DISTRICT OF CAMPBELL RIVER

WATERSHED MANAGEMENT PLAN

JULY 2001

DAYTON & KNIGHT LTD.

in association with

UMA ENGINEERING
CHARTWELL (FORMERLY HUGH HAMILTON)
ENKON ENVIRONMENTAL

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

CONTENTS

CONTENTS (cont'.d)

CONTENTS (cont'.d)

CONTENTS (cont'.d)

CONTENTS (cont'.d)

CONTENTS (cont'.d)

FIGURES

APPENDICES I

CONTENTS (cont'.d)

1.0 STUDY AREA

The water source for the District is the John Hart Lake reservoir. It is a high quality source with turbidity, colour and suspended solids usually very low. The only water treatment presently practiced by the District is chlorination.

The John Hart Lake reservoir is within a 1822 square kilometer watershed that includes significant water bodies such as McIvor Lake, Campbell Lake, Upper Campbell Lake and Buttle Lake and numerous rivers and streams. The natural watershed boundaries have been increased in area by diversion of the Quinsam, Heber/Crest and Salmon Rivers. Figure 1-1 identifies the watershed boundary and key features.

The John Hart Lake reservoir will remain the District's water source over the long-term. There are multiple uses in the watershed including power generation, transportation and utility corridors, residential settlement, recreation, water sports, camping, mining and logging. The lake level is controlled by BC Hydro and can fluctuate over a range of water levels. There are three Provincial Parks and numerous Forestry campsites in the watershed.

A very small area of the watershed is within the District boundaries. The remainder of the watershed is within the Regional District of Comox-Strathcona (RDCS) where the land is zoned "Upland Resource" with permitted uses including park, forestry, agriculture, low impact recreation, fishery and other minor uses. The land is generally Crown land with a number of granted land tenures.

1.1 Project Objectives

The District commissioned a watershed management plan with the goal being the long-term protection and maintenance of the water quality and supply. The District's goal is based on the following considerations:

- Increased public and industrial activities in the watershed;
- Changing environmental conditions;
- Changes in land use policy by the Provincial Government;
- Broader public expectations.

The District has also noted the water quality issues that have arisen not only in BC, but in the rest of Canada and the USA over the last decade and the utility and regulatory approaches taken to minimize this risk to the consumer, such as the adoption of filtration and disinfection. The principal issues include waterborne disease outbreaks associated with bacteria, viruses and parasites such as cryptosporidium oocysts and giardia cysts but include disinfection byproduct formation or byproducts formed through the reaction of disinfection and naturally occurring organics in the water.

The District's strategy through the plan is to identify watershed activities that could impact the source drinking water quality over both the short and long terms and work with the stakeholders to develop strategies to minimize the impact. The watershed plan identifies the strategies needed to protect the District's water source over the long-term and, through public consultation, on an implementation plan to be adopted by all stakeholders.

1.2 Water System and History

In 1949 the Village of Campbell River, under an agreement with the BC Power Commission, installed a new water supply system with a source from the penstocks of the John Hart Power Station. The John Hart dam was placed in operation in 1947. Penstocks

Numbers 1 and 2 were tapped with 250-mm (10-inch) diameter outlets. A 200-mm (8-inch) diameter steel pipe was installed to the Village of Campbell River boundary.

In 1957, the North Campbell River Water District installed a 250-mm (10-inch diameter) supply line connected to the Village's penstock connections. Under agreement with the Village, this line was increased from 150 mm (6 inch) to 250 mm (10 inch) diameter for which the Village received 1/6 of the line's capacity and a further 1/3 at agreed rates.
The original Willow Point water supply system consisted of a small rock filled crib dam forming an impounding reservoir on Willow Creek. Water was pumped from the reservoir into the system. By the early 1960's, this system was far from adequate, being severely limited by dependable flows in the creek. Before 1961, water supply for residents of the Quinsam Heights area was pumped from individual wells. During summer months, this supply was unreliable and generally inadequate.

In November 1959, the Village of Campbell River and the Willow Point Waterworks District requested engineering assistance from the Provincial Water Rights Branch to investigate a Greater Water Board for the area. In August 1961, the Water Rights Branch recommended formation of a Greater Water Board to include Willow Point, the Village of Campbell River and Quinsam Heights Improvement District.

The Greater Campbell River Water District was formed on August 6, 1962 as a bulk water supplier with the three partners maintaining control of their distribution systems. A number of improvements were made including a new 500 mm (20 inch) diameter steel supply main from the penstock connections to the Village boundary and a 400 mm (16 inch) diameter pipe to Willow Point. The Old Willow Creek water supply system was abandoned. Major pipelines and the Evergreen Reservoir were added to the system in the mid 1970s.

In 1986, the District of Campbell River took over ownership of the Greater Campbell River Water District. By the late 1980's most of the Willow Point area amalgamated with the District of Campbell River and the ownership of the Willow Point Improvement

District was transferred to the District. Likewise in 1991, the North Campbell and Quinsam Heights areas amalgamated with the District and the ownership of the distribution systems in both areas was taken over by the District.

The District also takes water directly from John Hart Lake independent of the BC Hydro penstock system, through the John Hart Lake pump station. The water source is for the District's Industrial Park system as well as for the Pacific Regeneration Technologies Campbell River Nursery and the John Howard Society.

Figure 1-2 locates the key features of the District's water system including the location of the disinfection plant, Evergreen Reservoir and Pump Station, Holme Road Reservoir and major transmission pipes ranging from 250 mm to 760 mm in diameter.

