersheds in influencing Schwatka Lake water quality, in a manner that is disproportionately large relative to the volume of water contributed to the Yukon River Basin.

Small local watersheds contribute a large portion of the turbidity found in Schwatka Lake

The Schwatka Lake 2002 source water and other data also indicate that turbidity levels may be considered by health authorities to be too high to ensure adequate pathogen reduction. This would be the case, in particular, if there were a simultaneous occurrence in raw source waters of elevated turbidity and elevated pathogen levels.

Coliform Contamination:

Coliform bacteria include a wide variety of species, including a family of common bacteria found in the intestines of human and animals, where the bacteria assist in the breakdown and fermentation of food. This sub-group is specifically referred to as fecal coliforms. Among the hundreds of different strains of *Escherichia coli*, there are also a large number of non-fecal varieties. The vast majority of fecal and non-fecal coliform bacteria are harmless to human health.

E. coli is released in fecal matter, and its presence is intended as a surrogate measure of environmental contamination with sewage or animal wastes. Among other causes, sources of such contamination may include naturally occurring wildlife, agricultural runoff, or the accidental mixing of sewage with drinking water in the water distribution system.

Coliforms may indicate the presence of sewage contamination in water.

Where there is a potential for humans to transmit diseases such as gastroenteritis or cholera to other humans through inappropriate sewage handling, and where the coliform bacteria in an environmental sample reflect human sanitary inputs as opposed to other coliform sources, fecal coliforms are a useful index of human health risks associated with some transmissible diseases.

The vast majority of coliform bacteria are not considered to be human pathogens *per se*; however, one particular strain of *E. coli* known as O157:H7 is a serious health concern. First identified as causing illness in 1982, O157:H7 did not gain wide recognition until 1993 when many people in the United States were infected by contaminated ground beef. In Canada, *E. coli* O157:H7 was responsible for the deaths and illnesses in 1999 in Walkerton, Ontario, a well-publicized incident that resulted from a combination of inadequate wellhead protection, introduction of livestock area runoff into the groundwater supply, and inadequate disinfection of source water coupled with inadequate compliance monitoring.

Symptoms of O157:H7 infection appear between 2 to 8 days after exposure. Most persons recover within 5 to 10 days of symptoms developing, although weaker, immunologically compromised, and/or more sensitive members of the population may experience far more severe consequences.

Technological advancements in the last three years allows researchers to confidently distinguish between different strains of coliform bacteria, and to identify the relative proportion of human sewage-derived versus livestock versus wildlife coliforms present in water samples.

The current guidelines for drinking water quality are no detectable faecal or total coliform bacteria in the treated, distributed water. In raw source waters prior to disinfection, total coliform levels of <10/100 mL generally indicate low pathogen risks

based on water consumption following disinfection. The Federal-Provincial-Territorial Subcommittee on Drinking Water is currently considering revisions to Canadian drinking water quality guidelines for coliform and thermotolerant bacteria.

Seasonal trends in source water temperature (Figure 3-4) parallel a variety of other seasonal trends. Figure 3-8 shows trends since 1986 in concentrations of total coliform bacteria in Schwatka Lake source water, based on weekly, biweekly or monthly monitoring. Figure 3-9 provides monthly averaged data, also averaged over the period 1986 to 2002, in order to illustrate seasonal trends. Figures 3-10 and 3-11 are similar to Figures 3-7 and 3-8, except that they illustrate the trends for faecal as opposed to total coliforms.

The increase in summer-time total coliform levels in Schwatka Lake during the mid-1990s (Figures 3-8, 3-10) cannot be explained based on inter-annual temperature trends. One possible explanation may be cyclic trends in wildlife populations that contribute coliform bacteria to the watershed (for example, migratory waterfowl).

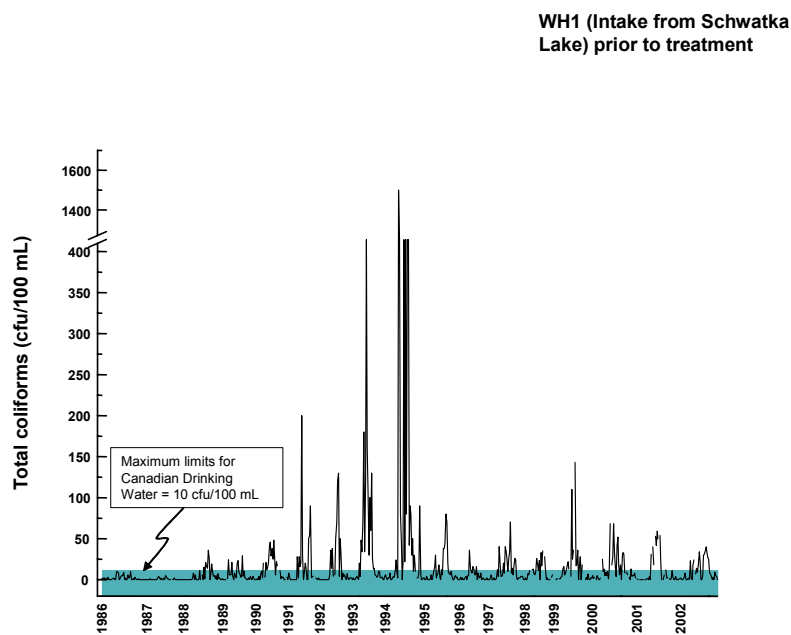


Figure 3-8: Trends in Total Coliform Concentrations in Schwatka Lake

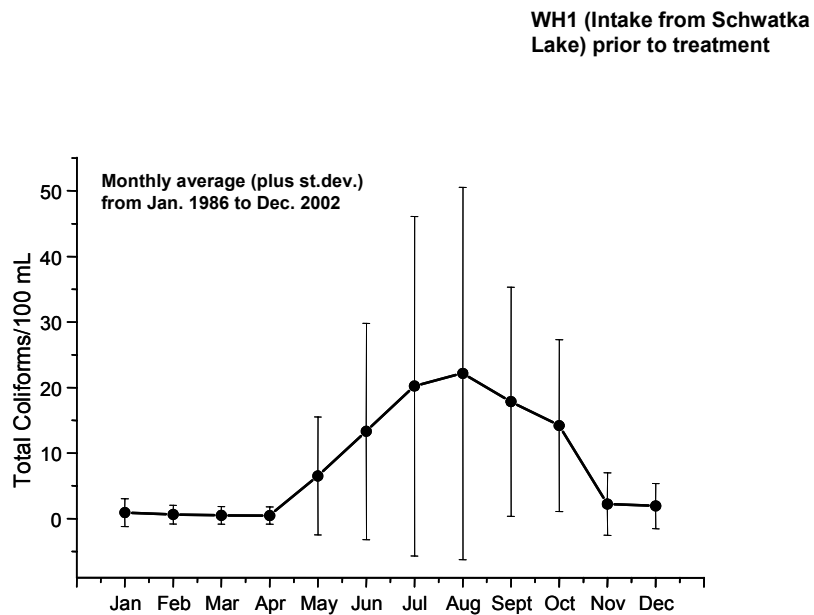


Figure 3-9: Seasonal Component of Trends in Total Coliform Concentrations in Schwatka Lake

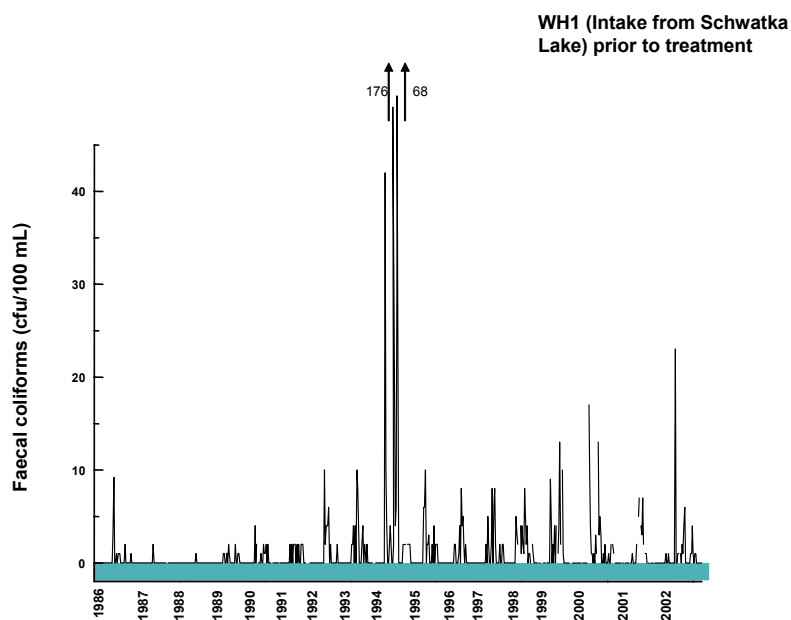


Figure 3-10: Trends in Fecal Coliform Concentrations in Schwatka Lake

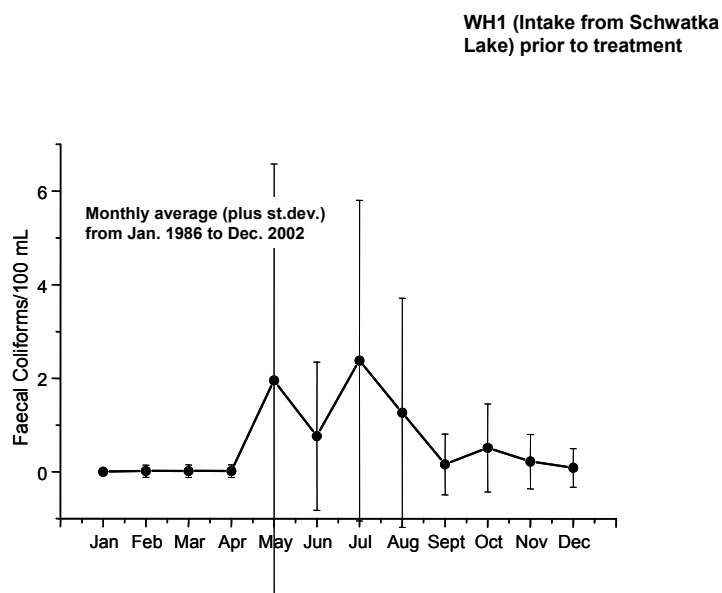


Figure 3-11: Seasonal Component of Trends in Fecal Coliform Concentrations in Schwatka Lake

The concentration in source water of fecal coliforms is a more direct, albeit still potentially misleading, indicator of human pathogen presence, relative to total coliform levels. The relationship between fecal and total coliform levels in Schwatka Lake source water is very weak.

Fecal and total coliform bacteria in raw water samples from the drinking water supply potentially originate from one or more of at least four distinct sources:

- 1) Human sewage, especially from inadequate septic systems;
- 2) Agricultural runoff from livestock areas;
- 3) Human recreational users; and
- 4) Wildlife.

The annual onset of increase in total and fecal coliforms beginning in April precedes the period of intense recreational use. The most likely major contributor to coliforms in the watershed appears to be wildlife, based on the annual trends.

The concentrations of total and fecal coliforms in raw source water notwithstanding, routine test results for these parameters in the water supply following chlorination disinfection have almost invariably shown non-detectable coliform levels in the distributed drinking water supply.

Giardia and Cryptosporidium:

Giardia lamblia is a common, globally distributed parasitic protozoan that lives and reproduces in the intestines of mammals. Domesticated animals (for example: dogs, cattle, sheep), wildlife (for example: beavers, muskrats) and humans can carry this parasite and subsequently introduce it to surface waters, primarily through deposition of fecal matter.

Giardia enters the water supply as a cyst. The outer shell of the cyst makes the parasite very resistant to chlorine disinfection, and inadequate pathogen reduction has variously been associated with inadequate disinfection contact time prior to water consumption, inadequate disinfectant concentration, and/or the presence of other dissolved, colloidal and fine particulate materials (e.g., measured as elevated turbidity) that either preferentially react with the disinfectant (oxidant) or shield the cyst from the disinfectant's action.

Once ingested, the shell of *G. lamblia* breaks down, and the parasite resumes an active growth mode primarily in the intestine, where it feeds on mucosal secretions and reproduces. New cysts are formed and entrained in the feces, allowing for further parasite transmission to new host organisms.

G. lamblia has been known to be transmitted within human populations; for example, to other humans from infected infants wearing diapers in public swimming facilities.

Cryptosporidium is also a single celled protozoan parasite found worldwide in the intestines of animals and people. Like *Giardia*, it enters source water through contamination with sewage or animal wastes. Sources of contamination include wildlife, agricultural runoff, or the accidental mixing of sewage with drinking water in the water distribution system.

During one stage in its development cycle, *cryptosporidium* is encased in a hard shell called an oocyst. The *Cryptosporidium* oocyst is highly resistant to both antibiotics, and traditional methods of water treatment, such as chlorination.

According to Health Canada, it is not possible to confidently establish maximum acceptable concentrations (MACs) for *Giardia* and *Cryptosporidium* in drinking water, because the methods available for the detection and measurement of cysts and oocysts are deemed to have low reliability (i.e., they tend to have low recovery rates, and do not provide any information on cyst viability or human infectivity).

Until better monitoring data and information on the viability and infectivity of cysts and oocysts are available, Health Canada recommends that measures should be implemented to reduce the risk of illness as much as possible. If the presence of

viable, human-infectious cysts or oocysts is known or suspected in source waters, or if *Giardia* or *Cryptosporidium* has been responsible for past waterborne outbreaks in a community, a treatment and distribution regime and a watershed or well-head protection plan or other measures known to reduce the risk of illness should be implemented.

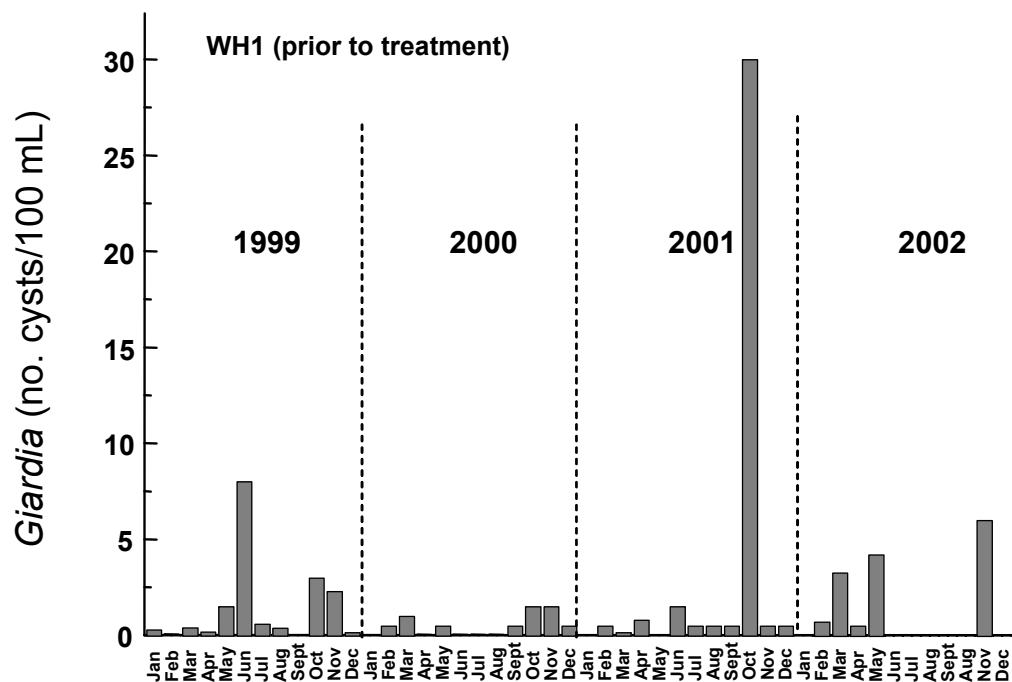


Figure 3-12: Giardia Cysts in Schwatka Lake (1999-2002)

Cryptosporidium has never been detected in Schwatka Lake source water; although routine analyses for this parasite only commenced in May of 2002.

On the other hand, *Giardia lamblia* cysts have often been found in Schwatka Lake water samples, beginning in 1999. The data are illustrated in Figure 3-12. The presence of *Giardia* in source water from Schwatka Lake may be accompanied by human health risks, depending on the viability of the cysts. The combination of detectable *Giardia* cysts and high turbidity levels in the ice-free season merits close scrutiny in the future.

In preliminary discussions, the Territory's Chief Medical Health Officer, Dr. Bryce Larke, stated that there is no evidence of episodes linking drinking water quality to human health outcomes in Whitehorse (see also Ref. 11). In 2001, there were 13 reported cases of *Giardia* among Whitehorse residents, however there was no definitive link to the public water supply, and most if not all of these cases were attributed to ingestion in water sources not linked to the treated City supply.

Schwatka Lake
water quality is
good, but there
are concerns

Other Aspects of Water Quality:

Figures 3-13 and 3-14 summarize trends data in nutrients, hardness and other parameters for the Schwatka Lake raw water supply. Metals/metalloids, nutrients, hardness, pH, and various other conventional parameters have generally been monitored at three- to six-month intervals.

In general, the Schwatka Lake source water has a hardness that falls well within the acceptable range for drinking water, based on aesthetic concerns. Nutrient levels recorded since 1986 provide no evidence of human-based inputs (for example, as occurs in some regions of Canada from sewage disposal in rural unsewered areas). The concentrations of metals/metalloids and other substances in the raw water have uniformly been observed at concentrations less than their respective drinking water quality guidelines.

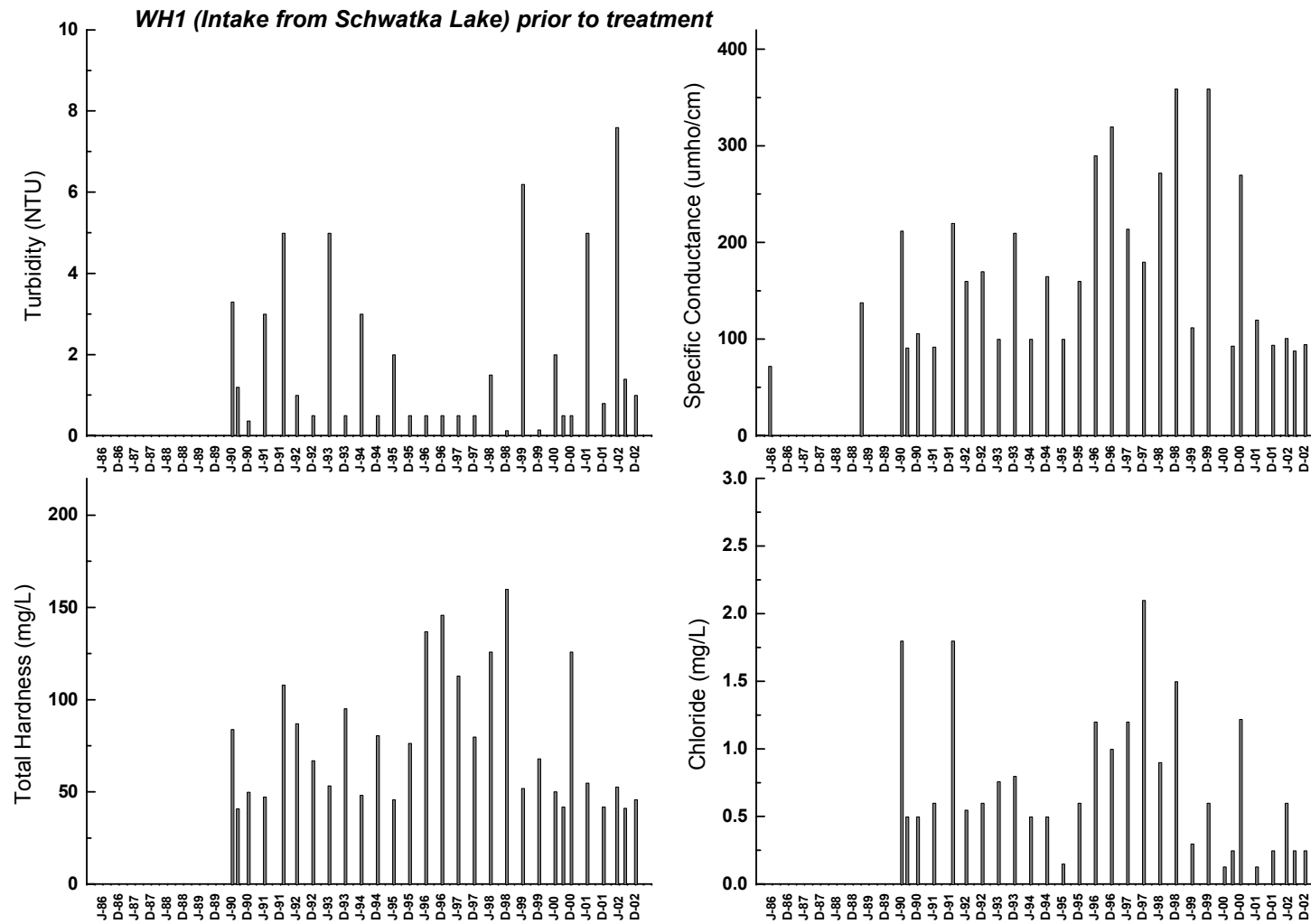


Figure 3-13: Water Chemistry Data - Schwatka Lake

WH1 (Intake from Schwatka Lake) prior to treatment

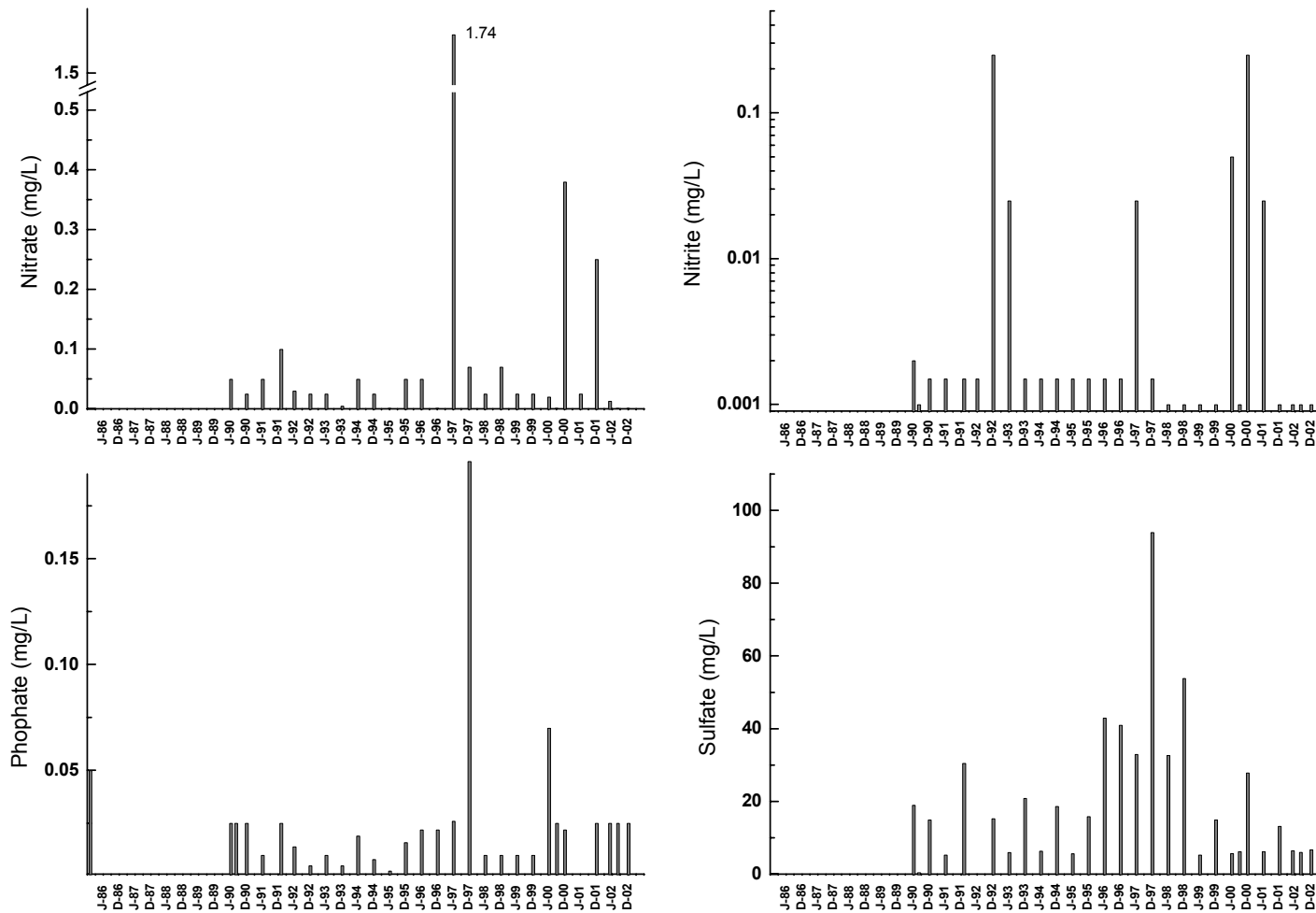


Figure 3-14: Nutrient Data - Schwatka Lake

3.5.2 Selkirk Aquifer

Source water samples drawn from the Selkirk Aquifer have consistently been of good quality. No total or fecal coliform bacteria have been detected (Table 3-8). The water hardness, as shown in Figure 3-14, is very similar to that of the Schwatka Lake surface supply (generally in the range of 50 to 160 mg/L), which would be expected given their common source. Nutrient data, as shown in Figure 3-15, indicate that at the point of extraction the aquifer is not appreciably affected by anthropogenic sources of nutrients.