1.3 Water Licenses

The Ministry of Environment, Lands and Parks has issued several water licenses to the District allowing withdrawal of water from John Hart Lake. The Ministry licenses to divert water from the BC Hydro penstocks are as follows:

License Number	Allowable Withdrawal
c018794	54 ML/yr
c022156	331 ML/yr
c023088	554 ML/yr
c061333	6020 ML/yr
c108060	1090 ML/yr
c108161	166 ML/yr
Total	8215 ML/yr.

There are five water licenses served by the John Hart pump station as shown in Table 1-1:

TABLE 1-1
WATER LICENSES SERVICED BY
JOHN HART LAKE PUMP STATION

Licence No.	Licence Holder	Purpose	Maximum Licenced Withdrawal		Issue Date
			Annual (m^3)	Daily (m^3)	
c064008	District of Campbell River	Waterworks	20,320	159	09/17/86
c032610 c033162 c037165	Forest District Forest District Forest District	Irrigation Irrigation Domestic	92,500 18,500	 13.6	03/07/67 08/25/67 11/18/70
c072194	John Howard Society	Work Camps		45.5	05/17/68
		Total:	131,320	218.1	

The District has two MOELP water licenses to divert up to 136 ML/yr from John Hart Lake into the Industrial Park system.

Water supply to the District is controlled by B.C. Hydro through a water supply agreement pursuant to the water licenses.

The District is permitted to divert the following volumes of supply pursuant to the terms of the agreement:

- Maximum Daily Flow = 20,000,000 imp. gal.
  = 90.8 ML/day
  = 1050.9 L/sec
- Maximum Annual Flow = 2,000,000,000 imp. gal.
  = 9,080 ML/year

The above flows are subject to the sole discretion of B.C. Hydro. B.C. Hydro retains the right to reduce or interrupt the flow of water without becoming liable to the District for any loss or damage resulting there from.

The maximum flow stipulated in the existing agreement is adequate to serve a population of slightly over 39,000 based on the Maximum Annual Flow and slightly over 43,000 based on Maximum Daily Flow.

1.4 Historical Water Quality

The District has an active source water quality monitoring program. A July 1998 report by Associated Engineering entitled "Water Quality Study" provided a summary of the water quality data. The report summarized the historical water quality by (i) physical/chemical, (ii) aggressiveness, (iii) disinfection byproduct formation potential and (iv) microbiological.

1.4.1 Physical/Chemical

Five water samples were taken in 1996, 1997 and 1998 from the John Hart source. They were analysed for thirty four chemicals including aluminum, arsenic, cadmium, copper, iron, lead, manganese, mercury, silver, uranium and zinc. Physical parameters such as turbidity, solids and true colour were also determined. In a comparison with the Canadian Drinking Water Quality Guidelines the report concluded that the source is " very high quality". A summary Table 1-2 taken from the report summarizes key water quality parameters and for comparison the Canadian Drinking Water Quality Guidelines Maximum Acceptable Concentrations (MAC).

TABLE 1-2
JOHN HART LAKE PHYSICAL/CHEMICAL PARAMETERS ***

Sample Dates	September 1996*	July 1997	November 1997	December 1997	March 1998	CDWQ Guidelines
PH	7.92	7.24	7.2	7.3	7.27	6.5 to 8.5
Conductivity uS/cm	50	46	45	45	45	--
True Colour (CU)	< 5	< 5	7	10	7	< 15
Turbidity (NTU)	0.24	0.31	0.35	0.39	0.18	<5(AO) <1(MAC)

Sample Dates	September 1996*	July 1997	November 1997	December 1997	March 1998	CDWQ Guidelines
Hardness (mg/L as $CaCO_3$)	21	20	20	21	20	--
TDS (mg/L)	47	41	40		37	< 500
TSS (mg/L)	< 1	< 1		< 1	< 1	--
Total Alkalinity (mg/L as $CaCO_3$)	31.6	21.0	22	23.1	29.8	--
Chloride (mg/L)	0.7	0.6	0.6		0.8	< 250
Sulphate (mg/L)	3.2	3.0	2.5		2.7	< 500
Aluminum (mg/L)	0.026	0.016	< 0.2**		< 0.2**	< 0.1 (WHO)
Calcium (mg/L)	7.43	7.29	7.19		6.77	--
Copper (mg/L)	0.03	< 0.001	0.04		< 0.02	< 1.0
Iron (mg/L)	< 0.03	0.06	0.06		0.04	< 0.3
Lead (mg/L)	0.002	< 0.001	< 0.08**		< 0.08**	0.01
Magnesium (mg/L)	0.69	0.65	0.65		0.65	--

* Previous testing, taken just upstream of chlorine injection station

** Detection limits higher due to laboratory error

*** John Hart Lake at the District's Intake.

An issue with coastal British Columbia waters is the "aggressiveness" nature of the water. The water is corrosive to materials used in plumbing and pipe wall materials such as copper (household piping), iron (distribution pipes), calcium (asbestos cement pipes) and lead (plumbing solder). It was concluded in the "Water Quality Report" that the John Hart water source is relatively aggressive.

1.4.2 Microbiological

The report identified that in the five water samples taken total and fecal coliform organisms were detected in the source water. The presence of total and fecal coliforms is, however, to be expected in a surface water source. Chlorination is used by the District to ensure that any bacteria and viruses do not reach the distribution system. Water samples were also taken for the presence of giardia cysts and cryptosporidium oocysts. The sampling and testing procedures have limitations. No cysts were detected on very

limited sampling and it was concluded that a negative result does not preclude that the organisms are not in the source water.

1.4.3 Disinfection Byproduct Formation Potential

Disinfection Byproducts are chemical compounds created when the disinfectant used in drinking water reacts with naturally occurring organic matter in the source water. Total Organic Carbon (TOC) is one indicator used to determine the organic matter concentration. Trihalomethane (THM) is one measure of the resulting compounds from the reaction of chlorine and the source water organic matter. The "Water Quality Study" identified that the TOC in the John Hart Lake water source varied between 1.3 and 4.6 mg/l. In the study, the THM formation potential was reported instead of the actual THM value as the water sample was taken prior to the addition of chlorine. The study also reported the actual THM levels at various locations in the District's water distribution system. The values varied between 0.011 and 0.045 mg/l which is within the Canadian Drinking Water Quality Guidelines of 0.10 mg/l.

1.4.4 Summary

The report concluded that the John Hart Lake:

- Is aesthetically excellent and potable in terms of health criteria,
- Is aggressive and as a consequence susceptible to corrosion of metals used in household plumbing and pipe wall materials in the District's water distribution system,
- The disinfection byproducts as measured by THM are present but in concentrations less than the Maximum Allowable Concentration (MAC),
- Fecal and total coliform organisms are present in the source water.

1.5 Supplementary Source

The report also suggested that the District pursue McIvor Lake as an alternative water source because it would improve water supply security and hydraulic performance of the distribution system. The key recommendations for a McIvor Lake source were as follows:

- Prepare a watershed management plan to assist in protecting against degradation of water quality,
- Focus on water treatment removal or inactivation of pathogenic organisms. Given the risk from the cryptosporidium oocyst the recommendation was to use either membrane filtration or direct filtration. The estimated cost being $15M and $18M respectively with operating and maintenance costs of $500,000 and $600,000 respectively.
- Make provisions for a corrosion control facility.

The District, however, would need a Ministry of Environment Lands and Parks water license to withdraw water from McIvor Lake. The intake would have to be sited in consideration of the impact on existing licensed water users, riparian owners and fisheries resources.

1.6 Water Supply Assessment and Direction

Associated Engineering prepared a report for the District entitled "Water Supply Study Update. Water Treatment Strategy" dated May, 2001.

Based on the historical water quality issues in terms of the "Guidelines for Canadian Drinking Water Quality" and the United States Environmental Protection Agency (USEPA) Surface Water Treatment Rule, the "Water Supply Study Update – Water Treatment Strategy Technical Memorandum 3" recommended a program to enhance the

water quality to the District consumers. The key features for a John Hart source were as follows:

- Primary disinfection using Ultra Violet light,
- Secondary disinfection using gaseous chlorine,
- A contact time to ensure an adequate CT value, (The CT value is a combination of C, the chlorine contact dose, mg/l, and T, chlorine contact time, minutes)
- Water conditioning using sodium carbonate.

The estimated cost was identified as $6,633,000 including treatment, storage and power generation. This approach is based on John Hart Lake water turbidity that is below the Maximum Acceptable Concentration so that filtration is not required.

The "Water Supply Study Update- Technical Memorandum No. 2 Water Source Development" dated February 19, 2001 identified that the District's water consumption will exceed the District's Ministry of Environment, Lands and Parks water license as well as the water volume agreement with BC Hydro. The study recommended a new intake located on McIvor Lake with a system capable of supplying fifty percent of the District's water demand in 2030. Based on a similar philosophy for the John Hart water source, the study recommended the following treatment steps for a McIvor Lake source:

- Primary disinfection using Ultra Violet light,
- Secondary disinfection using gaseous chlorine,
- A contact time to ensure an adequate CT value, (The CT value is a combination of C, the chlorine contact dose, mg/l, and T, chlorine contact time, minutes)
- Water conditioning using lime and carbon dioxide.

The study identified an estimated capital cost of $13,612,000 to develop a McIvor Lake source including treatment, storage and power generation.

1.7 Historical Water Demand

The District's monthly water demand profile for the period December 1994 to May 2000 is presented on the accompanying Figure 1-3. The demand includes low water consumption in December to March of each year and an increasing demand from March to a peak in July with a gradual decrease to the low demand period in December. The low demand in the winter is indicative of indoor water use (toilet, bathing, washing, consumption) and system leakage while the higher summer demands are a reflection of indoor use and leakage plus outdoor use. The outdoor use is associated with irrigation of lawns and gardens.

The District's average daily winter demand is about 10 million liters per day (Ml/d) (2.0 million gallons per day (mgpd)) while the peak summer demand in 1998 varied between about 38 Ml/d (8.5 mgpd) up to 48 Ml/d (10.5 mgpd).

The population is expected to grow from about 31,253 users in 2000 to about 65,600 users in 2030. The peak water demand is expected to increase to about 15,600 million litres per year in 2030 from about 7,444 million litres per year in 2000. This is based on a unit water demand on 635 litres per capita per day (lpcpd).

1.8 District Application for a Community Watershed Designation

The Forest Practices Code allows for water purveyors to apply for a community watershed designation to be placed on their watershed. By having the watershed designated a community watershed, a higher level of management and control is exercised on the forestry operations within that watershed.

When the Forest Practices Code came into effect, a number of community water systems within the Campbell River Forest District were grandparented into the community watershed designation. The District system however, didn't qualify for the designation due to its large area.

Approximately 2 years ago, issues arose that prompted the Ministry of Forest and District of Campbell River to apply for Community watershed status.

- BC Crown Lands proposed a land trade as an exchange for some private land that was desired for a park. This would be in effect privatizing a significant portion of the John Hart Lake watershed
- District of Campbell River had put a greenway designation in the OCP covering a portion of this area.
- Unregulated recreational activities (mountain biking, unregulated camping, dirt biking) on the south side of John Hart Lake were increasing,
- District concerns around the awarding of Small Business Forest Enterprise Program Timber Sales and the issuing of Woodlot Licence cutting permits.