Groundwater from the Selkirk Aquifer is of good quality.

Table 3-8 Coliform Bacteria in Samples from the Selkirk Aquifer		
Date	Total Coliforms cnts/10 ml (10)	Faecal Coliforms cnts/100 ml (nil)
May 21, 1986	nil	nil
March 29, 1989	nil	nil
December 13, 1990	nil	nil
June 19, 1991	nil	nil
January 7, 1992	nil	nil
June 22, 1992	nil	nil
December 9, 1992	nil	nil
June 25, 1993	nil	nil
December 13, 1993	nil	nil
June 2, 1994	nil	nil
December 5, 1994	nil	nil
June 5, 1995	nil	nil
December 13, 1995	nil	nil
June 10, 1996	nil	nil
December 2, 1996	nil	nil
June 2, 1997	nil	nil
December 27, 1997	nil	nil
June 4, 1998	nil	nil
December 8, 1998	nil	nil
June 8, 1999	nil	nil
December 7, 1999	nil	nil
June 6, 2000	nil	nil
September 14, 2000	nil	nil
December 6, 2000	nil	nil
June 12, 2001	nil	nil
December 5, 2001	nil	nil

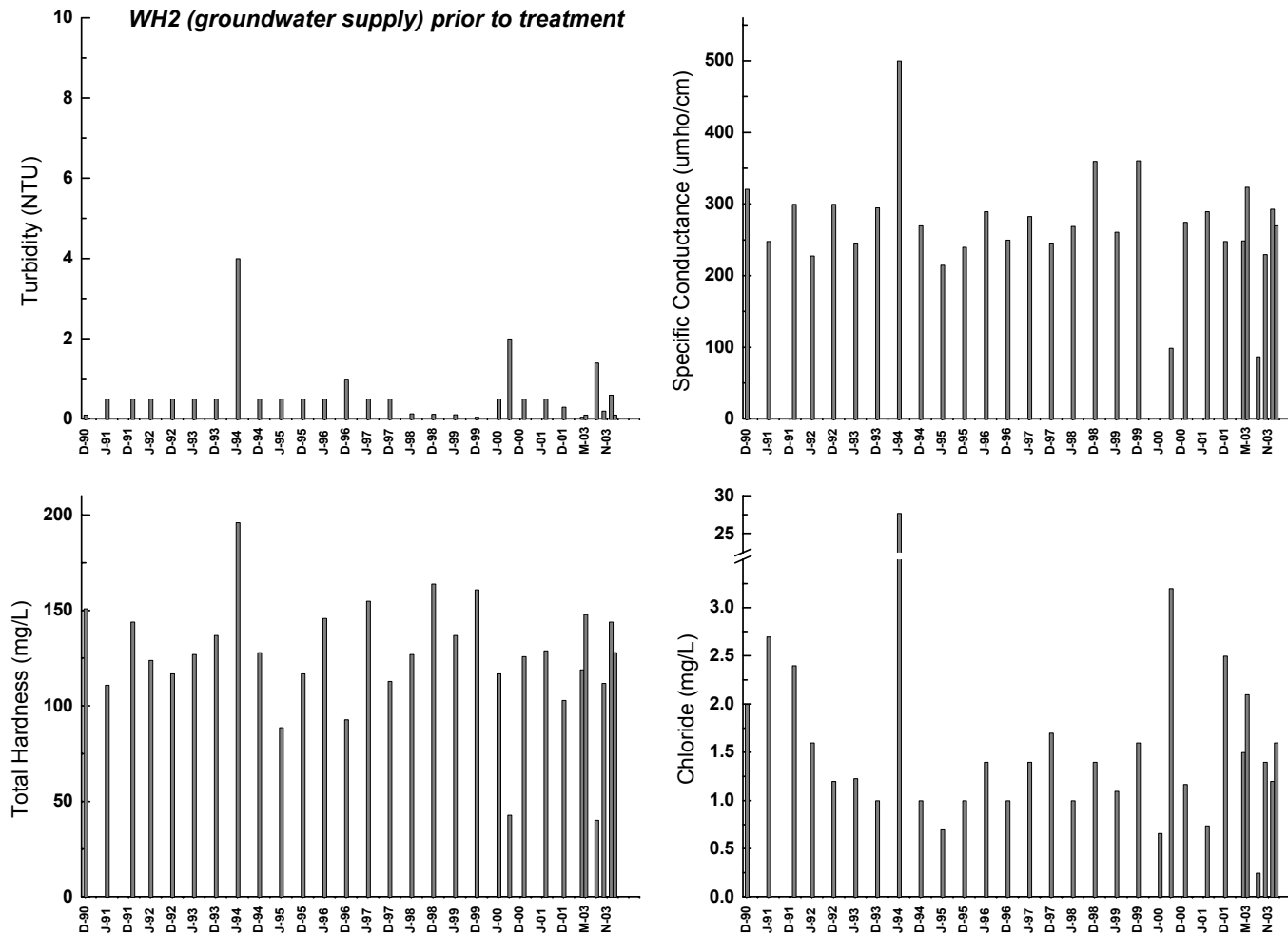


Figure 3-15: Water Chemistry Data - Selkirk Aquifer

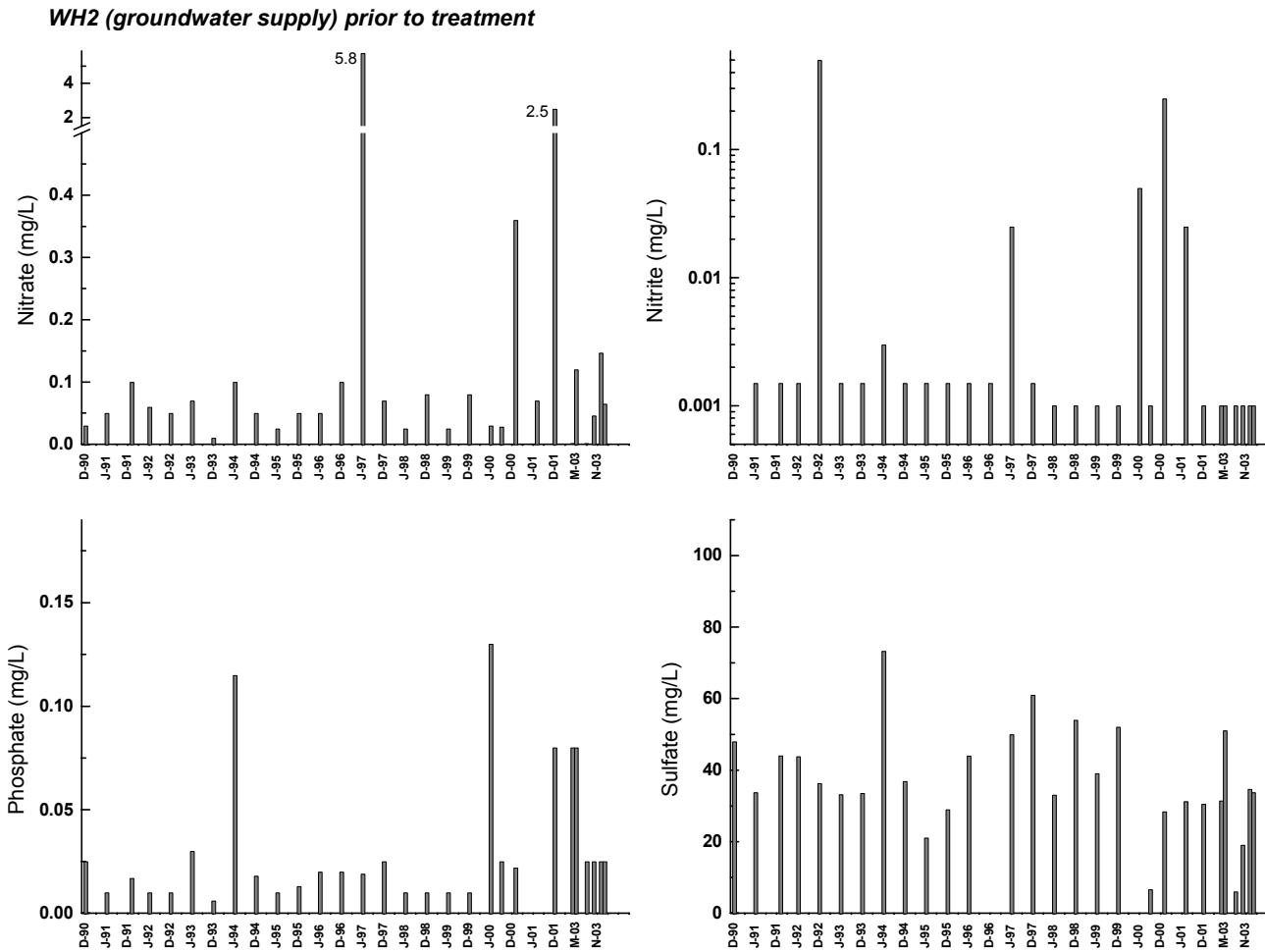


Figure 3-16: Nutrient Data - Selkirk Aquifer

3.5.3 Disinfection By-Products

Disinfection of surface waters used for human consumption is crucial for the protection of human health, because it eliminates pathogens that cause typhoid fever, cholera, and a wide variety of gastrointestinal illnesses. While chlorine is very effective as a disinfectant, it can react with dissolved organic substances in source water to produce chlorinated organic compounds sometimes referred to as disinfection by-products. Some of these by-products are suspected human carcinogens.

It is not yet possible to predict the rate of formation of disinfection by-products (DBPs) from source water characteristics. However, major inroads have been made in the last few years. The formation of DBPs has been reported to correlate with source water dissolved organic matter (DOM) concentration, chlorine dose, chlorination pH, temperature, contact time, and bromide ion concentration.

Some of the more commonly detected DBPs include trihalomethanes (THMs), haloacetic acids (HAAs) and chloroform. In Canada, Health Canada has assigned an interim maximum acceptable concentration (IMAC) for total trihalomethanes (TTHMs) of 0.1 mg/L. These interim guidelines are being updated, and a guideline is under development for haloacetic acids in drinking water.

Health Canada in 1993⁸ investigated 53 water distribution systems for DBPs. The systems represent most of the larger population centres in nine of the ten provinces. A summary of the data from the Health Canada study, showing chlorination by-product concentrations in the summer months, is provided in Table 3-9.

Table 3-9 Chlorination By-Products in Canadian Drinking Water			
Compound	Concentration (mg/L)		
	Mean	Minimum	Maximum
TTHM	0.062	0.0003	0.34
Dichloroacetic acid	0.019	0.0003	0.12
Trichloroacetic acid	0.049	0.0001	0.26
Chloral hydrate	0.0061	<0.0001	0.019
Dichloroacetonitrile	0.0019	<0.0001	0.0095
1,1-Dichloro-2-propanone	0.0006	<0.0001	0.0021
1,1,1-Trichloro-2-propanone	0.0019	<0.0001	0.0078
Chloropicrin	0.0002	<0.0001	0.0012

Table 3-10 provides the major portion of available data on DBPs for drinking waters from the City of Whitehorse distribution system. Values for total trihalomethanes (TTHMs) are below the Canadian Interim Maximum Acceptable Criterion (IMAC).

⁸ Health Canada, 1995. A National Survey of Chlorinated Disinfection By-Products in Canadian Drinking Water. Report 95-EHD-197. 21 pages.

Table 3-10 Chlorination By-Products in Whitehorse Drinking Water (mg/L)					
Location and Date	Bromodichloro-ethane	Bromoform	Chloroform	Dibromochloro-ethane	Total Trihalomethanes
<i>Jack Hulland</i>					
12-May-98	0.0005	<0.0002	0.018	<0.0001	0.0185
27-Aug-98	0.0006	<0.0002	0.017	<0.0001	0.0176
25-Nov-98	0.0008	<0.0002	0.0044	0.0002	0.0054
16-Feb-99	0.0006	<0.0002	0.0025	0.0001	0.0032
5-Feb-02	<0.0001	<0.0001	0.001	<0.0001	0.001
13-Aug-02	<0.0001	<0.0001	0.017	<0.0001	0.017
<i>Hillcrest Airport</i>					
12-May-98	0.0006	<0.0002	0.018	<0.0001	0.0186
27-Aug-98	0.0006	<0.0002	0.018	<0.0001	0.0186
25-Nov-98	0.0008	<0.0002	0.0048	0.0001	0.0057
16-Feb-99	0.0009	<0.0002	0.0036	0.0001	0.0046
5-Feb-02	<0.0001	<0.0001	0.002	<0.0001	0.002
13-Aug-02	<0.0001	<0.0001	0.012	<0.0001	0.012
<i>Crestview Pumphouse</i>					
12-May-98	0.0007	<0.0002	0.021	<0.0001	0.0217
27-Aug-98	0.0007	<0.0002	0.002	<0.0001	0.0027
25-Nov-98	0.0009	<0.0002	0.0069	<0.0001	0.0078
16-Feb-99	0.0011	<0.0002	0.0048	0.0002	0.0061
5-Feb-02	<0.0001	<0.0001	0.002	<0.0001	0.002
13-Aug-02	0.001	<0.0001	0.025	<0.0001	0.026
<i>Cooper Ridge PH</i>					
12-May-98	0.0015	<0.0002	0.016	<0.0001	0.0175
27-Aug-98	0.0008	<0.0002	0.023	<0.0001	0.0238
25-Nov-98	0.0009	<0.0002	0.0065	0.0001	0.0075
16-Feb-99	0.0011	<0.0002	0.0076	0.0002	0.0089
5-Feb-02	0.001	<0.0001	0.004	<0.0001	0.005
13-Aug-02	<0.0001	<0.0001	0.02	<0.0001	0.020

Table 3-10 Chlorination By-Products in Whitehorse Drinking Water (mg/L)					
Location and Date	Bromodichloro-ethane	Bromoform	Chloroform	Dibromochloro-ethane	Total Trihalomethanes
<i>Marwell Transit</i>					
12-May-98	0.0007	0.7	0.022	<0.0001	0.0234
27-Aug-98	0.0007	<0.0002	0.025	<0.0001	0.0257
25-Nov-98	0.0007	<0.0002	0.0052	0.0001	0.006
16-Feb-99	0.0007	<0.0002	0.0031	0.0001	0.0039
5-Feb-02	<0.0001	<0.0001	0.001	<0.0001	0.001
13-Aug-02	<0.0001	<0.0001	0.016	<0.0001	0.016
<i>Vanier School</i>					
12-May-98	0.0005	<0.0002	0.017	<0.0001	0.0175
27-Aug-98	0.0003	<0.0002	0.0075	<0.0001	0.0078
25-Nov-98	0.0007	<0.0002	0.0041	0.0001	0.0049
16-Feb-99	0.0006	<0.0002	0.0024	0.0001	0.0031
5-Feb-02	<0.0001	<0.0001	0.002	<0.0001	0.002
13-Aug-02	<0.0001	<0.0001	0.013	<0.0001	0.013

3.5.4 Other Surface Waters

This section discusses the quality of surface waters in the watershed other than Schwatka Lake. Analysis of surface water quality in the larger study area was carried out intensively in the late 1970s to early 1980s (Refs 1, 6, 9), and has been sporadic since then.

Yukon River headwaters:

Baker (Ref. 1) collected water chemistry data from six Yukon lakes (Bennett, Tagish, Marsh, Laberge, Kluane, Teslin) in the summer of 1977. The results were interpreted to represent baseline conditions for relatively pristine, oligotrophic lake systems. Of particular interest herein are the water quality data for Tagish Lake and Marsh Lake. Nutrient levels (phosphate, nitrate, nitrite) were below their respective detection limits in all lakes and at all sampling depths. Conductivity of Tagish and Marsh Lake water was in the range of 55 to 80 millimhos (mmhos). Baker noted elevated turbidity in

only one Marsh Lake sample (12 FTU), attributed to inputs from the McClintock River near the sampling station. All other samples exhibited turbidity in the range of <0.5 to 2.1 FTU.

Jack et al. (Ref 9) in 1983 collected baseline surface water quality data from the Yukon River mainstem and headwaters, as well as major tributaries (Klondike, White, Stewart, Pelly, Teslin, Takhini Rivers). All water samples tested in the Yukon River Basin were mildly alkaline (pH 7.0 to 8.3), and most water samples were also soft (<95 mg/L as CaCO₃). The slight alkalinity is attributed to the presence throughout the southern Yukon of a thin layer of volcanic ash, deposited approximately 1,200 years ago.

In general, the conductivity, alkalinity, and hardness of surface water increase from the upriver to downriver stretches of the Yukon River Basin. Samples collected near the Marsh Lake control structure had among the lowest hardness values. In addition, these parameters were noted to increase slightly during winter months. Overall, the hardness and alkalinity of the water was interpreted to be a result of progressively greater contributions of groundwater both downriver and after freeze-up.

Higher than normal non-filterable residues (suspended solids collected from a filtered water sample), often accompanied by elevated iron and/or phosphorus concentrations, were frequently observed in samples collected during the freshet and during rainstorms. Chemical parameters were within acceptable limits for drinking water quality in all samples analyzed. Bacterial analyses were not carried out on the samples.

Whitfield *et al.* (Ref. 6) in the late 1970's examined nutrient inputs through Schwatka Lake. Net nutrient outputs from the lake (at the Whitehorse Rapids Dam Raceway) were concluded to exceed net inputs via the Yukon River, suggesting nutrient contributions from groundwater. The researchers discounted surface drainage as a substantive contributor to the nutrient inputs in the lake, "due to the limited land surface area which drains into the impoundment." This tentative conclusion merits re-visitation, however, in light of the apparent disproportionate contribution of pollutants from localized surface drainage.

Fish Lake/McIntyre Creek:

Stanley and Associates (Ref 2) evaluated water quality in McIntyre Creek and the Fish Lake Watershed in 1979 and 1980. Bacteriological test results for the raw surface water ranged from 0 to 174 total coliforms/100 mL and 0 to 24 faecal coliforms/100 mL in 18 samples total. Fecal coliforms were detected in 9 of the 18 samples, or about 50%. Turbidity ranges from 0.7 to 6.4 NTU. All other chemical substances, as summarized in Table 3-11, were within acceptable range except phenols (0.002 to 0.1 mg/L, compared with previously published acceptable limits for Canadian Drinking Water of 0.02 mg/L). The water hardness, 76 to 126 mg/L as

CaCO₃, was generally within an acceptable range for drinking water except at one point on McIntyre Creek upstream from YECL powerhouse No. 2, where the hardness (as CaCO₃) was consistently around 240 mg/L on two separate sampling dates.

Table 3-11 Water Quality Data for the McIntyre Creek Watershed					
Analyte	Concentration (mg/L)				
	Range	¹ CDWQG	Analyte	Range	CDWQG
pH	7-6-8.1	6.5-8.5	Total P	0.016-0.05	No value
Conductivity	25-508	No value	Ortho-P	0.016-0.05	No value
TDS	138-396	≤500 ²	Suspended Solids	1-4	No value
Alkalinity	101-288	No value	Turbidity	1.0-5.2	≤ 5
Calcium	29-64	No value	Phenols	0.002-0.10	No value
Chloride	0.3-1.8	≤250	Mn (T)	0.02-0.11	0.19
Carbonate	0.0	No value	Fe (T)	0.14-0.17	≤0.3 ²
Bicarbonate	99-101	No value	Cu (T)	0.005-0.024	≤1.0 ²
Hardness	76-243	No value	Pb (T)	0.02-0.06	0.010
Potassium	0.7-1.7	No value	Zn (T)	0.02-0.07	≤5.0 ²
Sodium	4.0-8.5	≤200 ²	Cd (T)	0.01	0.005
Sulfate	10-19	≤500 ²	As (T)	0.005-0.011	0.025
Magnesium	6.1-22	≤0.05 ²	Cr (T)	0.01	0.05
Nitrate-Nitrite N	0.05-0.16	45	Ag (T)	0.02	No value
Ammonia N	0.05-0.5	No value	Al (T)	0.01-0.1	No value
TKN	0.1-1.7	No value	Hg (T)	0.02	0.001

¹Canadian Drinking Water Quality Guidelines (2002 Summary); ² Aesthetic Objective.