It was decided to apply for a Community watershed designation because it requires a higher standard of practice and allows the MoF to exercise a higher level of control. The process was initiated by the MoF while the District is involved in the application process.

Originally there was a Land Act Reserve placed around John Hart Lake. The MoF took the Land Act Reserve and redrew the boundary for the Community Watershed application. There were concerns that the south half of the application is not in the Provincial forest and therefore, the MoF does not have sufficient control over the activities. However, as long as it is Crown Land, the Forest Practices Code can be applied to all forest activities. The proposed boundaries of the Community Watershed designation are illustrated on Figure 1-4.

The application is currently (January, 2001) at the MoF Regional Manager's level, and once signed at that level, will go to a 60 day public advertising and public consultation period. (M. Di Orio Dunne, pers comm). The public advertisement period concluded April 13, 2001.

2.0 PUBLIC PROCESS

2.1 Overview

The Watershed Management Plan was completed through consultation with a technical and governmental stakeholder committee, which functioned as a project Steering Committee. In addition a more general public process was utilized to seek comments from the broader community. A total of three meetings were held with the Watershed Management Plan Committee (WPC), while two public open houses and presentations occurred at strategic times during the process. In addition to these specific meetings, members of the project team consulted informally and directly with several technical agencies and other stakeholders with the intent of discussing information and issues pertinent to the views and concerns of that organization. Discussions also took place with BC Hydro personnel engaged in the preparation of the water-use planning program associated with BC Hydro installations in the Campbell River area.

2.2 Watershed Planning Committee

A significant element of the watershed management plan was to have early, ongoing, and continuous involvement of the public. Key to this initiative was the creation, by the District of Campbell River, of a Watershed Planning Committee (WPC) representing key stakeholders and concerned members of the public. Composition of the Committee was tailored to represent both technical agencies and First Nations, allowing for an interchange of ideas, and a review of material prepared by the consulting team.

The function of the WPC was to assist as a resource group in the development of the Watershed Management Plan by:

- Providing information to the consultant team
- Identifying issues as they related to the wide variety of watershed stakeholders on the Committee
- Reviewing data collection, analysis and plan development
- Supporting a cooperative effort among stakeholders in the watershed
- Commenting on recommendations with respect to implementation of the Watershed Management Plan

Participants in the WMP provided broad representation of such groups as:

- First Nations
- District of Campbell River staff
- Land use planning advisory groups
- Provincial ministries and agencies
- Federal agencies
- Property owners (e.g. forest companies)
- BC Hydro
- Upper Island/Central Coast Community Health Services Society
- Regional District of Comox - Strathcona (RDCS).

Meetings of the WPC were held on November 14, 2000 to review key planning issues, and the scope of the project; on March 2, 2001 to examine the first draft of the report and to review draft risk analysis material, and on March 30, 2001 to examine additional public input and to make recommendations related to the final report. A complete listing of invited Committee members is incorporated in the Appendix 1.

2.3 B.C. Hydro Water Use Planning Committee

In the last couple of years BC Hydro has undertaken a water use planning program that focuses on water management at BC Hydro installations. The program was in response to

the increasing competing demands placed on the water resources. The goal is to find a balance between competing uses of the water.

In 1999 BC Hydro began a water-use planning program for the Campbell River System. The Water Use Plan (WUP) development is a thirteen step collaborative planning process designed to consider recreation, economic and environmental values. The WUP committee includes various stakeholders including the District. The WUP's plan was focused on developing a strategy to operate the BC Hydro facilities in a manner that recognized the interests of the other stakeholders in the watershed.

The Campbell River System WUP was facilitated by Compass Resource Management. BC Hydro provided access to WUP documentation.

2.4 Public Consultation Open Houses

Public open houses were held on December 7, 2000 and March 29, 2001. The format included an open house with presentation boards attended by District staff and members of the Watershed Planning Committee followed by a brief presentation and answer session lead by the consultant team. Questionnaires were provided at the session for participants to complete. The following summarizes the key issues raised by the attending public.

Meeting Date	Location	Format	Approximate Attendance	Key Issues
December 7, 2000	Sportsplex, Alder Street	Open house 7 pm Presentation 7:30 pm	30	• Is filtration essential or mandatory? • Can water supply be split between potable and non-potable water, as for example in Vernon. • What is the nature of the water supply system? • What is the impact of water metering? • Several issues and corrections were noted with respect to the display maps at the meeting.

Meeting Date	Location	Format	Approximate Attendance	Key Issues
March 29, 2001	Campbell River Downtown Community Centre Lounge	Open House and Meeting: 5 – 9 pm, Presentation made at 7 pm.	Approximately 35-40	• Has risk analysis been used before? • Should risk analysis not allow for an increase in risk scoring as we move closer to water areas? • Ownership should be identified in all risk zones. • Emergency plans need to be identified and established in the event of a problem. • How have First Nations been represented? • Notification to owners an issue with regard to field trip. • Have lake septic tanks been tested? • Questions raised about proposed second water intake at McIvor lake • Are there alternatives to recreation at McIvor Lake

3.0 DEFINITION OF TERMS

This chapter provides a summary of terms and definitions used throughout this report.

Anadromous	Fish or species that spend a portion of their life in salt water and in fresh water.
Barrier	The strip of land between big bay on Campbell Lake and the western end of John Hart Lake.
Blue List	Species and ecosystems at risk have been identified through the cooperation of scientists and experts throughout the province, and each has been assigned a global and provincial rank. The "Blue List" includes vulnerable indigenous species or subspecies (taxa) that are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. It also includes species that are generally suspected of being vulnerable, but for which information is too limited to allow designation in another category.
Bathymetry	Mapping the contours of ocean floors or lake beds.
Consequence	Circumstance which follows as an effect or result from something preceding.
Diversions	BC Hydro has dammed creeks outside the main Campbell River drainage and diverted a portion of the flow to provide additional water to the John Hart generating facilities.
ECA	Equivalent clear-cut area – the area that has been harvested, cleared or burned, with consideration given to the silviculture system, regeneration

	growth and location within the watershed.
Fecal coliforms	A sub group of total coliform bacteria that are distinguished in laboratory tests at elevated temperatures. The fecal coliform is of fecal origin. It is used as an indicator organism for potential waterborne disease risk.
Freshet	High water levels that occur in the spring during snow melt
Fission	Type of asexual reproduction characterized by division of the body into two or more.
Gazetted	A term that shows that a stream or other land feature has officially been named and identified in government records
Haloacetic Acid	A sub group of trihalomethane compounds formed by the reaction of chlorine with naturally accompanying organic compounds. They are known to be carcinogenic in certain circumstances.
Hazard	In determining risk, the hazard is the likelihood of an event happening, and for this analysis includes probability, size and time duration.
Heterotrophic bacteria	Is used as an indicator of the microbiological risk associated with drinking water. It measures a broad group of bacteria and the significance lies in its indication of poor general biological quality of the drinking water.
Hypolimnetic oxygen Depletion	The bottom layer of water (the hypoliminion), because it is cold, tends to not mix with warmer surface water (the epilimnion), and therefore has no opportunity for oxygen replenishment from the atmosphere.
Legionealla	Bacteria that can be found in thermally enriched waters and can cause acute respiratory illness.
Log Scaling	The measuring of harvested logs to determine the volume. Used to calculate the value to the Crown in stumpage payments.
NTU	The unit of turbidity measured in nephelometric turbidity units.

Oligotrophic	Nutrient-poor and oxygen rich, containing relatively little plant life and nutrients in its waters but rich in dissolved oxygen.
Oocysts	Resistant cells that are one part of the life cycle of the cryptosporidium organism.
Peak Flows	The highest amount of stream or river flow occurring in a year or from a single storm event.
Penstock	Pipelines used to convey water between the source water body and a power generation facility.
Periphyton	Aquatic plants and animals that live attached to rocks and other submerged objects.
Pesticide	A term that is used to group chemicals that attack pests, such as insecticides, herbicides or fungicides
Phytoplankton	The plant members of the plankton.
Radionuclides	Radionuclides are radioactive atoms that break down to release energy (radioactivity).
Rate of Cut	The yearly level of logging that can occur. It is calculated by the landowner for private land, or is determined by the Chief Forester on public land.
Red List	Species and ecosystems at risk have been identified through the cooperation of scientists and experts throughout the province, and each has been assigned a global and provincial rank. The "Red List" includes indigenous species or subspecies (taxa) that are either extirpated, endangered, threatened, or are candidates for such status. Extirpated Taxa no longer exist in the wild in B.C., but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. One red-listed species is the Vancouver Island

	Marmot.
Riffle	A shallow set of rapids in a stream where water flow swiftly over completely or partially submerged obstructions to produce surface disturbances, but where standing waves are absent.
Risk	Risk is the product of hazard and consequence as is determined for water quality. Risk can also be determined for other resources or values.
Root Rot	Species of fungus that live on the roots of trees. The fungus is endemic in most forests, but can kill individual trees when the trees are stressed.
Sediment	Soil particles in the water, primarily silts and clays held in suspension.
Slash	Debris, such as branches, limbs and tops, left after logging has been completed.
Stream Order	A method of classifying streams where the smallest streams on the hillside are designated as the first order, and order increases when streams join.
Suspended solids	Solids in drinking water that are retained on a 0.45 micron filter. Measure of particulate matter in drinking water.
Total coliforms	An indicator group of organisms mostly of intestinal origin used to appraise the microbiological risk to drinking water. It includes E. Coli.
Trihalomethanes	Halogen – substituted single carbon compounds formed in drinking water as result of chlorination of organic supplement matter present in raw water. They are known to be carcinogenic in certain circumstances.
Trophozoite	Mobile cell that is one part of the life cycle of the giardia organism.
Turbidity	Turbidity measurement relates to the optical property of water that causes light to be scattered and absorbed rather than transmitted in a straight line through water sample. It is a measure of the suspended matter in water.

µg/l	Micro grams per liter.
Unregulated Camping	Camping in sites not managed by the Ministry of Forest, Ministry of Environment Lands and Parks – Parks Branch or private operators.
Zooplankton	The animal members of the plankton.

4.0 BACKGROUND

This Chapter provides an overview of the activities carried out within the Campbell River watershed. Figure 4-1 highlights the location of key features described further in this chapter and photographs 1 to 24 which show various areas of the watershed are included at the end of this chapter.

4.1 Watershed Activity

4.1.1 Forestry

Logging has been a constant activity in the vicinity of the Campbell River system since the 1880's. Initially timber was harvested for the shipbuilding industry and for export. Logging was done using ground skidding methods such as oxen and horses. Over time, the use of steam donkeys began to take place, along with the use of small railway lines to move the logs. The logging practices of the era, were to only take the valuable Douglas fir and Western Red cedar logs and leave other species and low grade material. The logging left a very high level of slash in the bush, which became an extreme fire hazard.

In 1938, a huge forest fire occurred in the Sayward Forest, which include the lower portion of the Campbell River Watershed.