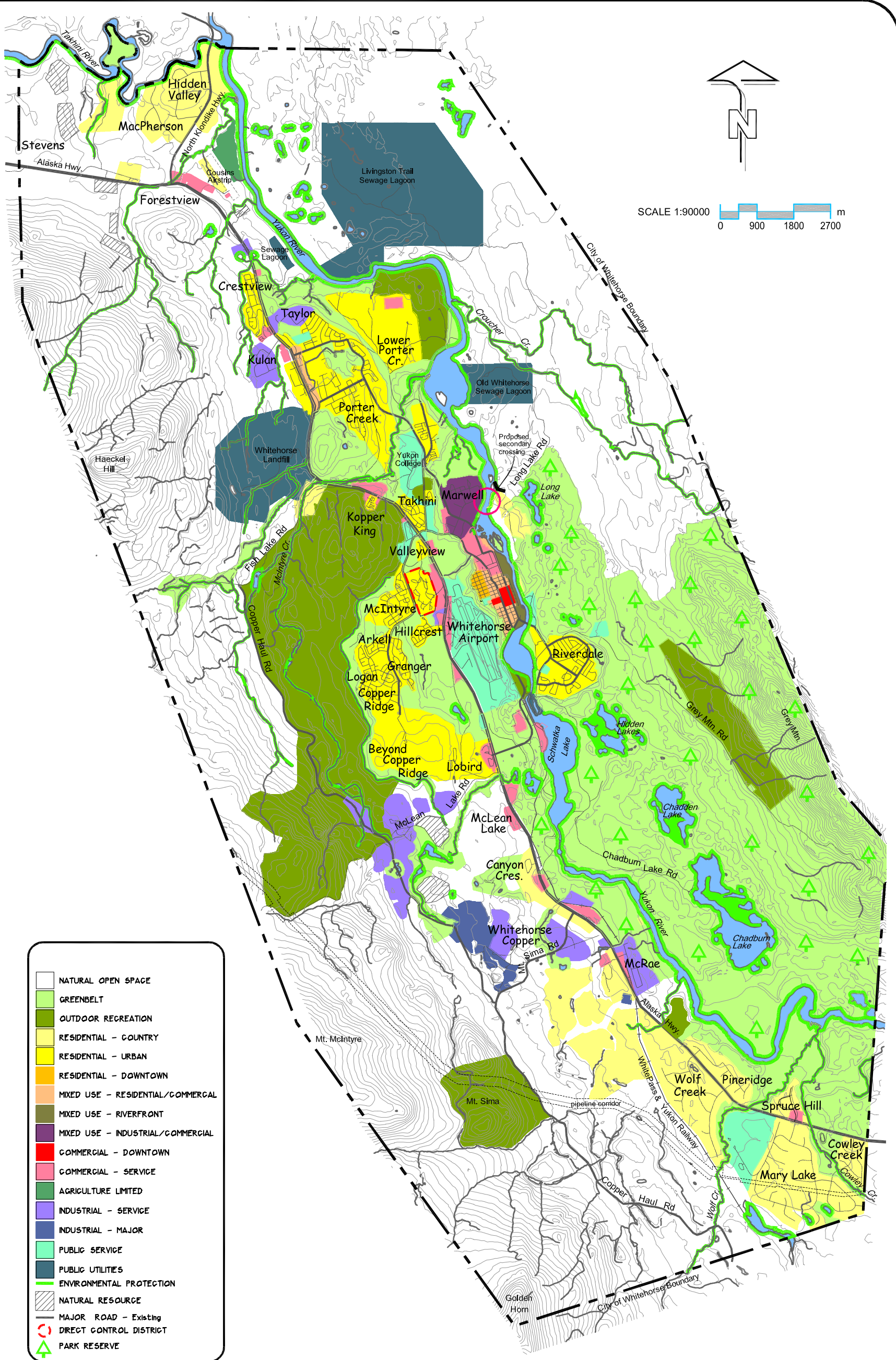
Lead levels measured in 1979-80 might indicate unacceptably high dissolved concentrations in the source water prior to treatment. It should be emphasized, however, that the data are limited in quantity and potentially outdated.

3.6 Land Use

Land use designations within the City of Whitehorse are defined in the Official Community Plan (OCP). Figure 3-2 shows these designations.

3.6.1 Land Ownership

Privately owned land within the City of Whitehorse is subject to the OCP land use designations. Crown lands and lands selected by First Nations within the City would probably be used and developed in accordance with the designations, but formal means of enforcement may be lacking. Parcels of land in the watershed, both inside and outside the City limits, have been selected by the Kwanlin Dun and Ta'an Kwach'an First Nations. The First Nations have expressed an interest in land development, but also a respect for watershed protection. These land selection areas are shown on Figure 3-1 (page 20).



3.6.2 Residential Development

The City of Whitehorse includes a series of neighbourhoods separated by green space or hydrological features such as the Yukon River. In general, all urban development is serviced by a system of gravity sewers and lift stations (nine total).

Major unsewered “Country Residential” areas within the study watershed include the Wolf Creek, Pineridge, Spruce Hill, Mary Lake and Cowley Creek subdivisions. These developments offer country residential living, primarily on lot sizes of 1.0 ha and larger, and the lots and residences have been in consistently high demand over the last decade. The 2002 Whitehorse Official Community Plan (OCP) specifically recognizes that country residential living “represents a valued lifestyle for a portion of the population”. The OCP reinforces the need to have soils in new Country Residential lots tested for adequacy of percolation, and potential for conflict with groundwater resources.

Country Residential developments are popular but create some concerns for groundwater resources

The White Pass Tank Farm, Lower Porter Creek and Beyond Copper Ridge areas have been identified in the OCP as potential fully serviced neighbourhoods; however the feasibility of sewer servicing has yet to be accurately assessed, pending preparation of Area Development Schemes.

The OCP identifies the Wickstrom Road and Long Lake area, east of the Yukon River as having potential for future development. This area in particular, merits special attention with regard to protecting the Selkirk and Long Lake Aquifers through recharge area and well-head protection strategies.

The City’s storm sewer system consists of a series of independent systems, draining into local streams or wetlands, and eventually into the Yukon River.

3.6.3 Forestry

The main concern related to forest operations is sediment input from riparian harvesting and road building. To mitigate this concern, the Yukon Timber Regulations of the *Territorial Lands (Yukon) Act* require significant buffers along all streams.

Forestry development within the Schwatka Lake study watershed generally has been for personal use only, according to representatives from the Forestry Management Branch, Energy Mines and Resources in Whitehorse. These uses include firewood cutting and miscellaneous clearing for other purposes (i.e. residential development and agriculture). It appears that no significant forest development operations have occurred in recent times, nor are they planned within the city limits. Timber lands on which future logging activities may take place are shown on Figure 3-1 (page 20).

Forest activity in the watershed is minimal

Outside of the study area, there is limited small timber harvest licence potential. Such licences are regulated by the Timber Regulations.

3.6.4 Agriculture

Agriculture is limited to the major river valleys including those of the Yukon, Takhini, Pelly, Stewart and Liard. For the most part, agricultural activity is located on river sediments. The total amount of land devoted to agriculture in the Yukon is approximately 12,500 hectares. Forty percent of this land is cropland and another 20 percent is under development for future agricultural use.

The Yukon Dept of Energy Mines and Resources Agriculture policy is intended to:

- encourage agricultural development;
- ensure that development is sustainable and in accordance with sound conservation practices;
- release agricultural land for sale or lease in a fair and equitable manner;
- preserve agricultural land; and
- ensure that competing land uses are fully considered.

Approximately half of the developed land is in crops, while the remainder is used for pasture or grazing. Most of the land used for agricultural purposes in the Yukon is located near the major communities. Seventy percent of the Yukon's farms are located within 100 km of Whitehorse.

Soil-based agriculture within the study area is limited to a number of parcels south of the city of Whitehorse, on the west side of the Yukon River. Some of these parcels have not been brought into production yet, and some of them are not intensely farmed at present. Known parcels on which agricultural activities have taken place are shown on Figure 3-1 (page 20).

According to David Murray (pers. comm. 2003), there are six titled agricultural parcels in the study area:

- Lot 1045, Quad 105 D10; 60.9 ha
- Lot 1093, Quad 105 D10; 65 ha
- Lot 1095, Quad 105 D10; 41.4 ha
- Lot 1127, Quad 105 D10; 58.4 ha
- Lot 1046, Quad 105 D10; 8.05 ha
- Lot 1047, Quad 105 D10; 17.8 ha.

The lots are primarily located adjacent to but on a bench above the Yukon River. Portions of the larger lots have been cleared for forage production. Buffers along the river have been retained to at least 30 m from the high water mark, as required by the Territorial Lands Act (section 13).

Of the larger lots, only Lot 1045 and Lot 1127 are currently being farmed. The owner of Lot 1045 is in the process of applying for permission to draw water from the Yukon River for irrigation purposes. Producing forage crops is the primary agricultural activity at the moment; however, the land could be used in the future for other agricultural purposes, such as livestock production. In addition to the above parcels, there are a number of rural residential and “non soil-based” (i.e. greenhouse operations) agricultural parcels in this area.

Agricultural land
use within the
watershed bears
monitoring

It is believed that there is relatively limited chemical pesticide and fertilizer use in the area; however, the application and use of such chemicals must follow territorial regulations. In the Yukon, all farm operations and developments must abide by the Environment Act and regulations.

AGRICULTURE POLICY FRAMEWORK AGREEMENT (APF)

The five-year agreement signed earlier this year between the Federal and Territorial governments is aimed at enhancing, strengthening and expanding the Yukon’s agriculture industry. Through the APF the Yukon is allocated an additional \$321,000 per year from the Federal government for agriculture development. This dollar amount is based on a 60/40 split, wherein the Federal Government will provide 60 per cent of the program funding which the Yukon Government will match with an additional 40 per cent in policy framework expenditures.

Over the next few months the farming community will be consulted on how to allocate this money. All of the money has to flow through five program elements: food safety; science and innovation; environment; skills training; and risk management. A majority of the funding is to be allocated to a risk management program in the hopes of stabilizing some of the financial risks faced by farmers from unpredictable sources such as the weather. We have also been allocated transition money for the move to the APF.

3.6.5 Recreation

For both residents and tourists, the Schwatka Lake watershed represents a significant and valuable amenity. Recreational activities take place year round, including the following:

- Activities on Schwatka Lake and the Yukon River downstream of Marsh Lake include power boating including “sea-do’s” and other personal watercraft, fishing, canoeing and kayaking, swimming, and water skiing, mainly on Schwatka Lake itself.
- The west side of Schwatka Lake provides docking facilities for floatplanes, which provide charter flights and aerial sight seeing tours. One of the floatplane companies also operates the *MV Schwatka*, a motor vessel that provides tours of the lake, Miles Canyon, and points upstream as far as McRae Creek.
- The Chadburn Lake Park Reserve, east of Schwatka Lake, incorporates trails, picnicking facilities and a boat launch, though camping is not allowed.
- An extensive network of trails encourages walking and hiking in the watershed, as well as nature interpretation activities, mountain biking, cross country skiing, and orienteering.
- In the winter, snowmobile races are held on Schwatka Lake, and ice fishing is a common activity.

Recreational activities in the watershed are varied and popular

There is a need for public education and cooperation in caring for this valuable amenity

These activities are well documented in References 13 (*Schwatka Lake Aviation and land Use Study*), 41 (*Parks and Recreation Master Plan*), and 42 (*Trail Plan*), and are also reflected in the *Official Community Plan* (Ref 28). Concerns related to human activities in the watershed include the potential for fuel and oil spills, bacterial and viral contaminants associated with human wastes, increased soil erosion, and the potential release of various chemicals associated with increased human activities.

3.6.6 Mining

Mining operations have been carried out in the watershed in the past, but to our knowledge there are no current operations. Mining operations, past or present, may increase soil erosion and sediment in watercourses, and potentially contaminate groundwater through the leaching of minerals in tailings piles or fractured surface rock.

Most notably in the Canyon Creek/Copper Creek sub-watersheds, as shown on Figure 3-1, there is an abandoned mine that has left behind large tailings ponds. Residents of neighbouring country residential developments complain of blowing dust from these tailings ponds, and have expressed concern about groundwater contamination.

There are no placer claims within the City limits, nor is the staking of placer claims within City limits allowed. However, there is an active placer claim just outside of the study area, on a small stream that flows into the Yukon River just upstream of the highway bridge over the Marsh Lake outlet.

In the case of quartz and hard rock mining, there are active claims in the study watershed, including several along Wolf and Cowley Creeks, the Mclean Lake area and the old Coppermine area, as shown in Figure 3-1. There is no prohibition on these types of claims in the City, however the City would have some input in the development of any such claims.

3.7 Erosion and Sediment Concerns

Water-borne sediment arises from both natural and man-made (anthropogenic) sources. Natural sources include the banks of the Yukon River, of which some sections are made up of clay (lake deposits) and some of fine sands (wind deposits). Erosion along the edges of Schwatka Lake is minimal, because of the slow water velocities in the lake. Fluctuations in water levels due to the operation of the YEC dam are small, and have minimal impact on shoreline erosion.

Applied Ecosystem Management Ltd. (Ref 26) described site sensitivity, defined as places where sediment can be transferred from hill slope to stream channel, for many of the streams within the City of Whitehorse from ortho-photographs, maps, and field sampling. This study revealed many areas of high sensitivity, mostly due to the presence of steep south facing eroding slopes adjacent to watercourses. The specific results of this survey relative to the Watershed Management Plan are outlined in the following table.

Table 3-12	
Sensitivity of Study Area Streams to Erosion	
Stream	Areas of Site Sensitivity Documented
Yukon River Mainstem	Site sensitivity is high in almost every reach of the Yukon River within the City due to the presence of steep, eroding slopes immediately adjacent to the river channel.
Wolf Creek	No areas of moderate or high site sensitivity mapped.
Cowley Creek	No areas of moderate or high site sensitivity mapped.
MacRae Creek	No areas of moderate or high site sensitivity mapped for MacRae, Sima or Sowdon creeks.
Basalt Creek	Site sensitivity is moderate on the first tributary of Basalt Creek due to the presence of steep south facing eroding slopes.

Anthropogenic factors possibly adding to turbidity and total suspended sediment include roads and access points to the Yukon River, stream crossings and various recreational uses. There are a few access points to the mainstem Yukon River that are

probably not routinely or frequently maintained. One such example is the US Laundry Site near MacRae where a gravel road was observed to have some minor erosion problems during a spring snowmelt event.

In addition, there are a number of roads and right of ways that intersect the left bank (looking downstream) tributary streams within the study area. These include not only the Alaska Highway but also secondary roads such as the Trans Canada Trail (old Copper Mine Haul Route). An old inactive portion of White Pass & Yukon Route railway line also crosses many of the streams that are tributaries to the Yukon River. While not yet built, the Foothills pipeline right of way also intersects a number of streams in the study watershed and will have the potential for sediment inputs during and after construction.

Recreational activities may also create erosion/sedimentation issues such as vegetation disturbance and removal along trails and wave action created by motorboats operating on the Yukon River. The wave action from motorboats along the cutslopes of the Yukon River has been witnessed to generate some localized short term turbidity along the shore.

The total impact of most sediment inputs to the turbidity levels of the City's water supply is likely buffered by the nature of the Yukon River within the study area. Upstream of Schwatka Lake the Yukon River is a wide slow moving stream with little areas of significant discernible flow and as such acts mainly as a depositional area in which much of sediments can settle out before reaching the water intake (see Section 3.5.1).

3.8 Wildlife in the Watershed

The presence of wildlife is an indicator of a relatively pristine watershed on the one hand, but on the other wildlife is a potential contributor to surface water bacteria and protozoan parasites. There are many wildlife species documented within the City of Whitehorse. Major species groups and including descriptions used in identifying ecologically based significant wildlife areas for the City of Whitehorse are presented below in Table 3-13.

Table 3-13 Major Wildlife Species in the City of Whitehorse¹		
Group	Species Group	Description
Birds	Avian Predators	Hawks, accipiters, falcons, eagles and owls
	Forest Birds/neotropical	Warblers, passerines, woodpeckers, corvids, grouse and ptarmigan
	Water Birds	Marsh and shore birds, waterfowl, gulls and terns
Mammals	Ungulates	Moose, deer, sheep, caribou
	Large Predators	Bear (black and grizzly), wolf, coyote
	Semi-Aquatic Mammals	Red fox, lynx, wolverine
	Small Forest Mammals	Beaver, muskrat, mink, otter
	Microtine Mammals	Hares, squirrels, etc.
		Mice, voles, shrews, lemmings, bats
Amphibians	Frogs	Wood frog
Fish	Fish	Fresh water fish species and salmon

¹Taken from Applied Ecosystem Management, 2000.

According to the 1995 Yukon State of the Environment Report,

"The greatest human impact on wetlands in the Yukon has been from hydroelectric development. The hydro dam at Whitehorse and the control dam downstream from Marsh Lake have significantly altered the high water regime upstream on Marsh, Tagish and Bennett Lakes. The most noticeable change is that wetlands on those lakes, noticeably McClintock Bay, Lewes Marsh, Tagish Narrows and Nares Lake, have extremely high water in the fall until after freeze-up, rather than a decline after a mid or late-summer peak. This has probably reduced the value of these wetlands for waterfowl during fall migration."

The report goes on to note that this has also had a detrimental effect on muskrats, an important species for local trappers.

Seventeen significant wildlife areas within the City of Whitehorse were identified and mapped by Applied Ecosystem Management Ltd. in 2000 (Ref. 20). Areas with high wildlife values encompass seven percent of the total City land base and twelve percent of the mapping area. Three wildlife values and environmental sensitivity land classes (high wildlife values, high environmental sensitivity; high wildlife values, moderate environmental sensitivity and high environmental sensitivity) were assigned to each significant ecosystem unit and are described below:

High Wildlife Values, High Environmental Sensitivity: Ecosystem units considered critical to the continued long-term use of the area by significant levels of wildlife and that have a high level of environmental sensitivity.

High Wildlife Values, Moderate Environmental Sensitivity: Ecosystem units considered important to the continued long-term use of the area by significant levels of wildlife and that have a moderate level of environmental sensitivity.

High Environmental Sensitivity: Ecosystem units with a high level of environmental sensitivity defined by either a low tolerance to disturbance or by the importance of that unit in the long-term functioning of adjacent areas.

Table 3-14
Significant Wildlife Areas and Environmental Sensitivity Land Classes

Area	Land Class	Comments
Wolf Creek/Cowley Creek-Yukon River	1, 3	Avian predators, forest birds/neotropical migrants, water birds, semi-aquatic mammals, ungulates, amphibians and fish are documented in this area. Moose documented in the Cowley Creek basin. The open water habitat of the Yukon River is important waterfowl staging area, while Wolf Creek is rehabilitating salmon stream. Lowland forests, marshes, meadows, fen and shrub communities are present throughout the area.
Chadburn Lake	1, 3	Water birds, forest birds/neotropical migrants, semi-aquatic mammals and microtine mammals documented in this area. The open water habitat and the sheltered bays of Chadburn Lake along with flooded shoreline habitat provide high wildlife values.
Chadden Lake	1, 3	There are shallow, open water habitats available for waterbirds. Wildlife species groups have not been documented in this area, but should be similar to Chadburn Lake.
Schwatka Lake and Area (including Hidden and Ear Lakes)	1, 2, 3	Water birds, forest birds/neotropical migrants, semi-aquatic mammals and microtine mammals have been documented in this area. A small colony of little brown bats was documented in the steep bluffs below the Whitehorse airport. Schwatka Lake is a significant wildlife area for waterfowl.
Riverdale-Yukon River Flats	1	Water birds, forest birds/neotropical migrants, semi-aquatic mammals and fish are documented in this area. Spawning and rearing habitat is present in the shallow side channels and along Robert Service Way. Two salmon enhancement channels have been constructed (on the west bank of the Yukon River and adjacent to Robert Service Way). There has been past documentation of active beaver activity near the Lewes Boulevard Bridge.
Quartz Road- Yukon River	1, 2	Avian predators, forest birds/neotropical migrants, water birds, semi-aquatic mammals and fish are documented in this area. Nesting habitat for water birds is influenced by water levels in the Yukon River and during low water periods, most islands are exposed and nesting birds become vulnerable to predation by terrestrial mammals. Areas near Kishwoot Island were identified as containing salmon and other fish rearing habitat.
Long Lake	2,3	Wildlife groups have not been documented for this area, but should be similar to Chadburn, Chadden and Hidden Lakes.
Old Village (Marwell) Wetlands	1, 2, 3	Avian predators, forest birds/neotropical migrants, water birds, semi-aquatic mammals and fish are documented in this area. Salmon and fresh water rearing habitat were identified surrounding the small groups of islands along the east bank of the Yukon River.

Table 3-14 - Continued
Significant Wildlife Areas and Wildlife Values and Environmental Sensitivity Land Classes

Area	Land Class	Comments
Lower McIntyre Creek-Yukon River	1, 2, 3	Avian predators, forest birds/neotropical migrants, water birds, microtine mammals, ungulates and fish were documented in this area. Areas surrounding the small groups of islands within the Yukon River were identified as containing salmon and other fish spawning. Rearing habitat. Spawned out salmon carcasses provide an important food source for many species during the fall. Moose have been observed in the area (especially on the east bank of the river). A high concentration of bald eagles can be seen associated with the steep bluffs along the south shore of the Yukon River.
Croucher Creek	1, 2, 3	Wildlife species groups have not been documented in this area, but should be similar to the Wolf and Cowley Creek corridors.
Porter Creek-Yukon River Confluence	1, 2, 3	Wildlife species groups have not been documented in this area.
Little Takhini Creek	1, 2, 3	Wildlife species groups have not been documented in this area.
Mary Lake-Wolf Creek	1, 2, 3	Avian predators, forest birds/neotropical migrants, water birds, microtine mammals, semi-aquatic mammals, ungulates and amphibians were documented in this area. Little brown bats forage along the shore of Mary Lake and the adjacent wetlands. Woodland caribou were once common in the Mary Lake area, especially along the Cowley Creek corridor where there is an abundance of lichen.
McLean Lake	1, 2, 3	Wildlife species have not been documented in this area.
Logan-Arkill Wetlands	1, 3	Semi-aquatic mammals and frogs have been documented in this area.
McIntyre Creek Corridor	1, 2, 3	Avian predators, forest birds/neotropical migrants, water birds and semi-aquatic mammals have been documented in this area.
Crestview Ponds	1, 2, 3	Forest birds/neotropical migrants, water birds and semi-aquatic mammals have been documented in this area. Past beaver activity was observed in this area. It is highly probable that moose and coyotes use this area, but has not been documented.

¹Where 1=high wildlife values, high environmental sensitivity; where 2=high wildlife values, moderate environmental sensitivity; 3=high environmental sensitivity.



4. EXPERIENCE ELSEWHERE

There are a variety of reasons why Watershed Management Plans (WMPs) are initiated. In many examples from around the world, watershed management planning processes have been initiated to:

- protect fisheries and other aquatic resources,
- reverse ecosystem-wide degradation that has occurred over the last century based on land development,
- prevent flooding and erosion, and/or
- guide specific land uses such as forestry, mining and agriculture.

Outside of the United States, there is a limited number of examples of WMPs that have been initiated for the primary purpose of protecting drinking water supplies.

4.1 The Canadian Experience

Recent highly publicized outbreaks of waterborne disease in Walkerton, Ontario, and North Battleford, Saskatchewan, along with concerns about the detection of some pharmaceuticals in groundwater used for drinking water, have heightened public concerns. Canadian scientists, environmental and health planners and regulators have recently emphasized the need for source water protection and, specifically, a “source to tap”, or watershed-based approach. **There is currently no legally enforceable requirement at any jurisdictional level in Canada, however, for the development of watershed management plans for the protection of drinking water and human health** (see also the brief description of jurisdictional division of responsibilities in Section 1.2).

Watershed and
source water
protection
planning is
voluntary in most
of Canada

Conservation Ontario⁹ and Ducks Unlimited¹⁰ called for the implementation of mandatory watershed management as the major message in their submissions to the Walkerton Inquiry. Similar messages have been delivered in various venues by many Canadian scientists, non-governmental organizations, and planners. **A few municipalities have voluntarily prepared WMPs for drinking water protection. Among these are the cities of Victoria, Vancouver¹¹, Kelowna¹² and Halifax.**

⁹ <http://www.conservation-ontario.on.ca/projects/walkerton/walkerton.htm>

¹⁰ <http://www.ducks.ca/news/prov2002/021118.html>

¹¹ <http://www.gvrd.bc.ca/services/water/sheds/default.html>

¹² <http://www.kjwc.org/index.php3>

Victoria, Vancouver, Prince Rupert, Halifax, and a limited number of other Canadian communities derive their drinking water supply from restricted access, single- or limited-use watersheds (wherein all activities are strongly subordinate to the primary goal of maintaining the watershed for drinking water protection). This is by no means a panacea for the avoidance of water quality issues, however.