On the southern portion of the watershed, the land was located within the Esquimalt and Nanaimo Railway belt, a parcel of land which includes a significant portion of eastern Vancouver Island. This land was granted as an incentive to the construction of a railway from Victoria to Campbell River. Over time, the ownership of this land has changed hands several times, and is currently owned by TimberWest.

Virtually every aspect of Timber West operations is certified under ISO 14001 including logging operations, dry land sorts, shipping facilities and lumber mills. This certification is a verification of an Environmental Management System that is set up to ensure that all aspects of environmental protection are taken into account within their operations.

Timber West is also certified under the Sustainable Forestry Initiative by the American Forest & Paper Association for all their private forestland operations. This certification is a set of eleven sustainable forestry objectives developed by professional foresters, conservationists, scientists, landowners, and academicians. Its stated purpose is "Managing forests to meet the needs of the present without compromising the ability of future generations to meet their own needs by practicing a sustainable land stewardship ethic". It is based on having ISO 14001 certification.

4.1.2 Mining

Background

The area around the Campbell River watershed is fairly rich in mineralization. A lot of exploration work has been carried out over time in the area. Five mines have been developed in the watershed or diversion watersheds.

The earliest record found for an active mine is for the Big G mine located on Greenstone Creek. This mine was operating in the mid to late 1910's. It was a relatively small operation, having mined under 100 tonnes of ore. Minerals recovered were copper, silver and gold.

The Buttle Lake mine, classified as a past producer, was a limestone mine located on the east side of Buttle Lake, about 22 km south of the Gold River Road bridge. This was a small quarry located on the side of the lake. The mine operated in the early 1970's.

Myra Falls

Myra Falls operation is a base metal mine located near the south end of Buttle Lake within Strathcona Park. The Myra Falls operation began in 1972 under control of Westmin Resources with the present owner being Boliden. The operation currently consists of two mines (the Battle and H-W) and the Myra Falls mining operation. The original Myra Falls mine was depleted in 1985. A fourth mine, the Price deposit has yet to be worked. The Myra Falls operation is located at the south end of Buttle Lake and is located within Strathcona Park. Minerals produced at this mine include gold, silver, copper, lead, zinc and cadmium.

The mine access is by a 90 kilometer highway from Campbell River. The operation produces about 3650 tonnes of ore per day. The proven reserves are adequate to continue mining for ten years with exploration continuing to increase the ore reserves. The operation includes an active underground mine, three inactive underground and one inactive open pit mines, a concentrating plant, hydro electric facilities, camp and office facilities and a tailings management system with water treatment facilities.

The electrical power to meet the mine power needs is through on-site hydro and diesel generation systems. Usually about 90% of the electrical energy needs are met through hydro and 10% met by diesel.

Boliden holds a number of Provincial Government regulatory permits as follows:

Permit	Permit Number	Description
Ministry of Energy and Mines	M26	Mine Operating and Mine Reclamation Permit.
BC Parks- Parks Use Permit	ST9710029	Thelwood Creek Power Development and Generation
	ST9710035	Main Permit for Mining
	ST9710036	Tennent Lake Power Development and Generation
Ministry of Environment Lands and Parks	PE6858	Tailings Management and Water Treatment Systems. An annual report is required by March 31 of each year.
	PA2408	Air Emissions
	PR2561	Refuse Permit
Ministry of Environment Lands and Parks- Water Management Branch	Numerous licenses	Water Diversion and power generation.
Ministry of Health	Premise Number 1440494	Operation of a Drinking Water Supply System.

Ministry of Energy and Mines-Permit M26 - This permit identifies conditions and requirements for operating a mine generally as follows:

- A mine site reclamation plan is required including the waste dumps and open pit areas. The plan is to be updated by Boliden in 2002.
- A re-vegetation plan,
- Stabilzation of watercourses through the site,
- Access road reclamation,
- Methods to control, monitor and remediate acid generating materials,
- After-effects environmental monitoring to ensure reclamation objectives are met,
- Post a reclamation bond, currently about $10M.

Ministry of Environment Lands and Parks, Effluent Waste Discharge - This permit identifies the effluent discharge criteria from the mine site to the environment including scheduled water quality monitoring. The primary Ministry water sample locations are

Myra Creek upstream of the mine site, Myra Creek downstream of the mine site and from the outfall of the polishing ponds. Water quality monitoring is required from Buttle Lake at Karst and Henshaw Creeks and Gold River Bridge. The mine operator also monitors the water quality in the Upper Campbell Lake, John Hart Lake and the Campbell River system. All water quality results are submitted to the Ministry.

The effluent permit has three subsections generally differentiated by different discharges.

.1 This subsection applies to the discharge of refuse from a copper-zinc milling operation, water treatment ponds and two sewage treatment plants.

.2 The authorized rates of discharge are a daily maximum of 8 000 m^3/d and an annual average of 4 250 m^3/d.

.3 The characteristics of the discharge shall be equivalent to or better than typical thickened mill tailings slurry, typical paste tailings and tailings sand, typical solids from water treatment ponds and domestic type sewage treatment plant sludge.

.4 The authorized works are:

a) for thickened mill tailings slurry; a tailings thickener, tailings impoundment structures referred to as Areas 1 and 2 (also to be used for the discharge of domestic type sewage treatment plant sludge), related distribution piping, decant system, sloping filter, inner drain, outer drain, vertical drains, spillways, pump stations and related appurtenances.

b) for typical paste tailings; a paste tailings plant, Lynx pit paste tailings impoundment structure referred to as Location 1, related distribution piping, and tailings sand storage cells referred to as locations 2 and 3, and related appurtenances.

.5 This subsection authorizes effluent discharges to Myra Creek. It applies to the discharge of effluent from the Lynx open pit mine drainage, tailings impoundment area subsurface and surface collection systems, Myra mine drainage, HW mine drainage, HW mine treated domestic type sewage treatment plant effluent, Lynx mine drainage, mill yard drainage, diesel generator cooling water, tailings thickener overflow, paste tailings plant overflow, paste tailings and tailings sand deposition area drainage and Lynx mine treated domestic type sewage treatment plant effluent.

.6 The authorized rates of discharge are a daily maximum of 110,000 m^3/d and an annual average of 48,000 m^3/d. The Regional Waste Manager may allow an effluent discharge in excess of 110 000 m^3/d during heavy rainfall events. The permitted shall notify the Regional Waste Manager if a discharge in excess of 110,000 m^3/d is anticipated.

.7 The characteristics of the discharge shall not exceed:

Total Suspended Solids	25 mg/L*
PH	<11
Total Cu	0.60 mg/L
Dissolved Cu	0.20 mg/L
Total Zn (maximum)	1.0 mg/L
Dissolved Zn	0.50 mg/L
Dissolved Cd	0.005 mg/L
Dissolved Pb	0.05 mg/L
Toxicity	(96 hr LC50) 100%

*A total suspended solids level of up to 50 mg/L may be allowed by written authorization of the Regional Waste Manager for authorized discharges in excess of 110 000 m^3/d.

The characteristics of the domestic type sewage treatment plant effluent at the sampling points identified as Myra STP and HW STP shall not exceed:

5 day Biochemical Oxygen Demand	45 mg/L
Total Suspended Solids	60 mg/L

.8 The works authorized are a lime addition system, CO2 addition system, Superpond, Myra and Lynx settling ponds, surface and subsurface water collection and drainage systems, integrated recycle system, two sewage treatment plants for domestic type effluent, and related appurtenances.

.9 A final subsection applies to the discharge of effluent from Price mine drainage system.

.10 The authorized rates of discharge are a daily maximum of 5,400 m^3/d and an annual average of 3,450 m^3/d.

.11 The characteristics of the discharge as measured at the east side of Price Pond #1 shall not exceed:

Total Suspended Solids	25 mg/L
pH	6.5 - 8.5
Total Cu	0.60 mg/L
Dissolved Cu	0.20 mg/L
Total Zn	1.0 mg/L
Dissolved Zn	0.50 mg/L
Dissolved Cd	0.005 mg/L
Dissolved Pb	0.05 mg/L

.12 The works authorized are a drainage ditch, two infiltration ponds and related appurtenances.

.13 The works authorized must be complete and in operation on and from the date of this amended permit.

Air Emissions Permit- The air permit is for discharge of dust and other contaminants.

Refuse Permit- The refuse permit is for the discharge of up to 1,440 m^3/year of non-putrescible refuse to a landfill at the minesite.

Quinsam

In the Quinsam watershed above the diversion, there are two mines, Quinsam Coal and the Argonaut. Quinsam Coal is located at the north end of Middle Quinsam Lake. The deposits consist of high volatile bituminous coal, with some kaolin and fireclay. Quinsam Coal is currently owned by Hillborough Resources and is an operating producer. The Argonaut Mine is located on the east side of Upper Quinsam Lake. The mine operated from 1951 to 1957, and produced iron, limestone, garnet and magnetite. The tailings and waste pile contain fine grained magnetite and garnet and a proposal is underway to recover these minerals for industrial uses.

4.1.3 British Columbia Assets and Land Corporation

BC Assets and Land Corporation is a crown company that provides land and asset marketing and land management services for the government of British Columbia. The government established the company as W.L.C. Developments Ltd. in 1982 to sell Crown Land in the Whistler area. In 1997 the provincial government expanded the role of the company to sell Crown lands throughout British Columbia. In 1998 the company was renamed British Columbia Assets and Land Corporation (BCAL), and was assigned the additional responsibility of selling government assets such as vehicle fleets and information systems.

In October 1998 the province assigned BCAL another major responsibility: managing tenures on provincial Crown Land. These tenures range from recreational properties to commercial ski resorts.

There are forty eight active BCAL permits in the watershed for activity on Crown Land as summarized on Table 4-1. This list was compiled from information and files provided by BCAL Nanaimo.

4.1.4 Urban

There is little development of urban-type land uses within the watershed study area. For the most part, development within the study area is limited to residential and recreational properties:

- a lakeshore ring of single family development on McIvor Lake within the District of Campbell River,
- the Strathcona Park Lodge tourist accommodation facility, and
- a small pocket of recreational cottages adjacent to the lodge on Upper Campbell Lake, within the Regional District of Comox - Strathcona.

The water source is typically surface water while sewage treatment and disposal is an on-site septic tank and ground disposal through a tile field. There are no licensed or known outfalls discharging treated sewage into the water courses. The Upper Island-Central Coast Community Health Services Society has the regulatory authority to approve, inspect and manage the on-site systems with flows of less than 22,700 L/d. The society was not able to easily provide a summary of the number of permits issued for on-site systems and the age of the installations. The Ministry of Environment Lands and Parks have responsibility to permit sewage treatment system treating greater than 22,700 L/d. The Ministry could not provide a summary of waste discharge permits issued.

4.1.5 Recreation

There are several types of recreation undertaken in the watershed.

Formal

- Ministry of Forest recreation sites
- BC Parks Sites
- Strathcona Park
- Strathcona Lodge
- Municipal and Regional Parks

Informal

The area offers abundant recreational opportunities. Area features include: camping, picnicing, hiking, swimming, boating, canoeing, and mountain biking. Recreational resources are operated by several government organizations including: BC Hydro, BC Parks, the Ministry of Forests, and the District of Campbell River (at McIvor Lake).