In 1995, Greater Victoria experienced a toxoplasmosis outbreak. Toxoplasmosis is an infection caused by a single-celled parasite called *Toxoplasma gondii*. It has been estimated that approximately 20% to 25% of the North American populace probably carry the *Toxoplasma* parasite, but very few have symptoms because the immune system usually keeps the parasite from causing illness. However, serious symptoms may arise in pregnant women and those with compromised immune systems. In the Victoria case, it was likely that the *Toxoplasma* parasite was introduced to the water supply from animal feces. Domestic and feral cats are known to harbour the parasite in their feces, and are considered by parasitologists to be the primary host.

In Greater Vancouver, studies conducted in 2000-2001 confirmed a statistically significant relationship between turbidity in the reservoir and then unfiltered source water and an elevated chronic incidence of gastroenteritis. The relationship was strongest among susceptible members of the Greater Vancouver population, especially young children and the elderly. Lag times between maximum turbidity in the source water and maximum daily reported cases of gastroenteritis corresponded well to the known incubation times in humans of waterborne bacterial and protistan organisms that cause gastroenteritis. The increased turbidity is thought to decrease the effectiveness of chlorination disinfection. The high turbidity in the reservoir is a result of the fine-textured soils in the watershed and which form the sides of the reservoir, exacerbated by high rainfall events, as well as reservoir drawdown and wind-generated wave erosion.

4.1.1 Current Status of Drinking Water Supplies

Environment Canada maintains a Municipal Water Use Database (MUD) that contains water and sewage system information for 1,359 Canadian municipalities with populations greater than 1,000. The database covers approximately 85% of all Canadians. An additional 0.9% of the database population includes rural residents from nearby non-surveyed areas that are served by the municipal water systems. The database was initially created in 1986, and has been substantially updated in 1989, 1991, 1994, 1996, and 1999. In the Yukon, the database includes information for Whitehorse, Dawson, Faro, and Watson Lake.

Based on all available data for Canadian municipalities, as shown in Figure 4-1, the average daily flow for drinking water supplies can be estimated as – $\text{Log}_{10}(\text{Average Daily Flow}) (\text{m}^3/\text{d}) = 1.042 \bullet \text{log}_{10}(\text{Population Served}) - 0.404$ (1)
($n = 1217$; $r^2 = 0.89$; $p < 0.001$)

Figure 4-1: Potable Water Use in Canadian Communities

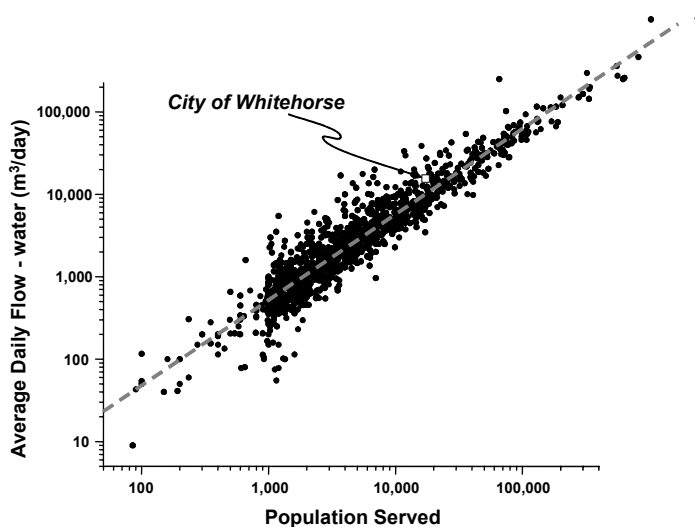
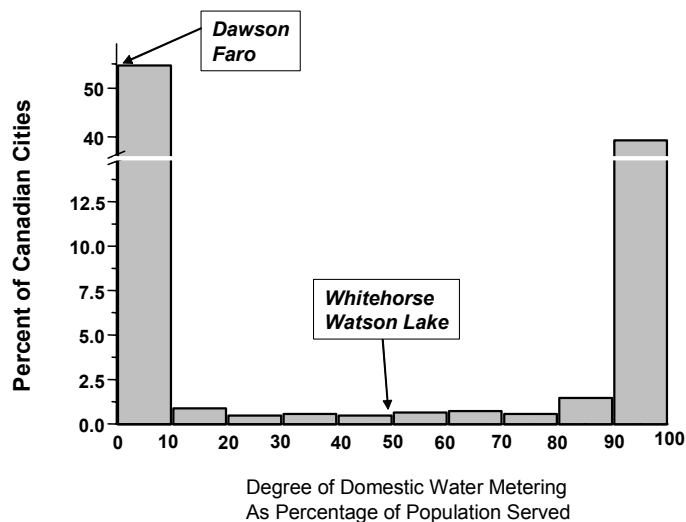


Figure 4-2: Water Metering in Canadian Communities



An estimated 12 % of the Canadians within communities larger than 1,000 people rely on groundwater for their drinking water (Figure 4.3). All of Prince Edward Island, for example, relies on groundwater supplies.

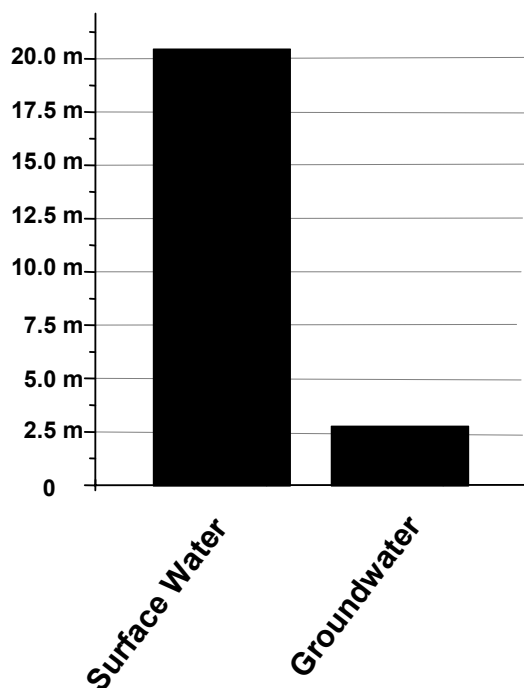


Figure 4-3: Canadian Drinking Water Sources

Of the 1,359 municipalities included in the database, 574 of them, or around 42%, have reported water quantity problems in one or more years since the database was created. Problems with adequate volume of potable water have not been reported in Yukon communities. Water quantity issues often arise as a result of severe summer-time drought conditions or lack of snowfall in the preceding winter, increased domestic or industrial demand, or often both.

Drinking water quantity and quality issues have occurred in many Canadian communities

Issues associated with adequate quantities of drinking water often co-occur with problems with drinking water quality. Reservoir drawdown often results in increasingly stagnant water being drawn into the distribution system with concomitant increases in 'fishy' taste and odour problems as well as the concentration of bacteria in the supply.

The localized depletion of groundwater can have several negative effects on water quality. It may require increased use of alternative sources with lower quality. The drawdown can alter groundwater flow patterns and encourage the movement toward the extraction well of water masses and dissolved materials from adjacent areas, which may be elevated in naturally occurring metals/metalloids (such as iron, manganese, or arsenic) or salts. In marine coastal environments, the over-extraction of groundwater has in many examples throughout the world resulted in increased inland intrusion of salt-water from the adjacent sea, rendering the groundwater source unfit for human consumption.

Drinking water quality problems have been reported in 565 municipalities for one year or more (~42% of municipalities). The types of water quality problems, as concisely self-reported, are shown in Table 4-1. No problems were recorded in the MUD database for the 1999 or previous surveys for Whitehorse or other Yukon communities. However, see Chapter 3 for a more complete summary of water quality issues.

The issues listed in Table 4-1 provide a rough indication about the issues that might arise in the future in the watershed serving the needs of the City of Whitehorse. The number of actual cases of chemical contamination of drinking water supplies that has occurred in Canada, for example, should serve as an indication of the importance of source water and wellhead protection.

In order to provide an indication about how Whitehorse stacks up against some other Canadian municipalities of similar size, the Municipal Water Use Database was used to extract information about drinking water issues for twelve other western Canadian communities with served populations in the range of 15,000 to 30,000, which are removed from larger urban centres, and which are predominantly located in the northern boreal forest. A more detailed breakdown of the drinking water supply and issues that have arisen for each of twelve communities is provided in Table 4-2.

Table 4-1 Drinking Water Quality Problems in Canadian Municipalities (1986-1999)	
Major Category (with examples)	Number of Municipalities Reporting Issues
Bacterial Contamination (including coliforms) - coliforms in surface waters; - bacterial regrowth; - boil order advisories; - agricultural pollution; - manure spill; - <i>Campylobacter jejuni</i> - increased coliforms during heavy rains.	85
<i>Cryptosporidium</i>	4
<i>Giardia</i>	17
Chemical Contamination - contamination by landfill site; - perchloroethylene, tri- and tetrachloroethylene contamination (degreasing agents) (8 separate cases) - salt contamination from road salt storage area; - industrial spills (3 separate cases); - vandalism; - phenols (2 separate cases); - NDMA (N-Nitrosodimethylamine) contamination at Elmira, ON, released from fertilizer manufacture; - detergents in river water; - industrial effluent into reservoir due to faulty distribution system; - benzene, TCE, iron; - elevated copper; - selenium levels; - arsenic levels; - barium levels;	32

Table 4-1 Drinking Water Quality Problems in Canadian Municipalities (1986-1999)	
Major Category (with examples)	Number of Municipalities Reporting Issues
- oil spill; - diesel spill.	
Elevated Disinfection Byproducts (such as Trihalomethanes)	8
Taste and Odour, Algal Blooms and or Colour - algal blooms during low level conditions in reservoirs; - stagnant water; - colour, taste and odour from a broken beaver dam; - extreme algal growth; - taste and odour problems associated with spring run-off; - taste and odour problems associated with summer and fall algal blooms; - high dissolved organic matter; - brown water.	82
Turbidity - intake silting up; - high suspended solids in surface water supplies; - high suspended solids in groundwater supplies; - seasonally increased turbidity due to logging in watershed; - high turbidity after storms; - surface supply too turbid; - upstream work enhanced turbidity.	78
pH	13
Elevated Iron and Manganese	70
Water Hardness	7
Ammonia or Nitrate	6
Temperature	2
Flooding in Watershed - intake damaged by flood; - flooding increased turbidity; introduced bacterial contamination.	6
Intake/Distribution Main Breaks or Plugging	15
Chlorination Disinfection Failures and/or Inadequate Chlorine Residual	10
Filtration Problems - air binding of filters; - failure of clarifier and filters; - plant undersized; filter failure; - slow filtration during spring-time high flow turbid conditions.	8
Miscellaneous - depleted aquifer, catalyzed move to surface water supply; - compromised surface supply quality, catalyzed move to groundwater supply;	44

Table 4-1 Drinking Water Quality Problems in Canadian Municipalities (1986-1999)	
Major Category (with examples)	Number of Municipalities Reporting Issues
- increased boat traffic; - cottonwood fluff; - gravel infill in impoundment; - high fluoride; - high sodium; - salt water intrusion into groundwater supply; - ice formation; - land and mud slides, slumping into source waters (6 separate cases); - hydrogen sulphide in supply; - main source well bio-fouled; - well contamination; - colour from post-treatment flocculation; - chlorine resistant coliform bacteria; - cross connection caused contamination; - zebra mussels.	

**Table 4-2
Municipal Water Use and Issues for Western Canadian Communities**

MUNICIPALITY	Date revised	Current Pop.	Hydrometric Area (Env. Canada)	Pop. Served - Water	Pop. Served - sewers	Average Daily Flow-Water	Commercial/Industrial Water Use as % of Total	% of supply from groundwater	DW disinfection type	Fluoridation?	Additional Water Treatment
SALMON ARM, BC	00/09/01	15,000	08LE	15,000	8,500	7,135	9%	0%	Chlorination	N	none
FORT ST. JOHN, BC	97/01/22	15,000	07FC	15,000	15,000	5,700	30%	0%	Chlorination	Y	coagulation
SWIFT CURRENT, SK	00/07/10	16,500	05HD	16,000	16,500	6,819	41%	0%	Chlorination	Y	coagulation, sedimentation, sand filter, activated carbon, Fe/Mn removal
YORKTON, SK	00/08/04	16,000	05MB	16,000	16,000	5,455	35%	100%	Chlorination	N	Fe/Mn removal
PRINCE RUPERT, BC	00/09/01	16,000	08EG	16,000	16,000	38,641	65%	0%	Chlorination	Y	none
YELLOWKNIFE, NWT	00/09/10	17,250	07SB	17,250	17,250	7,000	29%	0%	Chlorination	Y	none
CRANBROOK, BC	00/01/06	18,300	08NG	18,000	18,000	15,456	22%	0%	Chlorination	Y	none
PORT ALBERNI, BC	00/07/10	18,500	08HB	18,500	18,200	15,000	47%	0%	Chlorination	N	none
COURTENAY, BC	00/08/04	19,000	08HB	19,000	18,000	11,600	25%	0%	Chlorination	N	none
WHITEHORSE, YT	00/07/20	23,000	09AB	20,000	17,500	15,500	33%	~30%	Chlorination	N	none
VERNON, BC	97/01/22	33,100	08NM	24,075	26,500	14,550	20%	0%	Chlorination	N	none
CAMPBELL RIVER, BC	00/08/04	29,000	08HD	29,000	28,000	11,500	11%	0%	Chlorination	N	none
GRANDE PRAIRIE, AB	97/04/16	29,242	07GE	29,242	29,242	10,250	46%	0%	Chlorination	Y	coagulation, sedimentation, sand filter

Table 4-2 - continued Municipal Water Use and Issues for Western Canadian Communities						
MUNICIPALITY	Declared problem years - Drinking water quantity	Declared problem years - Drinking water quality	Type of Quantity or Quality Problems Reported	Imposed Water Restriction Days, 1998	Est. population without centralized sewage treatment	Sewage Treatment Type
SALMON ARM, BC	'90-'95		Excessive Demand; High population growth		6,500	Tertiary
FORT ST. JOHN, BC	'91-'94	'91-'94	Quantity = Drought; Quality = colour and odour			Primary with Waste Stabil.
SWIFT CURRENT, SK		'86-'97	Algae	0		Primary with Waste Stabil.
YORKTON, SK		'86-'94	Taste & Odour, hardness complaints.	0		Secondary
PRINCE RUPERT, BC	'94-'96		Near capacity	0	16,000	
YELLOWKNIFE, NWT		'94-'96	Turbidity in Spring			Primary with Waste Stabil.
CRANBROOK, BC	'91-'95	'93-'96	Quantity = excessive demand; Quality = turbidity, <i>Cryptosporidium</i> in 1996.	365	300	Secondary
PORT ALBERNI, BC	'85-'93	'90	Quantity = seasonal shortage; quality = not stated.	90	300	Primary with Waste Stabil.
COURTENAY, BC					500	Secondary
WHITEHORSE, YT				0	5,000	Primary with Waste Stabil.
VERNON, BC	'94	'93	Quantity = Water Licence (?); Quality = turbidity in spring.		6,600	Tertiary
CAMPBELL RIVER, BC	'87-'94		High peak demands.	0	1,000	Secondary
GRANDE PRAIRIE, AB						Secondary

As noted earlier, source water protection as well as the maintenance of a watershed that minimizes movement of particulates, nutrients, bacteria, and other substances into surface and groundwater reduces the subsequent effort required to reclaim and disinfect drinking water to render it safe for human use.

A large proportion of the drinking water quality and quantity issues reported by Canadian municipalities over the last decade and a half have originated with the source waters, as opposed to post-intake treatment and distribution.

Figure 4-4 summarizes the types of drinking water disinfection used in Canada, while Figure 4-5 shows the proportion of municipalities that had moved to filtering source waters as of the last reporting date (1999 for most).

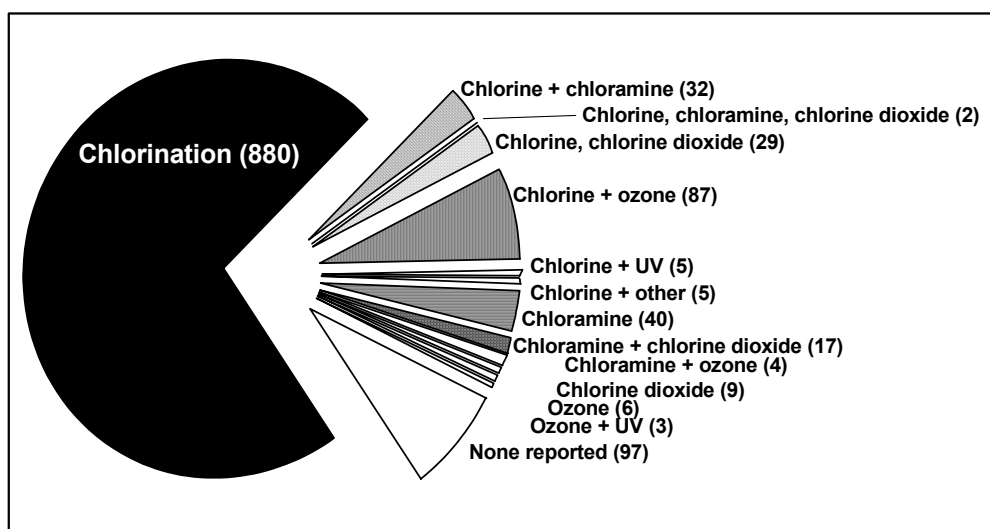


**Figure 4-4:
Summary of Drinking Water Disinfection Regimes in Canada**

Whitehorse is among a minority of mid-sized communities that have not yet had to upgrade to a filtered water supply.

Approximately 27% of all Canadian municipal water providers apply pH correction to their water supplies prior to distribution.

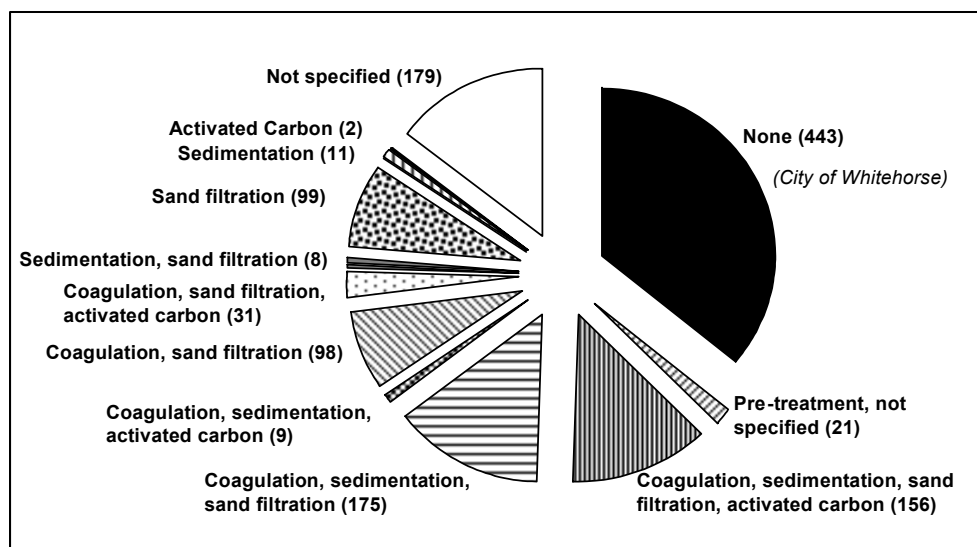


**Figure 4-5:
Summary of Drinking Water Pretreatment in Canada**

4.1.2 Source Water Protection in Eight Communities

In 1998, personnel representing the British Columbia Auditor General's Office visited eight mid-sized communities, to better understand the effectiveness of source water protection in the province¹³. The communities were Fort St. John, Prince George, Williams Lake, Prince Rupert, Cranbrook, Kelowna, Abbotsford and Nanaimo. The resulting report also covers source water quality and protection in smaller BC communities.

The visits revealed that every drinking water system is unique. The reliance on ground-water supplies versus surface water varied, as did the major threats to the source supply. The major identified concerns in the study communities are excerpted from the Auditor General's report, as Table 4-3 below. The drinking water quality in all eight of these communities is good, although it might be argued that an ability to predict and prevent future episodic declines in water quality still requires improvement. According to the Auditor General's report:

"The high water quality provided in these communities was not simply due to the quality of the source water - it was also a result of considerable effort by the communities to deal with the impacts of other activities in their water-source areas. In most cases, large expenditures to ensure adequate quantities of safe drinking water for community use had been incurred or were being contemplated."

¹³ <http://www.oag.bc.ca/pubs/1998-99/report-5/sec-2.htm>

Table 4-3 Major Threats to Source Water in Eight BC Communities ¹ .								
Activity/Issue	Approx. Population	Forestry	Mining	Cattle Grazing	Agriculture	Human Settlement	Recreation	Transportation
Groundwater Sources								
Fort St. John	20,000							X
Prince George	80,000					X		X
Williams Lake	12,000					X		X
Abbotsford	110,000				X	X		X
Surface Water Sources								
Fort St. John	20,000					X		
Prince Rupert	17,000							
Cranbrook	19,000	X		X			X	X
Kelowna	92,000	X		X		X	X	X
Nanaimo	75,000	X					X	
Abbotsford	110,000	X					X	

Fort St. John (population 20,000):

In Fort St. John, the water supply was drawn from Charlie Lake from 1942 to 1997, a shallow lake approximately 8 km northwest of the community. Lake water was treated by coagulation and straining, followed by filtration through layers of charcoal, sand, aggregate and garnet, and then disinfection using chlorine. The shallowness of this eutrophic lake, however, coupled with increased drawdown over time due to increasing water demand resulted in recurring blue-green algal blooms and high levels of faecal coliforms. The nutrient and coliform concentrations were very likely exacerbated by agricultural runoff and substandard sewage disposal practices on the surrounding private lands. The treatment was effective in removing coliform bacteria from the distributed supply, but could not resolve the green colour and fishy odour imparted by blue blue-green algae.

Increased complaints about taste and odour, along with inadequate quantities to serve future needs, prompted the city to switch in 1997 to a shallow (ca. 8 m depth under the Peace River floor) groundwater supply. This supply is similar to the groundwater currently used by the City of Whitehorse, in that the water is likely a combination of water introduced to the permeable glaciofluvial materials from rainfall and snowmelt within the recharge area at higher elevations and river water that infiltrates into the

In Fort St. John, a compromised surface water supply compelled a switch to groundwater

extraction well drawdown area during active pumping. Turbidity and pathogen levels, however, are low, owing to the ability of the soils to filter out non-dissolved constituents from the river water.

The groundwater is chlorinated to disinfect it, at roughly half the levels that were required for the Charlie Lake supply prior to 1997. Although not explored in the Auditor General's report, this should have resulted in a substantial decrease in disinfection by-products (trihalomethanes, for example) in the City's drinking water supply. Pressure filtration is applied to reduce iron and manganese levels in the groundwater supply, for aesthetic reasons.

No information was provided regarding possible future threats to the currently used groundwater supply, based on human activities and developments in the recharge area of the watershed, or based on a detailed consideration of the groundwater supply versus future human and other needs in the watershed. As such, the Fort St. John case provides a reactive as opposed to proactive example.

Prince George (population approximately 80,000):

Prince George, at the confluence of the Nechako and Fraser River, draws its potable water from wells that extract groundwater from at least three of six semi-discrete shallow aquifers that underlie the City. There has been no shortage of water based on the potential supply, but there are challenges with the interconnections in the collection and distribution system between the wells, leaving the system vulnerable to interrupted water delivery should one or more of the major wells fail. Eighty percent of the drinking water supply comes from two wells, each consisting of two layers of horizontal collectors feeding into a central well shaft.

Two wells have been abandoned in the last decade, one because of high groundwater manganese concentrations and a second because of potential petroleum hydrocarbon contamination from fuel released from a nearby tank farm. One currently operating well is also being closely monitored for petroleum hydrocarbon contamination from a large fuel truck spill in 1997. There is also concern about the possibility of future faecal and nitrate contamination from nearby housing developments with disposal-to-ground septic systems.

Like both Fort St. John and Whitehorse, a major portion of the withdrawn groundwater (an estimated 55% for Prince George) originates in the adjacent river, and is drawn into the wells based on a combination of natural and enhanced infiltration into the drawdown area.

No elevated turbidity or detectable protistan parasites (*Giardia*, *Cryptosporidium*) have been observed in the groundwater supply, nor would they be expected. Two wells installed downstream from the sewage treatment plant, however, have occasionally

Groundwater contamination has forced well abandonment in many cases

For communities in river valleys, surface and groundwater supplies are intimately interconnected

had low detectable fecal coliform counts in the raw water, generally when the river level is low. Experience globally has shown that contamination of groundwater supplies predominantly has been through the wellhead. Chlorination of the Prince George supply has been adequate in preventing faecal coliform contamination of the distributed water.

In terms of source water protection, as of 1999 the City of Prince George had yet to map important and potentially sensitive aquifer recharge zones, and had not yet, therefore, maximized the use of zoning and other bylaw mechanisms for source protection. Major roads, rail links, industrial yards, and other possible contaminants sources are located along the river valley over the aquifer close to some of the wells, creating potential risks. The City has yet to consider source water protection for groundwater or surface water sources that may possibly be important in the future (for example, by 2050).

Vulnerable areas need to be mapped en route to developing protection strategies

Williams Lake (population: 12,000)

Williams Lake has obtained its entire drinking water supply from regional groundwater since the 1970s. Four deep wells, located at Scout Island at the west end of Williams Lake, are connected to the community distribution system by twin transmission mains. Water in each main is independently chlorinated and the system is continuously monitored using a computer-assisted system. Source water quality has consistently been excellent, except that water tends to be hard.

Studies undertaken since 1991 suggest that the major recharge zones for the extraction wells lie on the slopes above the lake and its feeder stream. Non-sewered residential developments and trailer parks above this zone on the south side of the lake have been identified as a potential threat to the recharge area and source water quality. The city is currently planning to incorporate these subdivisions into the City, and to hook up residences to city sewers and water. A major rail line and bulk plants are located beside the lake, and these have been provisionally identified as being of concern. The City intends to develop contingency plans for these based on potential for contamination of the drinking water supply.

Non-sewered residential development poses a threat

Contingency plans are needed for chemical spills

Prince Rupert (population: 17,000)

Prince Rupert is a coastal community. Drinking water is piped by gravity from Woodworth Lake. Shawatlan Lake formerly provided 80% of the City's potable water needs, but is now maintained solely as a back-up supply. The switch in sources was enabled by the construction of a new water line in 1995, at a cost of \$5.4 million. The impetus for the change was based more on quantity than water quality issues: The Shawatlan Lake supply was too limited to provide both contingency supply for fire fighting needs while still maintaining adequate supplies for the economically important cannery industry.

Prince Rupert's water supply is located within a pristine, restricted access watershed

The watershed for both lakes (approximately 50 km²) is protected to a large degree since it is on crown land, and can only be accessed via boat, either through city land or the Shoowahatlans Indian Reserve. Entry into the watershed is strictly prohibited except on official business related to the water supply. The watershed has never been logged, and is considered by local Ministry of Forests managers to be too sensitive to allow harvesting. It is designated as a community watershed under the British Columbia Forest Practices Code.

There is no evidence of *Giardia* or *Cryptosporidium* in the water supply, based on previous tests, a result that is attributed to the limited number of wildlife in the watershed owing to its steep sides. Stool tests are routinely carried out to ensure that workers entering the watershed are not carrying protistan parasites. According to the Auditor General's report "Tannins in muskeg around the lakes give the water some colour. However, they also raise its acid content, which makes the city's chlorination more effective against *Giardia* and coliform bacteria."

No information was provided on levels of disinfection byproducts in the chlorinated drinking water supply.

Cranbrook (population: 19,000)

Cranbrook obtains its potable water from the Joseph Creek and Gold Creek watersheds, to the southeast of the city, with an area of approximately 200 km². The water is stored in a reservoir created by an impoundment on Joseph Creek. The water in Joseph Creek is augmented by a diversion pipe from Gold Creek, which later flows into Joseph Creek through an open channel. The water is chlorinated at the reservoir and then gravity fed a few kilometres to the city's distribution system.

The City of Cranbrook has little control over its source waters

The city suffered an outbreak of cryptosporidiosis in 1996, which prompted the closing of swimming pools, as well as the use of bottled water in restaurants, dentistry and commercial operations. According to the Auditor General's report, "The cause of the outbreak is still under debate".

The Joseph Creek watershed is a multi-use watershed with a large number of possible threats to the water source, similar in many respects to the upper Yukon River basin including Schwatka Lake. There is a public road through the watershed, which travels close to the reservoir and beside the Gold Creek diversion channel, which is used for limited residential access and logging, but primarily for off-road motorized recreation. The City has attempted unsuccessfully to have the road closed to public access. The City plans to replace the diversion channel from Gold Creek with an enclosed waterline.

The major portion of the Cranbrook watershed is on Crown land, and much of this is designated for active logging. The city and the logging company work cooperatively to

monitor water quality and educate the public. Cattle grazing is also allowed in the watershed on both private and crown land. The City restricted cattle access from the reservoir and portions of Joseph Creek using fencing. Apparently, cattle can still get access from time to time to the creek channel and its tributaries by walking down the Gold Creek Road from crown grazing leases higher up in the watershed.

Episodically high turbidity is associated with high rainfall and runoff events. The City intends to construct a bypass around the reservoir for such periods. Currently, the turbidity is treated only through settling in the reservoir. During high turbidity episodes, the City switches to two downtown wells as an alternative source, but lacks the necessary infrastructure to supply all parts of Cranbrook using this groundwater supply.

Kelowna (population: 92,000)

Kelowna derives its drinking water from five different water systems. The largest of these, serving about 50,000 people, is the intake from Okanagan Lake located at a depth of approximately 22 m. Kelowna experienced an outbreak of cryptosporidiosis in 1996, following high rainfall and creek flows that reached 100-year records. The long-term monitoring experience by city staff suggests that both *Cryptosporidium* and *Giardia* levels increase in the water supply during high runoff events, including the spring melt and after extended heavy rainfall.

In 1996
Kelowna had a
Crypto-
sporidiosis
outbreak

Specific sources of the parasite to Okanagan Lake at the intake point were not confidently identified, but the BC Centre for Disease Control suggested following the outbreak that, although the city chlorinates the lake water at the pump station, there may have been insufficient contact time from the point of chlorination to various points of distribution to realize an optimum level of reduction of the protistan parasites.

The depth of the intake (22 m) compelled many to discount the water intake as a primary source of contaminated water, since widespread contamination of *Giardia* or *Cryptosporidium* was not expected at this lake depth. The lake, however, and its many feeder watersheds are influenced by a myriad of human activities and large scale land uses including transportation, agriculture, livestock grazing, logging, human settlement including non-sewered residential development, and recreation.

The 1996 episode brought attention to the fact that the city's primary supply was not immune to potential human health risks, and that existing infrastructure was insufficient to allow short-term or longer-term use on one or more of the four alternative sources for the entire needs of the city.

Two possible solutions have been identified. One, which is currently being implemented, is the reduction by community users in water consumption based on metering and public education. Kelowna residents are, on average, profligate users of water

relative to the average Canadian. The second proposed solution involves approximately \$44 million in improvements to the disinfection and distribution system, including an ozonation plant. This had yet to be approved as of 1999.

Abbotsford (population: 110,000)

Abbotsford, since 1994, includes the amalgamated Districts of East Abbotsford, Matsqui and Clearbrook. Prior to 1994 the majority of residents obtained their drinking water from the massive unconfined Abbotsford-Sumas Aquifer, which extends from the Fraser River southward into the State of Washington.

The aquifer currently serves the potable water needs of approximately 40,000 people in this area of southern B.C. In the mid-1990s, however, it became evident that many wells drawing on the aquifer have water with elevated nitrate levels, a direct result of the cumulative, long term application of manures and fertilizers on Fraser River delta lands at rates that allowed contamination of the underlying groundwater. Poorly located or poorly functioning septic fields in more rural areas may also be a contributing factor. Two of eleven major water extraction wells have been shut down because of nitrate concentrations in groundwater that often exceed Canadian Drinking Water Quality Guidelines. Several rural drinking water supplies are also compromised by elevated nitrate levels.

Decline of
a major
groundwater
supply

In addition to agricultural nutrient inputs, the Abbotsford-Sumas Aquifer is vulnerable to potential contamination at a myriad of points within its recharge area, from pesticide use, major transportation corridors, tank farms, underground storage tanks, and so on.

In spite of the size of the Sumas-Abbotsford Aquifer, there are concerns about its ability to satisfy future needs. Well production has been increased in recent years, and City studies suggest that little if any excess capacity remains in the useable parts of the aquifer.

The majority of community members (approximately 70,000) are served by surface water supplies drawn from the Norrish Creek watershed (approx. 100 km²) and Cannell Lake and surrounding watershed, both located north of the Fraser River at Mission. The surface water system is under the direct jurisdiction of the Central Fraser Valley Water Commission, and also supplies the approximately 30,000 residents of Mission.

Norrish Creek is turbid during high flow periods, and at times has elevated coliform levels prior to treatment. Chloramine is used instead of chlorine for disinfection, which has benefits for maintaining a stable chlorine residual in the distribution system. Spills from distribution systems into fish-bearing waters, however, become a larger concern owing to the greater environmental persistence of chloramines and increased

risks to fish populations. Norrish Creek is also maintained as important fish habitat, requiring the water commission to release water from the Dickson reservoir to maintain minimum creek flows.

The Norrish Creek watershed has a long history of logging activity. There were problems identified in the early 1980s with logging related effects on slope stability in the watershed, and on stream turbidity. This, along with concerns for the overall vulnerability of the watershed, resulted in the development of an integrated watershed management plan for the Norrish Creek watershed in 1987.

For Abbotsford, as for Cranbrook, multi-use management is challenging. The use of forestry road networks by the general public, and especially by recreational users has been identified by the Watershed Commission, local health authorities, and the Ministry of Water, Land and Air Protection as a concern based on potential risks to the water supply from both a human health and fisheries perspective. Attempts to limit vehicular access using gates across logging roads have been resisted through acts of vandalism.

The Central Fraser Valley Water Commission has estimated future water demands by the year 2035 based on an Abbotsford and Mission population base of at least 275,000 people. Long term plans call for installation of a large-scale slow sand filtration plant by 2005 to overcome limitations in the use of Norrish Creek during turbid, high flow periods. By 2015, the Commission anticipates the need to begin piping water from the Harrison River, an additional 20 km to the north, based on its current status as a relatively plentiful, low turbidity source.

Nanaimo (population: 75,000)

Nanaimo's water supply is managed by the Greater Nanaimo Water District. The major supply source is an intake on the south fork of the Nanaimo River, from the lower of two dams on the river. The water is chlorinated before entering city limits. Watershed management for Nanaimo has its own challenges since virtually the entire watershed is privately owned forest, most of which is actively being harvested. The company manages and limits public access, and monitors the creeks for siltation and blockages. Although turbidity levels occasionally exceed drinking water guidelines in the raw water supply, monthly testing has not indicated any elevated source water risks from *Giardia*, *Cryptosporidium* or coliform bacteria.

The City has gated the access road to the south fork of the Nanaimo River. In collaboration with the logging company and the local fish and game club, access is restricted to those who purchase an access licence. As part of the purchase, the interested individuals must first watch a video describing the importance of protecting the watershed, and are issued written materials outlining the rules to be followed.

Population growth estimates for the Nanaimo area will likely require the construction of additional storage facilities and/or securing of new supplies. Groundwater in some portions of the Cassidy Aquifer may already be over-used for domestic irrigation, community and industrial purposes, and seasonal draw-down likely exacerbates low-flow conditions in the Nanaimo River, along with associated problems for salmonid migration and survival.

4.1.3 Watershed Management Planning in Halifax, NS

The **Halifax Regional Water Commission** (HWRC)¹⁴ manages five watersheds in Nova Scotia, for the specific purpose of achieving the first step in a multi-barrier approach to drinking water protection. Two of these watersheds serve as active drinking water sources. The Lake Major Watershed (7,000 ha of which 2,900 ha are owned by the Crown, 2,100 ha are owned by HRWC, and 1,100 ha are privately owned) serves the needs of the City of Dartmouth (Lake Major) as well as North Preston (Long Lake).

Lake Major Watershed has been formally designated a “Protected Water Area” under subsection 106(5) of the Nova Scotia Environment Act, thereby providing authority to the HWRC to protect the watershed for drinking water protection. The protection is further enabled through the Lake Major Watershed Protected Water Area Regulations made under subsection 106(6) of the Nova Scotia Environment Act.

The regulations prohibit the operation of any vessel on Long Lake and operation of a vessel on Lake Major with an engine greater than 9.9 hp. The regulation prohibits the fuelling of vessels within 20 m of the shoreline of either lake. Swimming is prohibited in Long Lake, and restricted in Lake Major to a distance greater than 100 m from the drinking water intake. Fishing from the shoreline (or from a boat in Lake Major) is restricted to areas more than 100 m away from the intake pipe. Forestry and related practices such as road building are prohibited in the entire watershed.

Restrictions on
motor vessels,
swimming,
fishing, forestry,
and roads

Pockwock Lake Watershed (5,661 ha primarily owned by the crown) is the water supply for Halifax, Bedford, Sackville, Timberlea, Fall River and Waverley. The watershed is protected by provincial designation and HRWC jointly manages the watershed with the Nova Scotia Department of Natural Resources. As for the Lake Major Watershed, the protection of drinking water quality in the Pockwock Lake watershed is enabled through designation under the Nova Scotia Environmental Act. In general, boating, swimming and off-road vehicle use are prohibited on or near the lakes in the watershed. Limited forestry practice is currently allowed in this watershed, and there is a major research initiative underway to investigate the links between various forestry management practices and watershed functioning, including nutrient dynamics.

¹⁴ http://www.region.halifax.ns.ca/hrwc/water_quality/watersheds.html#pockwock

Wherever possible, the Halifax Regional Water Commission purchases managed watershed lands from private land owners to best control activities there.

The Commission has also designated three watersheds for protection and management for possible future or back-up use as a drinking water supply. The Tomahawk Lake watershed, encompassing approximately 1500 hectares, is 90% owned by the Commission.

The watershed is reserved as a potential future supplementary supply for the areas now served by Pockwock Lake. The Topsail/Lamont Watershed (350 ha located in the heart of Dartmouth) is part of the former water supply for the Dartmouth area, and is maintained as a backup water supply. The Chain Lakes Watershed (240 ha) is located west of Northwest Arm Drive in Halifax, and serves as the backup water supply to Pockwock Lake.

4.1.4 Watershed Management Plans With Broader Goals

Several watershed management initiatives have been undertaken where the major interests relate more to watershed boundaries than to municipal boundaries. One example is the Grand River Conservation Authority in Ontario, a formally established corporate body, whose vision statement is:

“Our vision is one of leadership in ensuring a healthy and sustaining relationship between the natural environment of the Grand River watershed and the demands on this environment by all forms of life.”¹⁵

The mission statement is:

“Our mission is to work with partners to conserve the natural processes and resources that support a safe and healthy environment for future generations in the Grand River watershed.”

The Grand River watershed is home to 34 small to large municipalities, including Hamilton, Halton, Brant, Brantford, Guelph, Oxford, and Waterloo.

Another example is the Nottawasaga Valley Conservation Authority’s “Healthy Water Program”, the goals of which are:

¹⁵ <http://www.grandriver.ca/index.cfm>

"To protect and enhance water quality and quantity in the Nottawasaga Valley Conservation Authority Watershed for environmental and economic benefits for all 18 municipalities, through the implementation of an enhanced water quality protection and improvement program."¹⁶

According to the website, "The first recommendation of the Healthy Waters Taskforce was that the NVCA requires significantly increased financial support to protect our water resources for the future".

The Taskforce has also identified the following major program initiatives:

- A matched funding model to sustain long-term funding for all program areas.
- Development of a "hard hitting" community outreach program to improve the overall knowledge of watershed residents regard stream health and water quality and quantity issues.
- Development and implementation of "Best Management Practice" demonstration sites to show the environmental and economic benefits of BMPs that address rural and urban water quality issues.
- Implementation of a "Healthy Waters Incentive Program" to increase uptake of BMPs that address rural and urban water pollution.
- Performance monitoring of all program areas.

4.2 Source Water Protection in the United States

In 1996, the United States Congress passed amendments to the Safe Drinking Water Act, thus establishing a national Source Water Assessment and Protection Program. This program has significant funding that has enabled federal and state agencies to make major inroads into the transition to ecosystem-based source water protection. The United States has become a global leader in the enabling mechanisms, level of effort, and overall interest in ecosystem-scale integrated planning and management approaches, and Canadians would do well to understand how this has (or has not) served long-term sustainability and drinking water protection goals.

Initiatives that have been undertaken in the United States around watershed-based source water protection are far too extensive to cover in a brief review. A quick search of the Internet on watershed protection or source water protection will reveal thousands of useful US sites. Briefly, Section 1453 of the U.S. Safe Drinking Water Act directed individual states to complete by 2004 comprehensive assessments of the susceptibility of all public water systems to contamination, and to provide a summary of the findings to the public.

¹⁶ http://www.nvca.on.ca/healthy_waters/index.htm

While there are some variations on the theme, each source water assessment must include the following four components:

- 1) Delineation and mapping of drinking water source areas (including supply watersheds and important recharge areas);
- 2) Inventory of the potential contaminating activities and identification of the possible contaminants;
- 3) Assessment of the susceptibility of the water supply to those contaminants; and
- 4) Public release of the assessment information.

Administrators of Public Water Systems are expected to develop appropriate management plans for protecting drinking water sources, and contingency plans for man-made or natural catastrophes and events. In the United States, special attention has been directed toward contingency planning for terrorist attacks on drinking water integrity in the aftermath of September 11, 2001.

The Source Water Assessment and Protection Program builds on previous initiatives such as the previously established Well Head Protection Program and Sole Source Aquifer Program. Programs under the U.S. Clean Water Act may be at least as important as Safe Drinking Water Act programs in assessing, protection, and restoring water quality using a watershed-based approach.

One of the premises behind U.S. federal actions is that, while operators of public water systems are legally accountable for the delivery of safe, clean drinking water, no system should have to provide a greater level of treatment than that required to safely remove naturally occurring contaminants as opposed to anthropogenically enhanced contaminant levels.

The Office of Ground Water and Drinking Water of the United States Environmental Protection Agency is actively compiling instructive examples of local source water protection programs. Each case study is collected and reviewed for accuracy and then posted on the EPA site¹⁷. The cases represent a variety of approaches to protecting sources of drinking water supplies for a diverse group of communities that differ in size, geography, economic and social characteristics, and type of source water used (surface water, groundwater, or both). All cases share a demonstrated comprehensive approach to source water protection that reflects a strong commitment to safeguarding the public's health.

¹⁷ <http://www.epa.gov/safewater/protect/casesty/casestudy.html>

5. SOURCE WATER PROTECTION STRATEGIES

In Canada, considerable discussion and deliberation has occurred over the last five years about the value of drinking water and source water protection. Nationally, in the territories and provinces, and at the municipal and regional level. National coordination is provided through the **Canadian Council of Ministers of the Environment**¹⁸ (CCME) as well as the **Federal-Provincial-Territorial Subcommittee on Drinking Water**. The latter is comprised of representatives from all provinces, the Yukon, Northwest Territories, Health Canada and Environment Canada. Health Canada acts as Secretariat to the Subcommittee.

The Guidelines for Canadian Drinking Water Quality are published under the auspices of the Subcommittee. These guidelines serve to minimize human health risks largely by establishing 'safe' levels of potential sources of risk at the point of consumption of drinking water. The Subcommittee, however, has been active since 1999 in developing policies and tools for drinking water protection beginning farther up in the supply system (for examples, see <http://www.hc-sc.gc.ca/hecs-sesc/water/publications.htm>). The Yukon Territorial Government participates in the subcommittee through the Department of Health and Social Services.

Canada's territories and provinces, with the mandate to regulate most aspects of source water protection, have generally adopted policies and legislation to enable the provision of clean, safe and reliable drinking water. Most of the ten provinces, but none of the three territories, have since 1999 formally re-evaluated their policies and legislation with the specific intention of bringing into legislative force a source to tap scheme for drinking water protection.

An obvious question for any jurisdiction is whether the existing policies and legislation are sufficient to avoid short to longer-term problems with drinking water quality. The previously described cases provide a good test of the sufficiency of current Yukon territorial approaches. A simple question is – *Can similar problems be confidently ruled out in Yukon communities?*

Within the Yukon, the *Municipal Act* of 1999 provides the authority for local governments to operate drinking water and sewerage infrastructure, among other things, but does not specifically enable source protection. Until recently, watershed protection has been enabled primarily under the Yukon *Environment Act* (May 29, 1991), which was established at a time when ecosystem-based protection and cumulative effects issues, as opposed to point-source issues, were not in the forefront of concerns within the Canadian consciousness. The new *Waters Act* came into force on March 20, 2003. The Water Resources Branch of the Yukon Territorial Government administers water-related policies, regulations and programs under this Waters Act (Yukon). This water

¹⁸ <http://www.ccme.ca>

management responsibility was transferred from the federal government to the Yukon government on April 1, 2003. The Yukon Department of Health and Social Services is responsible for drinking water quality in the Yukon.

The Yukon Waters Act is very similar in structure, wording, and intent to the NWT Waters Act of 1992. Among other things, the Act establishes the nine-member Yukon Water Board, and establishes authority for regulating water use and discharges to surface waters.

Some of the other partially relevant acts and regulations include the *Sewage Disposal Systems Regulation* (1999) under the *Public Health and Safety Act* and the *Regulations Respecting Public Health* (1958), also under the *Public Health and Safety Act*.

The Northwest Territories Waters Act of 1992, which is in fact federal legislation, governs water extraction and watershed activities in the NWT. The Act establishes the authority for some activities in Water Management Areas, and generally prohibits the extraction of water, its diversion, or the introduction of wastes and deposits without prior licence or permit approval. Beginning in 1998, the NWT Waters Act was superseded on NWT lands falling under the Gwich'in Comprehensive Land Claim Agreement and the Sahtu Dene and Metis Comprehensive Land Claim Agreement by the *Mackenzie Valley Resource Management Act*.

In Nunavut, the Nunavut Waters and Surface Rights Tribunal Act has yet to be passed, and the NWT Waters Act temporarily remains in effect.

5.1 British Columbia Action Plan

The amended *Drinking Water Protection Act*¹⁹ and regulations came into force in BC on May 16, 2003, replacing the Safe Drinking Water Regulation under the *Health Act*. These new measures were specifically intended to govern drinking water protection from “source to tap”. The intent was to establish a more comprehensive and more coordinated framework for drinking water protection. Key features include:

- Increased expectations for assessing water systems, certifying operators and suppliers, and for monitoring and reporting on water quality;
- Increased powers to protect water sources from contamination by any drinking-water health hazard; and
- Creation of 20 new dedicated drinking-water officers positions (employed by the regional health authorities) who will oversee a source-to-tap assessment of every drinking-water system in the province.

Dedicated
Drinking Water
Officers will
oversee a
Source-to-Tap
assessment
in BC

¹⁹ <http://www.healthplanning.gov.bc.ca/protect/water.html#bulletin>

Since British Columbia is in the early stages of implementing the *Drinking Water Protection Act* and its regulations, the City of Whitehorse is a bit ahead of the vast majority of B.C. municipalities in working toward a source-to-tap assessment and development of a watershed protection plan. There is only limited experience in British Columbia, therefore, from which Whitehorse and the Yukon can draw.

5.2 Alberta Water Strategy

According to the Alberta Environment website²⁰:

“Municipalities cannot adequately determine surface water treatment requirements without knowing the baseline quality of the raw water they are treating. To implement the appropriate level of technology in each case, ongoing watershed assessment and protection are required. Pollution prevention and control programs establishing the quality parameters for industrial and municipal wastewater discharges are examples of watershed protection.”

Watershed assessment and protection have been implemented through an increased commitment to monitoring of quantity and quality of groundwater and surface water supplies, coupled with further formalization of a variety of water data collection networks for hydrometric, snow survey, meteorologic, telemetry, groundwater and water quality data.

The province’s groundwater observation well network, established to monitor water levels and water quality in aquifers that have a potential to be used for water supply purposes, consist of 340 observation wells, ranging in depth from 6 to 240 m and 200 piezometers. In addition, groundwater is also monitored in the vicinity of reservoirs, rivers, lakes, dams and oil sand developments to determine impacts on local groundwater systems. The Yukon recently saw the establishment of its first long-term groundwater monitoring well (Ref 24, herein), in the Wolf Creek subdivision of Whitehorse.

Alberta is focussed on obtaining the knowledge needed for effective water management decisions

Surface water quality in Alberta is monitored monthly at 13 river and 4 lake sites to evaluate long-term trends. Additionally, approximately 500 river water samples and 550 biota samples are taken annually to evaluate specific issues.

Overall, the Alberta approach appears to be focused on comprehensive monitoring and the acquisition of the necessary knowledge for the facilitation of effective water management decisions.

²⁰ <http://www3.gov.ab.ca/env/Water/DWQ/dwprogram.html>

5.3 Saskatchewan's Water Management Framework

The stated vision for Saskatchewan's *Water Management Framework*²¹ is "Safe and reliable water supplies within healthy and diverse aquatic ecosystems." Six principals were established:

- 1) Stewardship;
- 2) Partnership;
- 3) Integrated Management;
- 4) Value of Water;
- 5) Sustainable Development; and
- 6) Best Practice

The Water Management Framework is a comprehensive strategy and builds nine goals, 16 objectives and 58 actions around 3 themes:

- Protection of water and wetlands;
- Management and Development of the resource; and
- Co-ordination of government activities and Public Involvement in decision-making.

A strong component of the Saskatchewan approach is the focus on implementation. According to the Framework document:

"The outlined actions supplement ongoing activities of provincial agencies with water management responsibilities. The 58 actions have been developed to deal with new and emerging issues that are not adequately addressed by existing programs and policies. They will be initiated by provincial agencies over the next five years. The Framework will help ensure optimum management of our water resources into the next century."

Saskatchewan is
focusing on
implementation.

The architects of the Framework clearly foresaw situations for source water protection that fell outside of the bounds of existing tools and regulations.

²¹ <http://www.se.gov.sk.ca/ecosystem/water/framework/PAGE1.htm#Executive%20Summary>

5.4 Manitoba's Proposed Strategic Plan

The stated vision for Manitoba's strategic planning exercise is adapted from the Bruntland definition of sustainability; i.e.

"To manage our resources so as to meet the present and future needs of Manitobans, while ensuring the integrity of our ecosystems"

Manitoba has developed a series of policies toward achieving 7 major objectives:

1. **Water Quality:** To protect and enhance our aquatic ecosystems by ensuring that surface water and groundwater quality is adequate for all designated uses and ecosystem needs.
2. **Conservation:** To conserve and manage the lakes, rivers, and wetlands of Manitoba so as to protect the ability of the environment to sustain life and provide environmental, economic, and aesthetic benefits to existing and future generations.
3. **Use and Allocation:** To ensure the long-term sustainability of the province's surface water and groundwater for the benefit of all Manitobans.
4. **Water Supply:** To develop and manage the province's water resources to ensure that water is available to meet priority needs and to support sustainable economic development and environmental quality.
5. **Flooding:** To alleviate human suffering and minimize the economic costs of damages caused by flooding.
6. **Drainage:** To enhance the economic viability of Manitoba's agricultural community through the provision of a comprehensively planned drainage infrastructure.
7. **Education:** To enhance the awareness and knowledge of Manitoba's water resources.

In Manitoba, comprehensive monitoring networks are important, as is education

The policy and associated implementation tools for protecting source water quality recognize in particular the importance of (i) comprehensive water quality monitoring networks tied to strong water quality objectives, and (ii) expanded education and awareness.

5.5 Ontario Safe Drinking Water Act (2002)

In the wake of the Walkerton incident, the Ontario government enacted the *Safe Drinking Water Act* to deal with matters related to treatment and distribution of drinking water. The purpose of the Act is to gather in one place all legislation and regulations relating to the treatment and distribution of drinking water.

Ontario is making source protection plans mandatory

Above all, the Act requires the development (in the future) and approval by the government of watershed-based source protection plans for drinking water supplies, a key recommendation of Commissioner O'Connor who oversaw the Walkerton Inquiry. However, the necessary watershed-based planning framework has yet to be worked out.

The *Sustainable Water and Sewage Systems Act*, also introduced in 2002, makes it mandatory for municipalities to assess and cost-recover the full amount of water and sewer services, including enhanced compliance monitoring and source protection.

One of the steps taken to refine strategies for source water protection was to conduct six case studies. The Ontario Ministry of the Environment and the Ministry of Natural Resources have conducted studies of six drinking water supplies, in order to critically evaluate approaches to managing and protecting the water resources and changing the way communities work together toward protecting their local watershed.²²

5.6 Quebec Water Policy

One of three main policy orientations of the Government of Quebec is “Integrated and Sustainable Water Management²³”:

“The various problems of water management in Québec, as in the rest of the world, are not only issues of protection, restoration and development of this resource. They are also questions of the ways things are done.

The road to integrated water management lies in consistent action at the different levels of intervention (government, local and regional) and the effective use of intervention tools. Thus, the Québec Water Policy will bring changes to sectoral ways of doing things through a genuine, integrated management using a watershed-based approach. A more global and sustainable approach to management appears necessary to prioritize actions or projects

“genuine, integrated management using a watershed-based approach”

²² Advisory Committee on Watershed-based Source Protection Planning, ON. April 2003. Protecting Ontario's Drinking Water L Toward a Watershed-Based Source Protection Planning Framework. 101 pp. (available online at <http://www.ene.gov.on.ca/envision/techdocs/4383e.pdf>)

²³ <http://www.menv.gouv.qc.ca/eau/politique/index-en.htm#issues>

based on cumulative environmental impacts. To this end, within an integrated management approach, the government of Québec recently appointed a Minister of State for the Environment and Water, whose primary role is to ensure consistency among all government actions related to water and aquatic ecosystems, in collaboration with the ministers involved in water management.”

This in turn, is intended to guide five major changes in the governance and use of water resources in Quebec:

- **Improved water governance** through the development and enunciation of a shared, comprehensive vision of water resources. This will require a better consolidation of legislation and policies, as was carried out in Ontario. It also entails the adoption of watershed management approaches, and acquisition of the requisite knowledge.
- **Integrated Management of the St. Lawrence River.**
- **Protection of Water Quality and Aquatic Ecosystems**, including the improved applicability and utility of water quality objectives and regulatory enforcement. Among other things, the Quebec government has committed to “By 2004, develop and implement an action plan for the protection, restoration, and development of the banks and littoral zones of lakes and watercourses, their floodplains, and wetlands”.
- **Continued Clean-up and Improved Management of Water Services – i.e.** Introduce a strategy for cleaning up watercourses at the watershed level.
- **Promotion of Water-Related Recreation and Tourism Activities.**

5.7 Nova Scotia Drinking Water Strategy

Nova Scotia’s Strategy Document²⁴ is short on details about how best to implement watershed-based source water protection. Among key government accomplishments in this area since 2000 was the establishment of a new funding program to assist municipalities with designing strategies for source water protection.

New funding
to develop
source water
protection
strategies

Since 2000, the Nova Scotia Government has also created or substantively revised five areas designated as municipal “protected water areas”. The government has also increased staffing in key areas; i.e. through the hiring of “four hydrogeologists, four inspectors, two watershed planners, one drinking water supervisor, one water monitoring technician, one water treatment facilities specialist, and one geographic information system (GIS) specialist”.

²⁴ <http://www.gov.ns.ca/enla/rmep/h2ostrat.pdf>

The following principles guide Nova Scotia's Drinking Water Strategy:

- Clarity of roles and responsibilities;
- Sustainable development;
- Partnership;
- Stewardship; and
- Value of water.

According to the strategy -

“The main concern is that the lands required to protect the water supply are often not owned by the user of the water supply. This inherent conflict reinforces the need to put aside the purely regulatory approach and enter into partnerships with the watershed community to carry out mutually beneficial, locally developed and administered, source protection programs.

Regulatory approach may be inadequate, given shared ownership of the watershed.

The development of a source protection program is a consensus-based, community-level process involving various stakeholders. The protection of source water is a continuous process that requires a long-term commitment and is essential in an overall program of drinking water protection. Source protection requires a strong commitment at the local level, a combination of strategies, and cooperation of all stakeholders.

The components of a source protection plan include four essential steps. First, there should be an appropriate inventory and characterization of the water source. Second, there should be development of an up-to-date inventory of all sources of pollution affecting the water source. Third, the type of pollutants discharged into each watershed must be quantified. Fourth, there should be development of goals and implementation of strategies for protecting, monitoring, and evaluating each watershed.”

5.8 Newfoundland and Labrador Action Plan

A report entitled “Source to Tap: Water Supplies in Newfoundland and Labrador” (May 2001)²⁵ outlines the governments plan of action for protecting drinking water quality in the province. Based on the report, it is clear that the major portion of funding over the last few years has been directed toward the construction and upgrading of collection and distribution infrastructure. The Newfoundland strategy is based on:

- knowledge,
- integrated decision making,
- incentives and recognition,
- a tiered network of safeguards, and
- partnership and consultation.

Of all the strategic documentation examined, the Newfoundland approach places the least emphasis on watershed processes and source water protection, as opposed to treatment, storage and distribution. Overall, there appears to be a strong strategic focus on enhanced compliance monitoring as opposed to source water assessment and management.

In 2001, an Interdepartmental Water Safety Committee began to identify legislative gaps that might affect drinking water protection. However, the Newfoundland approach departs substantially from that taken in Ontario and Quebec where integration of decision and regulatory tools under a comprehensive framework is seen as a necessary component of source-to-tap drinking water protection.

Of potential interest in the context of the Whitehorse Watershed Management planning process is the existence of a policy directive in Newfoundland entitled “**Policy for Land and Water Related Developments in Protected Public Water Supply Areas**”. The policy establishes a mechanism for issuing a certificate of environmental approval *Environment Act* for all development activities in a designated water supply area.

²⁵ <http://www.gov.nf.ca/env/SourceToTap/SourceToTap/Report.asp>

According to the policy, existing and new activities within a designated drinking water supply area are subject to a number of concrete restrictions and allowances. All developments require prior written approval by the Minister. Activities not permitted in a designated water supply area, by policy include:

- discharge of sewage, refuse, chemicals, municipal and industrial wastes or any other material which impairs or has potential to impair water quality discharging into a body of water.
- Using ice covered water body for transporting logs, riding skidoos/motor vehicles/all-terrain vehicles, leading of animals, or any other activity which impairs or has potential to impair water quality.
- Using or operating existing facilities in such a manner which impairs or has potential to impair water quality.
- Residential development (a subdivision of four or more lots), vehicle maintenance facilities, warehouses, service stations, industries, and chemicals and salt storage depots.
- Storage and disposal of pesticides and manure, application of manure and chemicals in specified buffer zones, extensive land clearing, and peat land drainage without adequate treatment.
- Clear cutting of forest in sensitive areas, establishment of camps and camp facilities, storage of chemicals, application of pesticides, drainage of peat land for afforestation, and application of toxic fire retardants.
- Resorts, hotels/motels, and golf courses.
- Activities, operations or facilities associated with aggregate extraction and mineral exploration such as work camps, vehicle parking and maintenance facilities, washing of aggregates, asphalt plants, discharge or deposit of waste material into a body of water, and significant disturbance to land for mineral exploration purposes.
- Application of herbicides in the right-of-way, and use of chemically treated utility poles and other related structures.
- Aquaculture development and associated activities having potential to impair water quality.
- Processing and manufacturing plants having potential to impair water quality.

- Cemetery, waste disposal facilities, and any other storage or disposal facilities that the Minister considers environmentally unacceptable.

In addition, the following activities are considered to be regulated activities, requiring prior ministerial approval.

- Expansion and upgrading of the existing activities, operations or facilities.
- Construction of residential, commercial, industrial and institutional facilities or any other related activity including land clearing or drainage, construction of access roads, servicing of lands for subsequent use, or extension and upgrading of existing buildings or facilities.
- Development of farm lands for crop production, forage production, vegetable production, and blueberry and other fruit production.
- Forest logging, resource road construction and use, stream crossing for controlled access, preparation of skid trails and landing areas, silviculture, tree farming, and other environmentally acceptable forestry operations.
- Recreational activities or facilities including cottage development, fishing, swimming, boating, hiking, campgrounds, or canoe routes, vacation or other camps, or recreational facilities.
- Mineral exploration related activities and aggregate extraction, or any other construction activity incidental to mining and quarrying including access roads, stream crossings, land drainage with adequate treatment, land clearing and excavation.
- Installation of storm or sanitary sewer pipelines, pipelines for transmission of water for hydroelectric generation, agriculture uses, or any other purposes.
- Construction of roads, bridges, culverts, and other stream crossings, and installation of power and telecommunication transmission lines.
- Modification to intake structures, pumphouse, reservoir, etc.
- Any other development or activity which, in the opinion of the Minister, has caused impairment or has potential to impair water quality.

6. PUBLIC CONSULTATION

6.1 Project Governance

The preparation of the City of Whitehorse Watershed Management Plan is overseen by a Steering Committee with representation from:

- The City of Whitehorse - Planning, Engineering, and Public Works Departments;
- Yukon Government - Environmental Health;
- Yukon Government - Environment;
- Yukon Government - Community Services;
- Yukon Government - Business, Tourism & Culture;
- Department of Fisheries and Oceans Canada;
- Kwanlin Dun First Nation;
- Ta'an Kwach'an First Nation;
- Yukon River Intertribal Watershed Council; and
- Yukon Energy Corporation.

The Steering Committee is specifically established to assist the City of Whitehorse with the preparation of a Watershed Management Plan (WMP). The committee is an informal body, with no decision-making authority, but the members provide technical expertise and advice toward the development of the WMP.

Routine project management is provided by Ross Burnett, Habitat Coordinator, City of Whitehorse Planning Department, to whom monthly progress reports are made. Direction is also provided by the City of Whitehorse mayor and council and senior City management.

6.2 Meetings

Key meetings and meeting categories are discussed below. Minutes of these meetings, and attendance, are included in Appendix B.

- **WMP Steering Committee** - The first meeting with the Steering Committee was held on April 22, 2003. Members of the Steering Committee each made a short statement outlining their interests and concerns relative to the Watershed Management Plan (WMP). UMA's Project Manager, Dr. Douglas Bright, made a presentation of the proposed WMP methodology and schedule.

- **Whitehorse Council and Senior Management** - On April 23, 2003, UMA's WMP Project Manager made a short presentation to City Council and senior managers of the WMP tasks and schedule.
- **Agency Consultation** - In addition to meeting collectively with the Steering Committee and its constituent agencies, UMA met separately with Yukon Economic Development on April 23 and with Yukon Territorial Government Water Resources Branch on April 24, 2003.
- **Key Stakeholders** - On April 23, UMA met with Mr. Eric Carpataux, the operator of the MV Schwatka and the proponent of additional development on his lakeshore property. On April 24, UMA and City staff met with six invited operators of floatplanes at a stakeholders' drop-in.
- **First Nations** - UMA representatives met with Kwanlin Dun on April 23 and with Ta'an Kwach'an on April 24, to discuss general principles and to obtain land selection mapping.

6.3 First Open House

The purpose of the first public Open House, held on June 5, 2003, at the High Country Inn, was to explain to interested parties the project intent and process, share baseline information with residents, seek confirmation of the goals and objectives for the community, discuss the issues, and identify any other outstanding issues or concerns. An information leaflet and a questionnaire/survey were handed out at the Open House. Copies of these are contained in Appendix C.

The Open House was attended by 15 members of the general public and interested stakeholders, in addition to several representatives of the UMA team and the City of Whitehorse. Three survey forms were returned at the Open House and two were received later. Comments received included the following points:

- a) Four of the five surveys indicated a strong concern about the present integrity of the water supply. One was not at all concerned.
- b) Four had concerns about drinking water, including the snowmobile races, and the presence of beaver fever, NTU's and petroleum products.
- c) Issues listed as important included:
 - Wellhead protection for the Selkirk Aquifer,
 - Siltation in the catchment,
 - Long-term effects of climate change,

- Degradation of water quality,
 - Need for public education, information on situations elsewhere,
 - Monitoring and cleanup after development, i.e. grading and reclamation,
 - Proposed hotel, more people, swimmers and feeding of gulls,
 - Private sewage systems,
 - Float plane bases and tourist operations.
- d) Three had a good understanding of the WMP and its development, and two a limited understanding.
- e) Regarding information about the process, two requests was made for more information regarding tools to be used and discussions to be held
- f) Additional issues raised were:
- Funds should not be spent without good reason, e.g. Giardia can only be removed with an expensive filtration system, and it is not a serious problem since it is easily treated. Encouraging exercise would be a better way to improve health.
 - Difficulty of protecting the large watershed.
 - Natural system is important for water quality.
 - Integrate habitat issues with water quality.
 - More requirements of developers to control erosion, provide proper stormwater management, and monitoring.
- g) Two respondents were interested in assisting with stewardship of the watershed. One didn't know, and two were silent on the issue. Ideas for personal contributions were:
- Education and awareness.
 - Conservation of water.
 - Should rely on legislation not voluntary efforts.
 - Filtration and treatment.

Additional issues and concerns raised verbally, and noted at the first Open House, were:

- The Whitehorse Cadet Camp, near Mary Lake, is installing a new septic field at the cadet camp, in the vicinity of Wolf Creek. A new shower, laundry and washroom facility (350 sq. meter “ablution building”) are being built.
- Concerns were voiced about the number of road crossings of tributaries in the country residential subdivisions south of town, and the potential for road salt and silt to get into the water. What about the issue of increased sediments in the tributaries being flushed into the river and lake, in the event of heavy rainfall and high flow levels?
- General concern voiced about agricultural parcels near the river and developments on Marsh Lake.
- Questions about outboard motor boat engines putting oil and gas exhaust directly into the water.
- Concern about fairly large amounts of dust from the old Whitehorse Copper Mine tailings site being blown into the river and lake. On some days it is actually a huge cloud of dust that can be seen rising up from the site and being blown north-northeast towards the river.

At their request, a separate **First Nations Open House** was held on June 5, 2003, at Nakwataku, Whitehorse, for the Kwanlin Dun and Ta’an Kwach’an First Nations. Three representatives were present from the Kwanlin Dun Land Use Planning Working Group and two from the Ta’an Kwach’an Council. The Open House was divided into a presentation, followed by a drop in open house.

The informal presentation was made outlining the contents of the information sheet provided for the open house. The open house portion (4-6 pm) was advertised in the Kwanlin Dun community; however no one showed up for this portion. All those hearing the presentation expressed an interest in the project and the importance of protecting water quality. The following significant questions/concerns were raised:

- Floatplanes and their impact on water quality
- The extensive development along Marsh Lake and the feeling that it should be included in the study area.
- It would be good to hear from the elders and see how they respected and protected the land and water.

- A positive response about the stewardship concept in the watershed.

Surveys and information sheets were taken by attendees and will be passed around to interested parties

6.4 Summary of Identified Issues

The issues to be addressed by the WMP, based on perceived concerns/potential threats that have been identified are summarized as follows:

6.4.1 Contamination by Human-Borne Pathogens

- Proposed hotel, more people;
- Swimming in Schwatka Lake;
- Feeding of gulls;
- Septic fields and urban/country developments, especially on tributary streams;
- Agricultural parcels near the river; and
- Development on Marsh Lake, especially re septic fields and flooding events.

6.4.2 Contamination by Animal-Borne Pathogens

- Proposed hotel, more people, swimmers and feeding of gulls;
- Beavers in the watershed;
- Use of Schwatka Lake by migrating waterfowl;
- Trail development and use, especially dog feces; and
- Developments on tributary streams.

6.4.3 Chemical Contaminants

- Recreation: RVs, ATVs, snowmobiles, power boats on or near Schwatka Lake,
- Floatplanes and their impact on water quality;
- Stormwater runoff and impervious surfaces;
- Adequacy of wellhead protection for the Selkirk Aquifer;
- Dust from the Coppermine tailings site being blown into the river and lake;
- Road salt use on road network;
- MacRae industrial uses;
- Spills on or near roadways;
- Presence of gas station, CYFN fuel tanks, YECL substation near Selkirk Street groundwater production wells;
- Use of creosote to treat rail ties at Carcross;
- Potential pipeline; and

- Upstream spills (concern about potential lack of response time before spill reaches Schwatka Lake).

6.4.4 Nutrient Inputs

- Septic fields and urban/country developments, especially on tributary streams;
- Agricultural parcels near the river;
- Developments on Marsh Lake;
- General increase in human activities in the watershed;
- Stormwater runoff and impervious surfaces; and
- Long-term effects of climate change.

6.4.5 Turbidity, Hardness, Dissolved Organic Matter

- Siltation in the catchment;
- Road crossings;
- Developments on tributary streams;
- Broader upstream developments such as forestry and mining;
- Grading and reclamation, associated with development;
- Agricultural parcels near the river;
- Developments on Marsh Lake;
- Stormwater runoff and impervious surfaces;
- General increase in human activities in the watershed;
- Trail development and use;
- Long-range plans of YEC in the watershed; and
- Long-term effects of climate change.

6.4.6 Other

- Need for public education, information on situations elsewhere;
- Support for stewardship concept in the watershed;
- Depletion of groundwater aquifers; and
- Number of individual water wells upstream.

7. SUMMARY AND POSSIBLE SOLUTIONS

This Background/Status report collates information on source waters that supply drinking water for the City of Whitehorse, and current knowledge about source water quality and the watershed in general. Chapter 8 provides a vision and Chapter 4



provides examples of how a Watershed Management Plan can be used in the context of source-to-tap drinking water protection.

A more formal and detailed analysis will be completed in a subsequent report, however preliminary impressions of the overall situation are provided herein.

The water extracted from Schwatka Lake and the Selkirk Aquifer is generally of good quality. There is no evidence of either incomplete disinfection in the distribution system or of any ill effects based on human consumption of drinking water. However, the juxtaposition of high late Spring/Summer turbidity in Schwatka Lake with routinely elevated raw water coliform concentrations as well as detected *Giardia lamblia* cysts suggests that the City cannot be complacent.

There are significant challenges with source water protection of the Yukon River/Schwatka Lake supply, given the patchwork of land ownership and jurisdictional responsibilities in the watershed, along with the myriad of access points to Schwatka Lake, the Yukon River, and its tributaries. The upper Yukon River, including the Watershed Management Plan study area, is a multi-use watershed.

The Selkirk (and Long Lake) aquifers, and possibly the slightly deeper Whitehorse aquifer, provide an excellent, consistent source of drinking water for the City. A major bonus is that human activities and developments have been very limited near or above the Selkirk production wells, on the east slope of the river valley within the City. This



creates the potential for effective well-head/recharge area source protection because the jurisdictional authority is vested in only a few parties, the major one of whom is the City of Whitehorse itself.

We note that many communities have developed source protection plans not just for active source supplies, but also for potential back-up and/or future supplies. In spite of the apparent large quantities of source water near the City, it is apparent that many potential sources are constrained (for example, the Fish Lake and Cantlie Lake watersheds) such that securing the necessary future supplies is far from guaranteed. This further emphasizes the need for protecting and enhancing existing supplies, including the Yukon River.

The City of Whitehorse has good information on source water quality at the point of extraction, but there are still many data gaps regarding source water quality and risks to quality in the larger watershed and important recharge areas. Assertions about the hardness of water from deeper unconfined aquifers to the east of the river, for example, appear to be based on very few actual sample results and these are over two decades old. In addition, the extent to which the shallow Selkirk and Long Lake aquifers connect with deeper, highly porous strata, remains unknown, but the local aquifers are likely to be spatially heterogeneous.



We provide a preliminary analysis of data that suggest the seasonal trends in the turbidity of Schwatka Lake are unduly influenced by local watershed processes relative to their small volume contributions in comparison with the Yukon River beyond the Marsh Lake control structure. This attests to the importance of monitoring throughout key areas of the watershed and subwatersheds, in order to better

establish links between land use and other human activities and surface or ground-water quality.

The Watershed Management Plan will be formulated following a more explicit analysis of possible risks, as identified in Chapter 6, which is intended to lead to pragmatic recommendations for a Watershed Management Plan that can be used to achieve source water protection. Some of the possible solutions to be considered in more detail include:

- **Access restrictions.** For example:
 - Establish a water intake protection/exclusion zone.
 - Limit or prohibit uses on or near Schwatka Lake and its source waters.
 - Decommission roadways.
- **Buffer zones**
- **Land use restrictions**
- **Land acquisition**
- **Enhanced monitoring**
- **Developing source water indicators and concrete response triggers**
- **Public education**
- **Community-based stewardship**
- **Switching water supplies**
- **Protecting viable future sources**



8. THE VISION

The purpose of the Watershed Management Plan is reflected in the City's Official Community Plan, which states:

"The protection of Schwatka Lake and the surrounding watershed is of paramount importance. The City shall preserve, protect and enhance water supply areas by keeping recharge areas free from incompatible development and sources of contamination."

The Watershed Management Plan is intended to set the direction for managing the City of Whitehorse source water quality. The year 2003 marks the first time that a formal watershed-based planning process has been undertaken. This initiative recognizes the importance of the watershed of the upper Yukon River basin for producing an ample supply of safe, high quality water for southern Yukon and especially City of Whitehorse residents. **The Watershed Management Plan is also guided by the knowledge that the watershed fulfills many other economic, social, cultural and environmental needs.**

Leadership
by the City
of
Whitehorse

The protection of source water quality through watershed management is important as the first element of a multi-barrier approach for protecting and enhancing human health and well being, given the importance of adequate supplies of safe drinking water. In simple terms, the failure to prevent inputs of pathogens or chemical contaminants leads to an over-reliance on treatment and monitoring. The presence of turbidity increases the possibility of inadequate disinfection. Elevated nutrient inputs increases risks of noxious and harmful algal blooms as well as the risks associated with disinfection byproducts. According to the Federal-Provincial-Territorial Subcommittee of Safe Drinking Water:²⁶

From
Source to
Tap – A
Multi-Barrier
Approach

"In the past, many agencies in Canada and around the world have relied heavily on compliance monitoring as the mechanism for managing drinking water quality and therefore protecting public health. Compliance monitoring relies on sampling small amounts of water in a drinking water system and testing those samples for the presence of known and quantifiable organisms or substances. This approach has major limitations, including the shortcomings of sampling and monitoring techniques; inadequate consideration of the range of factors that affect drinking water quality; and failure to provide an effective response to microbiological pathogens and contaminants without a prescribed numerical guideline value or established method of analysis."

²⁶ Federal-Provincial-Territorial Subcommittee on Drinking Water, 2001. Guidance for Safe Drinking Water in Canada: From Intake to Tap (12 pages) (available online at <http://www.hc-sc.gc.ca/hecs-sesc/water/index.htm>)

According to the Subcommittee², **a comprehensive multi-barrier drinking water program includes:**

- ☐ Source water protection;
- ☐ Sanitary surveys of the source area and distribution system to identify and prioritize risks to health;
- ☐ Watershed or well-head protection plans;
- ☐ Expansion capacity for population growth;
- ☒ For treated water, continuous optimal treatment;
- ☒ Routine maintenance of the distribution system;
- ☒ Treatment plant and distribution system classification, operator training and certification.

The checked boxes are the items that the City of Whitehorse, like the vast majority of Canadian municipalities, has already addressed through ongoing planning and day-to-day implementation (although treatment to date consists only of chlorination disinfection). In addition to these, the City has already started down the road to source water protection, and watershed or well head protection; for example through components included in the recently completed Official Community Plan.

For each of the seven components of a multi-barrier water protection approach as identified above, the following enabling mechanisms are important:

- ☐ Management, including legislative and policy frameworks, financial accommodation, designation of responsible parties, and standardized operating procedures;
- ☐ Monitoring (from source to tap);
- ☐ Contingency planning for emergencies and catastrophes;
- ☐ Research and development;
- ☐ Standards, guidelines, and objectives; and
- ☐ Public awareness and involvement.

Watershed-based planning for source water protection in the Yukon is a relatively new endeavour. One of the biggest challenges over the short term, therefore, will be to

establish an appropriate balance between all of the activities and land-uses that unfold in areas that serve to collect, filter, and channel water into surface and groundwater supplies that are readily accessible as a potable water source.

The implementation of a watershed-based plan for source water protection is built around a **risk management framework** that integrates the best available scientific understanding of watershed processes and human health risks from drinking water consumption, with viable management approaches. Risk assessment and risk management decisions are not based only on what is known about possible risks, but also on the degree of confidence in our ability to draw conclusions about or foresee risks.

Decisions that are accompanied by a high degree of uncertainty generally include an appropriate degree of conservatism: If there is a possibility of erring, then the risk management decision intentionally seeks to err on the side of being over-protective of human health as opposed to being under-protective. In addition to intentional over-protection, decisions in the face of a high degree of uncertainty will often lead to further research and monitoring as a practical means of reducing our uncertainty and increasing the assurance about the soundness of risk management decisions.

Adaptive management is also an important part of the plan, given the long-term goals. Finally, **community-based stewardship, public education, and the cooperation between many jurisdictions with partial control over activities in the watershed** are seen as integral parts of an effective long-term plan.

Building on the City's Official Community Plan, the following draft vision statement is proposed. We believe it captures the City's watershed management interests:

"The watershed of the Yukon River, its sub-watersheds and lakes in the Whitehorse region, and the groundwater aquifers they are connected to, are essential to the health of the community. Governance of these resources shall focus above all on the protection of source water quality.

In addition, watershed management strategies and initiatives shall recognize the value of the watershed for social, cultural and economic activities, as well as the integral role of these activities in sustainable communities. Strategies and initiatives shall embrace only those activities that are compatible with and enhance source water protection.

Finally, watershed management is a shared responsibility and brings with it a commitment to collaboration with all interested parties."

Proposed
Vision
Statement

8.1 Suggested Watershed Management Goals

Building on the vision statement, the Watershed Management Plan hereby suggests four management goals and policies to guide management programs and directions.

8.1.1 Raw Water Quality Goals

Raw water drawn from Schwatka Lake (or possibly other lakes in the future) or from the regional unconfined aquifer represents the integration of complex and diverse hydrological, physical, biological, geochemical, and hydrogeological processes occurring in the larger watershed. This includes, in particular, precipitation, run-off, infiltration, interactions with vegetation, microbial processes in soils, sediment transport in surface water, and dissolved materials transport in surface and groundwater.

Routine sampling of source waters provides direct evidence of source water quality. In addition, such sampling provides evidence of trends, which might indicate a deterioration of conditions in the watershed. Finally, sampling can be used to detect problem hotspots.

In light of this-

- 1) A major goal of the Watershed Management Plan is to maintain City of Whitehorse source water supplies so that they meet limits stated in the *Canadian Guidelines for Drinking Water Quality* as they apply to unfiltered water sources prior to treatment.**

Ideally, water collected from anywhere in the watershed should meet or exceed the quality specified in the drinking water guidelines with some key exceptions. Natural surface waters may be unsuitable for human consumption without prior disinfection due to fecal coliform bacteria, protozoan and other types of parasites, nitrates, and other substances contributed by birds and other wildlife. Also, turbidity may render surface waters unsuitable for human consumption.

The goal implicitly recognizes that maintenance of drinking water quality will evolve as Canadian drinking water quality guidelines evolves in response to our changing state of knowledge.

Maintaining water quality throughout the watershed minimizes reliance on either dilution within the watershed, or on processes in the lower watershed that encourage either the destruction of potentially harmful protozoans and bacteria or break down of chemical contaminants.

8.1.2 Riparian Zone Protection and Buffer Zones

The Riparian Zone may be defined as the area of vegetation that borders rivers, streams, and wetlands, and which is a transitional area between terrestrial and aquatic ecosystems. The plant and animal communities found in the riparian zone are typically different from those found farther upland. Although riparian areas may occupy only a small percentage of the area of a watershed, they represent an extremely important component of the overall landscape. The riparian zone has many important biological and hydrological functions. Of direct relevance to source water protection is the role of riparian zone vegetation in:

- filtering sediment, nutrients, and contaminants from upslope sources;
- stabilizing soils and preventing erosion on banks and floodplains;
- moderating downstream peaks in water runoff through temporary water storage;
- helping to maintain cool water temperatures by providing shade; and
- maintaining channel form and aquatic habitat.

Various studies suggest that the functional importance of the riparian zone is greater for smaller streams than for large streams and rivers. Riparian zone protection in headwaters may be more important for minimizing turbidity and other inputs into the Yukon River than protection of the lower reaches of the watershed. The cumulative area of the riparian zone in headwater areas, furthermore, is much larger than for the larger channels in the watershed.

In light of this –

- 2) A goal of the Watershed Management Plan is to encourage management decisions that recognize the significance of the riparian zone for water quality protection.**

8.1.3 Recharge Area Protection

An aquifer recharge area may be defined as the surface area that receives rain or snow and passes a portion downward where it replenishes groundwater. The primary recharge area of a specific aquifer may not correspond with the surface area directly above the aquifer, since much of the groundwater supply may originate from land areas many tens to hundreds of kilometres upgradient, especially for deeper aquifers. The extent to which water permeates downward into the local aquifer depends primarily on the permeability of soils, the interaction with vegetation, and cultural modification of the ground surface. For example, impervious surfaces such as roadways and parking lots increase surface runoff and diminish downward movement of water.

Recharge to an aquifer influences not just the quantity of groundwater, but also its quality. Human activities in the aquifer recharge area, if not properly managed, can add nutrients, chemicals and pathogens to the groundwater, and also impair the ability of soils and their associated microbiological communities to effectively treat the contaminants as the water passes through the soil.

In light of this –

- 3) A goal of the Watershed Management Plan is to protect groundwater quality in recharge areas for drinking water aquifers.**

8.1.4 Stormwater Management

Stormwater consists of that portion of rainfall and snowmelt that does not infiltrate through the soils, but rather runs across the surface, along with the materials (soils, chemicals, bacteria) that it collects as it runs downhill. Historically, stormwater collection systems have been constructed to prevent the pooling of water and flooding of parts of built-up areas, by rapidly channelling water toward lower areas of the watershed. An unfortunate consequence of historical stormwater management practices has been the creation of direct conduits by which contaminants may enter important waterways.

In light of this –

- 4) A goal of the Watershed Management Plan is to re-evaluate stormwater management as a component of community planning with the specific intention of protecting the quality of surface water and groundwater.**

8.2 Integration with the Yukon River Corridor Plan

Whitehorse City Council on December 13, 1999, adopted the *Yukon River Corridor Plan*, prepared for the City of Whitehorse in consultation with its residents by Gartner Lee Ltd., Applied Ecosystem Management, Aboriginal Public Relations Consulting Services, Midnight Arts Research and Writing, Mougeot GeoAnalysis and UMA Engineering Ltd. The overall objective of the plan is to guide future development activities within the municipal boundaries of the Yukon River Corridor. This plan also forms a substantial part of the basis of the more recently adopted Official Community Plan for the City of Whitehorse. The Yukon River Corridor Plan addresses the preservation of environmental integrity and heritage resources and seeks to encourage opportunities in consideration of the valuable attributes of the Yukon River Corridor, and to raise public awareness.

Planning principles used to develop the *Yukon River Corridor Plan* include:

The overall land use and preservation goals which are designed to guide planning for the Yukon River Corridor are reflected in the following statements:

- Respect the range of natural wilderness environments afforded by the Yukon River Corridor.
- Draw people to the Yukon River to appreciate and experience the ecology, natural and human history.
- Accommodate a range of outdoor and recreation activities that are compatible with the natural setting and character of the River.
- Encourage land use, tourism, and recreational pursuits that complement Corridor potential and the established built environment of the City.
- Blend new facilities built in the non-urban areas of the Corridor with their surroundings through extensive use of natural materials to complement the environment.
- Emphasize linking of green spaces to accommodate peoples desires for a wilderness experience, while preserving appropriate travel Corridors for wildlife.

Many of the principles contained in the *Yukon River Corridor Plan*, as well as Whitehorse' *Official Community Plan*, are consistent with the vision and goals for the City's Watershed Management Plan for drinking water protection. Above all, they share the premise that planning processes need to be integrated, are most effective at resolving conflict and avoiding unwanted surprises when centred around a landscape or ecosystem-level approach, and are most effectively implemented in concert with public awareness, education, and collaboration.

It will nonetheless be important to concretely identify potentially competing principles and priorities among the various planning exercises, toward the possible need to make some tough but balanced decisions.

APPENDIX A

LEGISLATION, BYLAWS AND POLICIES

LEGISLATION, BYLAWS AND POLICIES

Relevant federal, territorial, and City of Whitehorse legislation, bylaws, policies, and other management tools are listed and abstracted below. Numbering of the references is sequential, continuing from Section 3.1 of the main body of the report.. In general, the documents are ordered according to jurisdiction, from municipal guidance, to territorial, federal, and other.

Ref.29) City of Whitehorse, 2002 Official Community Plan (2002)

The OCP lays out policies and land use designations. The land use designations are shown on Map 13 (for all the land within the municipal boundary) and Map 14 (for the downtown area). Any proposed land development or use within the City should conform to the policies and designations laid out in the OCP.

The OCP defines policies for Schwatka Lake, and recommends the preparation of a detailed management plan to protect water quality. In addition, Chapter 11, Infrastructure, defines policies to protect Schwatka Lake and the watershed, to assess future upstream development relative to water quality, and to consider future water treatment and additional groundwater supply.

Chapter 12, Map 12, describes development phasing. The first phases (2002 to 2008) are mostly in the Whitehorse Copper area, upstream of Schwatka Lake on the west side, with some additional lands downstream of the lake and the City. Phase 2 (2009 to 2015) areas are mostly downstream of the lake, except for one strip above the highway in the Whitehorse Copper area.

The OCP designates all the land on the east side of Schwatka Lake and the west side of the Yukon River upstream of Schwatka Lake as either Greenbelt or Outdoor Recreation. Land on the west side of the lake and upstream river, between the river and the Alaska Highway, is mostly designated Greenbelt, except for the commercial floatplane area on Schwatka Lake, and some parcels adjacent to the highway but not beside the river. Notwithstanding these land use designations, there are a number of Kwanlin Dun Community Land Selections within the City of Whitehorse, which lie along the Yukon River in “Greenbelt” areas. The OCP designations may or may not be consistent with yet-to-be developed land use planning and management initiatives on Kwanlin Dun lands.

Ref.30) Gartner Lee et al., for the City of Whitehorse, Yukon River Corridor Plan, November 1999.

The report is a guiding document for planning in the City of Whitehorse, within the municipal boundaries of the Yukon River corridor. The *Plan* inventories terrain, soils, vegetation, wildlife habitat and heritage attributes of the corridor, sets out goals, analyzes constraints, and lays out land use policies. Relative to watershed protection, the *Plan* sets out a policy to review any developments located upstream of the water intake that could affect surface or groundwater quality.

Ref.31) City of Whitehorse *Zoning Bylaw 97-42*, adopted May 11, **1998**.

The bylaw divides the City into land use zones, as shown on maps.

Ref.32) City of Whitehorse, Council Resolution #99-24-09, *Schwatka Lake Waterfront Policy*, November 22, **1999**.

This *Policy* is to assist aviation and marine operations to locate on the lake, and to regulate their activities. It limits businesses on Schwatka Lake to commercial aviation and marine operations. Operations are to comply with certain conditions, including the limiting of aviation fuel handling and storage to the fuelling facility provided on a contract basis on City property. Parking on the shoulders of the lake is not permitted except for loading and unloading.

Ref.33) City of Whitehorse, Bylaw 443, *Public Health Bylaw*, May 24, **1983**.

The Bylaw empowers the City to prevent the discharge of any substance, which could endanger public health, into a watercourse. It also authorizes the City to deal with malfunctioning or inadequate on-site sewage systems.

Ref.34) City of Whitehorse, Bylaw 99-02, *Sewer and Water Bylaw*, May 23, **2000**.

This bylaw provides for the supply and use of water and the collection, conveyance, and discharge of sewage and drainage in the City.

Ref.35) City of Whitehorse, Bylaw 426, *Protected Areas Bylaw*, January 24, **1994**.

This bylaw regulates the operation of vehicles in protected areas in the City.

Ref.36) City of Whitehorse, Bylaw 90-15, *All Terrain Vehicle Bylaw*, April 23, **1990**.

This bylaw regulates the use of all terrain vehicles within the City.

Ref.37) City of Whitehorse, Bylaw 92-15, *Parks Recreation Areas Bylaw*, May 11, **1992**.

This bylaw applies to all parks and recreation areas in the City, governing park use, damage, vegetation, refuse, advertising, fires, closure, motor vehicles, business activities, overnight camping, and fees.

Ref.38) City of Whitehorse, *Snow and Ice Control Policy*, December 9, **2002**.

The *Policy* sets budgets, levels of service, priorities, and standards for snow and ice control. Thirteen snow dump sites are listed.

Ref.39) City of Whitehorse, Bylaw 99-24, *Solid Waste Bylaw*, July 10, **2000**.

This bylaw regulates the collection, removal, transportation and disposal of solid waste in the City.

Ref.40) City of Whitehorse, Bylaw 2001-01, *Animal Control Bylaw*, August 27, **2001**.

The Bylaw deals with the care and licensing of animals, and prohibits unsanitary conditions.

Ref.41) City of Whitehorse, Bylaw 92-60, *Maintenance of Property*, January 13, **2003**.

This bylaw establishes and enforces minimum standards relating to the state of repair of property in the City.

Ref.42) City of Whitehorse, Bylaw 2000-54, *Subdivision Control Bylaw*, January 8, **2001**.

This bylaw controls the subdivision of land within the City, sets application requirements and fees, and defines the subdivision process.

Ref.43) David Nairne & Associates Ltd. et al, for the City of Whitehorse, *Parks and Recreation Master Plan*, March 18, **1994** (adopted June 13, 1994).

The *Plan* sets out recommendations and policies on the use, development, and protection of the City's outdoor parks and open space resource.

Ref.44) City of Whitehorse, *Trail Plan*, June, **1997**.

The *Plan* contains an overview of the planning process, a description of the trail system design, trail maps, and strategies to guide the implementation of the *Plan*.

Ref.45) City of Whitehorse, Council Resolution #99-14-18, *Tree Removal Policy*, July 14, **1997**.

This *Policy* establishes management methods for assessing citizen applications for tree removal and consequent site cleanup on lands under City jurisdiction.

Ref.46) Yukon Government, *Agriculture for the 90s: A Yukon Policy*, **1991**.

The *Policy* is intended to encourage agriculture in a manner that maintains soil productivity, water quality, and crop diversity.

Ref.47) Parks Branch, Yukon Territorial Government, *Chadburn Lake Park Reserve Management Plan*, May **1985**.

This report formulates a management plan for the 31 km² reserve, which incorporates a number of lakes, including Chadburn, Chadden, Schwatka, Ear, and the Hidden Lakes. Appendix I describes the biophysical resources of the reserve, including surficial geology and landforms, soils, hydrogeology, climate, wetlands, forestry and vegetation, fisheries, wildlife, minerals and aggregate, heritage resources, aesthetic resources, and recreation resources.

Appendix II presents a management model for public discussion.

Ref.48) Legislative Assembly, Yukon Territory, *Municipal Act*, **1999**.

The *Act* provides the framework and authority for local government.

Ref.49) Government of the Yukon, *Environment Act*, May 29, 1991.

This major, 104-page *Act* governs and regulates activities in the Yukon Territory that impact the water, land or air quality in the Yukon Territory. It pertains to solid waste, special waste, litter, waste reduction and recycling, release of contaminants, hazardous substances, pesticides, and spills. It provides regulations and enforcement, and sets out penalties for offences.

Ref.50) Yukon Territorial Government, *Sewage Disposal Systems Regulation*, under the *Public Health and Safety Act*, June 1, **1999**.

The *Regulation* applies to all sewage disposal systems in the Territory, except for municipal sewer systems or as authorized under the Federal *Yukon Waters Act*. Setbacks from water bodies and wells are stipulated for disposal systems.

Ref.51) Government of Yukon, *Regulations Respecting Public Health* under the *Public Health and Safety Act*, August **1958**.

The *Regulations* apply throughout the Yukon, for the protection of public health. Relative to water supplies, it establishes a duty on the part of municipalities to provide a safe supply source, and empowers the Medical Health

Officer to inspect and test supply sources. It lays out setbacks for wells and water intakes relative to pollution sources and sets out rules for the disposal of excreta.

- Ref.52) Transport Canada, *Boating Restriction Regulations* under the Canada Shipping Act, updated to August 31, **2001**.

These *Regulations* empower enforcement officers to regulate the use of personal watercraft in Canadian waters, other than in the Northwest Territories and Nunavut.

- Ref.53) Health Canada, *Summary of Guidelines for Canadian Drinking Water Quality*, April **2002**.

This summary table is updated once every year, and supersedes the published *Guidelines for Canadian Drinking Water Quality*. The most recent edition of the Guidelines is the 6th, published in 1996. The *Summary* should be used in conjunction with the *Guidelines* in evaluating water quality relative to potential health impacts.

- Ref.54) Forest Resources (DIAND), *Timber Harvest Planning and Operating Guidebook*, May **1999**.

The *Guidebook* is a resource to help resource managers and proponents develop sound logging plans for review. One section describes strategies to protect riparian zones in terms of buffers and setbacks.

- Ref.55) Department of Indian Affairs and Northern Development, *Yukon Waters Act*, June **1992**, and *Regulations*, June **1993**. (Devolved to YTG in 2003)

This *Act* pertains to the use of waters in the Yukon, including the discharge of wastes. The *Regulations* provide details of licensing and water use fees.

- Ref.56) Transport Canada, *Navigable Waters Protection Act*, updated to December 31, **2002**.

This *Act* pertains to the regulation and control of any potential obstacle to navigation.

- Ref.57) Government of Canada, Fisheries and Oceans, *Fisheries Act*, updated to December **2002**.

This powerful act regulates the Canadian fishery. It prohibits the addition of any substance to water that would alter the quality in a way deleterious to fish.

- Ref.58) Government of Canada, Yukon Government, and Council of Yukon First Nations, *Yukon Environmental and Socio-Economic Assessment Act* (Draft, 2001, expected to come into effect in late 2004).

This federal *Act* will replace the *Canadian Environmental Assessment Act* in the Yukon, and will govern the assessment and approval of projects through a single entity. For assessable projects, the steps will include submission of a project proposal, screening and review, acceptance or rejection, and recommendation possibly with conditions.

- Ref.59) Health Canada, Federal-Provincial-Territorial Subcommittee on Drinking Water, *Public Document for DWS*, November **2001**.

The Federal-Provincial-Territorial Subcommittee on Drinking Water includes representatives from the Yukon, NWT, Nunavut, the Provinces, Health Canada and Environment Canada. The Subcommittee provides harmonization across Canadian jurisdictions on drinking water quality standards, and some other aspects of drinking water management. Of particular relevance is the detailed guidance released by the Subcommittee on Protozoans (*Giardia* and *Cryptosporidium*) and turbidity.

The Subcommittee has proposed modifying the existing turbidity drinking water guideline from 1.0 NTU to 0.3 NTU. The draft guideline also specifies criteria for deciding when a source water supply does not need to be filtered.

- Ref.60) Ta'an Kwach'an Council, Chapter 14 - Water Management, *Final Agreement & Self Government Agreement*, August, **2001**.

The *Agreement* states the objective of maintaining the water of the Yukon in a natural condition while providing for its sustainable use.

- Ref.61) Gartner Lee Limited, prepared for the Community Development Branch, Government of Yukon, *Jurisdictional Review of Hydrogeological Assessment Requirements for Rural Residential Developments*, March **2003**.

The report responds to public concerns regarding groundwater in rural residential subdivisions, particularly within the City of Whitehorse. The report recommends the hydrogeological information requirements that a developer would need to submit in support of an application for a rural subdivision in other jurisdictions, i.e. Ontario, Alberta, and British Columbia.

APPENDIX B

MINUTES OF MEETINGS

City of Whitehorse Watershed Management Plan

Minutes of Miscellaneous Meetings held during the week of April 21, 2003
and during the week of June 23, 2003

Minutes prepared by UMA Engineering Ltd.

200-415 Gorge Road East
Victoria, BC V8T 2W1

1) Meeting with Steering Committee - April 22/03

Attendees:	Ross Burnett	-	Project Manager, City of Whitehorse
	John Pattimore	-	Ta'an Kwach'an First Nation; Lands Management Branch
	Pat Brooks	-	Environmental Health
	Ric Janowicz	-	YTG Water Resources
	Bengt Pettersson	-	YTG Water Resources
	Judy Linton	-	YTG Community Services (Community Land Planning)
	Al von Finster	-	DFO
	Gillian McKee	-	Contract Planner to Kwanlin Dun First Nation
	Brian Crist	-	City Manager of Public Works
	Larry Shipman	-	City Engineering
	Cord Hamilton	-	Yukon Energy Corporation
	Doug Bright	-	UMA Engineering Ltd. (UMA)
	Tom Lidkea	-	UMA
	Pat Tobler	-	Environmental Dynamics Inc. (EDI)

Ross Burnett - introduced UMA, explained that the City wants a science-based rationale/plan with a strong public education component. Also wants the plan to be a guiding document to direct the development within the watershed. Ross requested those attending to speak for about five minutes each on their respective interests in the watershed management plan.

John Pattimore - The Ta'an are very interested in a large piece of the Yukon River. People use the river and its resources; pollution prevention is important. The Ta'an FN is beginning the preparation of a strategic environmental plan and is part of the Yukon River Watershed Management Working Group. Ta'an live mainly in Whitehorse, some at Lake Laberge and elsewhere.

PLEASE NOTE: If this report does not agree with your records of the meeting, or if there are any omissions, please advise, otherwise we will assume the contents to be correct.

Report of Meetings 22 - 24 April, 2003

File No. 2501 024 00 01

B-1

Pat Brooks – YTG Health has mandate for drinking water quality - want source water protection. The less challenge on source water, the less treatment is needed. The tourism development proposed on Schwatka Lake raised the issue of water quality. Concern re: sewage management. Concern re future contaminants associated with industry and agriculture. Agricultural development is being encouraged. Question re: emphasis on water quality upstream of the City. (A: Focus on watershed downstream of Marsh Lake dam, to Schwatka Lake dam, to wells).

Ric Janowicz - YTG has a mandate to manage Yukon's water resources, quantity and quality. Sets up drinking quality standards. The feds. Transferred former DIAND responsibility for this to YTG. YTG is very interested in the science related to water.

YTG water resources has information on flood monitoring, flood hazard mapping, inventory of water resources (surface and groundwater). Recently established first long-term groundwater monitoring well in Yukon.

RJ discussed groundwater research watershed - wolf creek: a series of significant projects has been carried out. \$2 - 7 m funding this year. Participants include USDA, University of Wales, 15 other universities. Calibrate hydrologic flow models, tie-in biology, atmosphere vegetation/snowpack. 10 years of data, 3 meteorologic stations, 60 parameters. Climate change prediction is a focus of this research (started out to calibrate hydrological flow models; specific emphasis on interactions between vegetation and snow pack.

Cord Hamilton - YEC has a water licence to regulate level of Schwatka Lake. Interested in water quantity, safe operation. Cord has information on lake flows and levels, also available from WSC (Hydat CD), and information on PMF's and low flows. (Dave Cass should contact Cord re hydrology).

Judy Linton - Community Land Planning: regulation, zoning, concerns regarding land use policies, taking into account water quality. Working on Gold Horn Plan (LAP), almost done, beginning local area planning in marsh lake area. Some plans around Marsh Lake deal with sewage issues. Also doing some planning in areas downstream including Mayo Road area and Lake Laberge. Information from various local area plans may be of direct relevance to the watershed management plan.

Al von Finster - This is a period of change for DFO related to devolution of responsibilities to YTG. DFO may act more as in a province. 1) Habitat Management will regulate land and water, is reactive and coercive, and 2) Stewardship/Net gain is concerned with restoration/enhancement. Tend to support potable water quality

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protection because this also protects fish. Support First Nations' enhancement programs. Support public access to and ownership of watersheds, because that leads to political support (bonding results in stewardship) for watershed protection.

Gillian McKee - Kwanlin Dun territory extends to Lake Laberge, upstream to Marsh Lake. Have land on Yukon R. and on tributaries, although claims not yet settled (may be completed by December). Have been planning for settlement lands, have begun a database on these lands. Support water quality protection, want to develop policies for development of settlement lands.

Brian Crist - the City is planning to build a water treatment plant and needs to know anticipated raw water quality. WMP should help define treatment needed. Gartner Lee has prepared a cursory model of groundwater that suggests the city may be able to use groundwater for full ultimate supply. Need physical pump tests to validate.

Two-thirds of the City's supply is from Schwatka Lake. Source to tap, concern re: quality. Looking for a tool to enable the City to better answer public concerns. The only treatment at present is chlorination. BC would like the WMP to gather existing regulations together and use existing regs as suitable rather than writing new rules. Define authorities. City relies on regulatory authorities outside the City.

Issues include: snowmobiles, boats, floatplanes, derelict cars pushed into River. City closed some accesses to River. Regarding development, the City is pro-development, but does not want threat to water supply. Need reasons.

In the context of providing a tool to allow the City to manage the drinking water supply, there are a few key questions that will need to be addressed:

- Do we (the City) have the authority?
- If not, who does?
- What is the concrete rationale for management options (such as limitations to watershed access)?

Larry Shipman - Began with a quote by a member of the public - "You people fence off sewage lagoons but allow unlimited access to the watershed." The Plan needs a good public education program, extended to businesses. Need simple rules and guidelines for public and businesses.

Doug Bright - Doug made a presentation of the proposed WMP methodology and schedule. BC asked about Persistent Organic Pollutants (POP's). Doug explained that POPs would not result in human health risks through the drinking water supply, as opposed to eating fish. POPs are very poorly water soluble and the main drivers of risk are associated with biomagnification in the food web.

PB said the Environmental Health tests 30 parameters, but could test 80. Can the plan define appropriate parameters? Briefly discussed stratified sampling wherein a larger suite tested at less frequent intervals and a very narrow focused indicator suite tested more regularly. PB also mentioned septic systems, and the northern practice of burying the distribution piping eight feet deep to avoid frost. (TL concerned about anaerobic conditions with deep burial). There was some discussion that the depth to groundwater was in most cases quite large. There is in many locations a deep unsaturated zone. Often, it is difficult to drill drinking water wells due to the large depths to water table and often large inconsistencies in depth to groundwater over short distances.

It was suggested that the first Open House could be in mid-May. GM was concerned that First Nations attendance might be poor and asked for consideration of ways to improve First Nations communications.

Miscellaneous Discussion:

Mentioned the "Yukon River Corridor Plan" (Ross has a word document with segments of this).

Also "Chadburn L. Park Management Plan"(in hard copy only). Some discussion about whether the plan was ever formally adopted. The Lake was posted "No motor boats", but there was no accompanying request through Canadian Coast Guard, as is required to make this enforceable.

2) Meeting with City Staff - April 22/03

Doug Bright, Tom Lidkea, and Pat Tobler met with the City's Project Manager, Ross Burnett, to discuss and receive appropriate documents as listed in the RFP: All documents listed were either already in UMA's possession or were borrowed from the City.

Relative to mapping, RB introduced UMA to David Boorse, with the City (867) 668-8373. The City has:

- Topographic maps '93
- GIS - cadastral, zoning, trails, soils, terrain, wetland (use mapinfo)

Contact David Boorse to get digital copies. The City can put the information on FTP site (File Transfer Protocol), give UMA an ID # and password. Another possible source of mapping is Laurie Butterworth (YTG)

Upon further discussion, it was agreed that the first Open House would be held on June 4 or 5. (Ross is away from May 15 to 20, and normally works Monday, Tuesday, Wednesday). A Questionnaire and information leaflet will be prepared for the Open House. Potential advertising would be in:

- | | |
|-------------------|-------------------------------|
| - Whitehorse Star | - weekdays |
| - Yukon News | - Monday, Wednesday, Friday |
| - City Info: | - In both papers "City Pages" |
| - Radio spots: | - CKRW |
| | - CBC |
| | - CHON FM |

3) Meeting with Kwanlin Dun First Nation - April 23/03

Attendees:	Gillian McKee	- Land Use Planner
	Josh Smith	- Band Resource Manager
	Doug Bright	- UMA
	Tom Lidkea	- UMA
	Pat Tobler	- EDI

Communications - Generally, open houses are not well attended by Kwanlin Dun. GM suggested a separate open house in Kwanlin Dun Village, during the time of the first main open house. Possibilities:

- separate Open House, 4:00 - 7:00 p.m. (could combine with Ta'an open house)
- Pat could make a presentation to the Land Use Planning Group at another time, perhaps the week following main open house

GM suggested UMA talk to the Yukon River Intertribal Watershed Council, Geraldine Pope.

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Regarding KD land selection, GM gave UMA maps showing the lands, and said we could get e-versions of the mapping. She will e-mail them to DB. [Note added in proof: In follow-up e-mail exchanges, Gillian thought that they may not have the most up-to-date information and suggested obtaining the land selection maps directly from DIAND]. Some lands are on the Yukon River upstream of Schwatka Lake. None of the parcels are on Schwatka Lake. Water supply to the lands could be by truck from the City system, as is done for the Marsh Lake fire hall and Takhini subdivision. KD would support ways of preserving water quality, BUT want to develop the selected parcels. KD has an engineering firm looking into existing service of selection sites for determining possible development types at these sites.

Brief discussion about important issues for watershed management that might be outside of the scope of the immediate needs of the City of Whitehorse. Discussion about the possibilities and roles for the Yukon River Inter-Tribal Water Council.

The Kwanlin Dun are just beginning to establish their own planning process for selected lands. Many questions remain, such as the types and intensity of development over the short term and long term, how will lands be serviced? And so on.

4) Meeting with Eric Corpataux - April 23/03

Eric Carpataux is the business owner who currently runs the MV Schwatka on Schwatka Lake, and whose company, Yukon Follies, applied for a Development Permit for a restaurant and other amenities on the lake.

Attendees: Eric Corpataux
Sylvia Stuck
Doug Bright, UMA
Tom Lidkea, UMA
Pat Tobler, EDI

EC acquired the land in 1999, and at the time talked to City about commercial development. The zoning was OK, and the City could see no problems. However, the development application was rejected by the City, despite the efforts of EC to provide proper environmental protection. (UMA has a copy of drawings and correspondence showing the proposed development). Increased human activity was the concern raised by the City.

The MV "Schwatka" has been operating since 1963. During the season, they generally run one cruise @ 2:00 PM from June to September, with additional cruises from June to August. There was a total of 252 cruises in 2002. The MV Schwatka has a 1000 L diesel tank, filled from a trailer tank (usually take on a max. of 650 L). No fuel is stored on site. Float planes fuelled from truck; no storage on site. The present operation uses pumpout and haulage off-site of sewage, by a company called NW Vacuum. There is no wastewater disposal on site either.

Eric discussed the positive aspects of having a modernized facility on the lake; i.e., ongoing presence/people around to assist with keeping an eye on activities that occur around the lake (the example was presented of the dumping of a snowmobile off the hill into the lake on the side opposite the MV Schwatka) and to assist with stewardship. Also, a modernized facility for which the issues for drinking water have been thought about and carefully planned for was proposed as a better alternative to uncontrolled activities that might otherwise take place.

Eric is open to incorporating environmental/drinking water stewardship aspects into the MV Schwatka development. Noted that the application was turned down perhaps because of concerns about encouraging increased recreational use of Schwatka Lake. Also noted the encouragement of recreational use of lands on the other side of the lake, and appeared to be supportive of a framework for strategic, equitable decisions.

5) Meeting with Yukon Economic Development - April 23/03

Attendees: Rick Sudeyko, Business & Trade Promotion
Sheila Dodd, BTC
Ross Burnett, City of Whitehorse
Doug Bright, UMA
Tom Lidkea, UMA
Pat Tobler, EDI

Rick did a "forensic" assessment of why approval was withheld for the Yukon Follies Project. He thought the Yukon Follies proposal was very sound compared to fuel storage at Black Sheep and others in area. RS asked to be on the Steering Committee, participated in preparing the Terms of Reference. RS referred to the 1995 Inukshuk report re: floatplanes which said "No problem." It is difficult to find an alternative to Schwatka Lake floatplane use. YTG has been talking about extending the trolley line to MV Schwatka Lake area. RS supports good environmental practice but wants economic development.

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The watershed management plan should to the extent possible ally unfounded fears if done correctly.

Sheila Dodd said there has been little or no growth in floatplane activity. Operations should have contained fuelling systems. Current waste (bathroom) practice on Schwatka Lake is poor/primitive, and would be improved by a proper operation such as is proposed by Yukon Follies.

Sheila and Rick talked about fears of the “thin edge of the wedge” associated with the first development, and the use of float planes in general. This may be unfounded. There have typically been no more than 8-9 planes on the lake, owing to both economic and “physical” reasons, and it is unlikely that any future expansions would see more than 16-18 float planes at a max. using the lake.

DB suggested that one method for addressing public concerns would be to include in the watershed management plan some triggers based on future expanded activities in the watershed that would catalyze the re-visitation of various management aspects.

Ross Burnett suggested the Whitehorse WMP should consider similar situations elsewhere, and suggested Okanagan Lake and Castlegar (Arrow Lake). SD suggested looking at Alaska (lots of floatplanes).

6) Meeting with YTG - April 24/03

Attendees:	Bengt Petterson	YTG
	Ric Janowicz	YTG
	Lesley Cabott	City of Whitehorse
	Ross Burnett	City of Whitehorse
	Doug Bright	UMA
	Tom Lidkea	UMA
	Pat Tobler	EDI

There was a general discussion about the possibility of additional funding for the Watershed Management Plan, from YTG.

RB - need to look at cottage lots at Marsh Lake
RJ - some contaminant studies upstream, snowpacks, atmospherics. Also has conducted ground and surface water studies for Pine Ridge and Wolf Creek, more coming out next week from GLL, which has database of well logs

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Report of Meetings - Continued
File: 2501 024 00 01

- LC - previous DIAND water manager thought funds could be available from YTG this year
BP - Lesley could write to Minister/Premier.

7) Meeting with Council and Senior Management - April 23/03

Attendees: Members of Council (Mayor Ernie Bourassa, Dave Stockdale, Doug Graham)
Sr. City Management (Rob Fendrick, Bill Newell, Mitch Moroziuk, Lesley Cabott, Ray Goruick, Linda Rapp), City of Whitehorse
Douglas Hnatiuk Facilities/Parks Branch Supervisor, City of Whitehorse
Ross Burnett City of Whitehorse
Doug Bright UMA
Tom Lidkea UMA
Pat Tobler EDI
Robin Sharples EDI

DB thanked Council for awarding the assignment, and gave a presentation of tasks and schedule. Council was interested in learning about the impact WMP might have on the need for and the timing of building the water treatment plant. DB explained that the WMP would not negate the need for water treatment, because the turbidity issue will remain, and that high turbidity can interfere with disinfection. However, strong protective measures of the source water may allow for less expensive treatment

8) Meeting with Ta'an Kwach'an Council - April 24/03

Attendees: John Pattimore
Geraldine Pope
Tom Lidkea, UMA
Pat Tobler EDI

Some mapping of Ta'an lands has been done. A hard copy was given to UMA. JP can probably get us an electronic version of "Inset C", showing the lands within the City of Whitehorse. Most of the lands are downstream of the City. The Yukon River Inter-Tribal Watershed Committee has no director at present, is in transition. JP suggested UMA check out the new Committee GIS website, which could contain useful mapping. (http://www.yritwc.com/GIS/GIS_party.htm). Also check for reports and other information.

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GP concerned re: floatplanes, cars going in lake.

It would be acceptable to have a common open house @ Kwanlin Dun during first main Open House.

9) Stakeholders Drop-In - April 24/03

Owners and operators of floatplanes were invited to drop in at Sport Yukon.

Attendees:	Klaas Heynen	Kusawa Outfitters Ltd.
	Eric Corpataux	Yukon Follies
	Sylvia Stuck	Yukon Follies
	John Faulkner	
	Jeff Faulkner	
	Cam Drinnan	Black Sheep Aviation
	Gerd Mannsperger	Alpine Aviation
	Ross Burnett	City of Whitehorse
	Tom Lidkea	UMA
	Pat Tobler	EDI

Klaas Heynen - Kusawa Outfitters Ltd. KH has operated a floatplane for 35 years. He is concerned about government interference and over-regulation. He said that it is ridiculous that a small dock on Schwatka Lake requires a million dollars liability insurance. Potential problems re fuel spills are grossly over-exaggerated. A central fuelling facility was tried before, but didn't work because of friction between outfitters and fuellers regarding times of operation and other things. There are too many regulations (e.g. placer mining). KH suggested a brochure for tourists explaining the history of watershed use, including floatplanes.

Eric Corpataux and Sylvia Stuck - The MV Schwatka carries 1,000 L of diesel fuel. No fuel storage on site. EC asked about water supply from Fish Lake. RB answered that this was looked at in the 1980s, from lower down on McIntyre Creek, and was rejected.

John Faulkner - Floatplane operator. There have been floatplanes in Schwatka Lake since 1959. To the best of his recollection, there has never been a crash on the lake. The number of planes is now limited by the policy of the City to limit the number of docks. City policy re docks and fuelling is unnecessarily restrictive. The \$1,000,000 dock insurance is required by the City. Fuel is now only to be dispensed at Cam's

dock - not a realistic requirement. Could require refuelling from small cans/attended. Should be better provision for servicing airplanes - some facility to pull planes out of the water for maintenance, allowing the opportunity to pull the planes out for service and when not using them). There is the potential for Schwatka Lake to be a larger economic driver than it is, and there is no convenient alternative. JF flies a Cessna 185, which carries its fuel in two rubber bladders. Total capacity is 78 gallons of aviation fuel. The absolute worst-case spill scenario, assuming full tanks, and both bladders breaking, would spill 78 gallons.

Jeff Faulkner - Floatplane operator, commercial flights.

Cam Drinnan - Black Sheep Aviation. Estimates there are about 20 planes on the lake. His fuel tank has a capacity of 63,000 L. May average ~15,000 to 20,000 L (EnviroTank).

There was a general discussion about snowmobile races on the lake. This has been occurring for 4 or 5 years. Organizers asked for a Permit in 2002. Although the lake itself is not in the City's jurisdiction, the Development Officer issued an approval. In 2003, permission for the race was given by the Federal government.

There was a general discussion about bathroom facilities on the lake. The park on the east side uses portapotties

RB will provide an orienteering map of the east side of the lake, showing parks and rec. site.

Gerd Mannsperger - Alpine Aviation. GM wants continued use of Schwatka Lake by floatplanes. There is no safe alternative site. GM operates 3 planes: Found Bushhawk (1960s Canadian design, made in Parry Sound), a Cessna 206, and a Maule-MS. He operates from early June to mid-October. It would be awkward using a central fuelling facility, taxiing back and forth, and difficult to find a site with enough room for parking cars. There could be congestion at and around the fuelling dock with planes.

DOT Regulations for fuelling practices are related mainly to safety. Alpine Aviation carries Tidy tanks, with filters, on a truck (160 gal. is biggest). Refill tanks daily offsite. People tend to criticize the highest visibility use of the lake (floatplanes). Giardiasis is a problem in Schwatka Lake - GM says he has had Giardiasis twice, from falling in the

lake. He agrees with the need to protect Schwatka Lake, but the lake is a valuable amenity, and the floatplane base itself is an attraction. Need a workable plan. GM has a spill response plan - ERP - involving the use of absorbents, and listing of emergency phone numbers.

10) Meeting with Council and Senior Management - June 25/03

Attendees:	Members of Council	Duke Connelly, Dave Stockdale, Samson Hartland....
	Sr. City Management	Mike Gau, Bill Newell...
	Ross Burnett	City of Whitehorse Planning Department
	Doug Bright	UMA

Doug Bright presented the draft Baseline/Status Report.

11) Meeting with Steering Committee - June 26/03

Attendees:	Ross Burnett	-	Project Manager, City of Whitehorse
	John Pattimore	-	Ta'an Kwach'an First Nation; Lands Management Branch
	Pat Brooks	-	Environmental Health
	Larry Shipman	-	City Engineering
	Rick Sudeyko	-	YTG Business and Trade Promotion
	Doug Bright	-	UMA Engineering Ltd. (UMA)
	Pat Tobler	-	Environmental Dynamics Inc. (EDI)

Doug Bright and Ross Burnett presented the Background/Status Report. In general, the Steering Committee felt that the report seemed to cover all the known issues and risks. There was a general and wide ranging discussion of many issues, as summarized in point form below.

- Local Area Plans, especially for Marsh Lake, and the need for jurisdictional cooperation
- Role of YTG
- Disinfection of drinking water, proposed under "Public Health and Safety Act"

- Conceptions & Misconceptions: Some people seem to feel there is no need for testing of drinking water, a misconception that should be corrected through public education. Another example is the concern about elevated metals from the old Whitehorse Copper mine, which testing has shown does not impact water quality.
- Waterfront policy passed by Council - Resolution & Enforcement
- Future triggers for action
- Follow-up - check on policies and issues for float planes in Alaska
- Check on mining claims relative to the potential for sediment generation