BC Park sites predominate in the study area and include the Provincial Parks of: Strathcona, Strathcona-Myra, Elk Falls, Loveland Lake. Various activities are offered in these park locations including overnight camping. The Ministry of Forests also operates campsites which are dotted throughout the study area. Some BC Forest Service camping locations also offer boat launch facilities and day use picnic sites. Camping at Strathcona Dam is provided by BC Hydro.

4.1.6 BC Hydro

BC Hydro currently has 3 dams and power generating stations located all within the watershed, and has three diversions which bring water from other watersheds into the Campbell River watershed.

The dams/power stations are:

- John Hart, which is located at the west end of John Hart Lake. The generating station is located about 1.5 km downstream, with the water being piped to the generating

station through three wood stave penstock pipes. The initial construction began in 1945 and was completed in 1953. The generating station produces 126 MW. The reservoir, John Hart Lake, contains no significant storage, and the regulation of flows into John Hart Lake is controlled by the Ladore Dam.

- The Ladore Dam is located at the bottom end of Lower Campbell Lake. The generating station is located about 2 km downstream from the dam and was constructed from 1955 to 1958. The generating station produces 54 MW.
- The Strathcona Dam and generating station is located at the lower end of Upper Campbell Lake and was constructed between 1955 and 1958. The generating station produces 67.5 KW

4.1.6.1 Water Diversions

The diversions are:

- Salmon River – the diversion facilities consist of a timber crib dam, concrete-lined canal, unlined rock cut and a wooden flume. Water is diverted a distance of over 16 km into Lower Campbell Lake via Brewster Lake, Gray Lake and Fry Lake chain.
- Quinsam River – the diversion and storage facilities consist of a 2.4 m high concrete dam at the outlet of Upper Quinsam Lake, a 12 m concrete diversion dam about 5 km downstream on the Quinsam River and a 1.6 km canal draining into Gooseneck Lake and Miller Creek and finally into Lower Campbell Lake.
- Heber/Crest Creek – the Heber River diversion facilities consist of a 10 m high timber crib dam and a 3.6 km woodstave pipeline to Crest Lake.

4.1.7 Roads

The Campbell River system has many miles of both public and private roads. The Ministry of Transportation and Highways has jurisdiction of the public roads. Boliden is responsible for snow removal on the 37 Km of road from the Gold River turn-off to the Myra Falls mine site along the east side of Buttle Lake.

4.2 Land Ownership Summary

The total watershed area including the diversion is estimated as 1,822 km^2 of which 1464.3 km^2 is in the Campbell River system, 61.2 km^2 in the Quinsam River system, 265.0 km^2 in the Salmon River system and 31.8 km^2 in the Crest Heber system.

The principal land ownership within the Campbell River system rests with the Provincial Government, TimberWest and B.C. Hydro. There is a very minor area under private ownership and it is concentrated in the foreshore around McIvor and John Hart Lakes.

The following Figures 4-2 and 4-3 provide approximate land ownership boundaries within the watershed with the Lower Campbell Lake area illustrated on Figure 4-2 and the remainder of the watershed on Figure 4-3. A breakdown of the land ownership is summarized on Table 4-2.

In summary, approximately 20 percent of the total watershed land is Crown owned in Provincial Forest, approximately 60 percent of the total watershed is Crown owned in Provincial Park and less than 0.5% is Crown owned managed by BCAL. Approximately 12 percent of the total watershed is owned by TimberWest, approximately 1.5% of the total watershed is owned by Hancock and approximately 0.06% is owned by B.C. Hydro. The remainder (0.5%) is privately held.

Table 4-2 Summary of Land Ownership Within Watershed				
Watershed		**Ha**	**% of Individual W/S**	**% of Total Watershed**
Crest-Heber	**Total Area:**	**3,177**	**100.00**	**1.74**
	Provincial Park	864	27.20	0.47
	Provincial Forest	2,313	72.80	1.27
Salmon	**Total Area:**	**26,513**	**100.00**	**14.55**
	Provincial Park	10,466	39.47	5.74
	Provincial Forest	16,047	60.53	8.81
Quinsam	**Total Area:**	**6,120**	**100.00**	**3.36**
	Lakes	569	9.30	0.31
	Hancock-Private Land	329	5.37	0.18
	Timber West-Private Land	5,223	85.33	2.87
Campbell River	**Total Area**	**146,430**	**100.00**	**80.35**
	BC Hydro	104	0.07	0.06
	Crown land within DCR Municipal Boundary – Managed by BCAL	987	0.67	0.54
	Hancock-Private Land	2,484	1.70	1.36
	Lakes	10.178	6.95	5.59
	Unknown Ownership outside DCR Municipal Boundary	333	0.23	0.18
	Other Private Land Outside DCR Municipal Boundary	40	0.03	0.02
	Provincial Park	97,404	66.52	53.45
	Private Land within DCR Municipal Boundary	219	0.15	0.12
	Provincial forest	17,784	12.15	9.76
	Timber West – Private Land	16,899	11.54	9.27

Total Area **182,240**

Notes: Provincial Forest – Crown Land managed by the Ministry of Forests
Provincial Park – Class A and Class B Provincial parks managed by Ministry of Environment Lands and Parks
Hancock and TimberWest Private Land – Owned in Fee Simple – Located within Forest Land Reserve
BC Hydro – All land owned or leased to BC Hydro
Lakes – Only includes Buttle, Upper Campbell, Campbell, John Hart, Brewster and Upper Quinsam Lakes
Private Land outside the DCR Municipal Boundary is primarily residential lots and Strathcona Lode
Unknown ownership – not stated on maps.

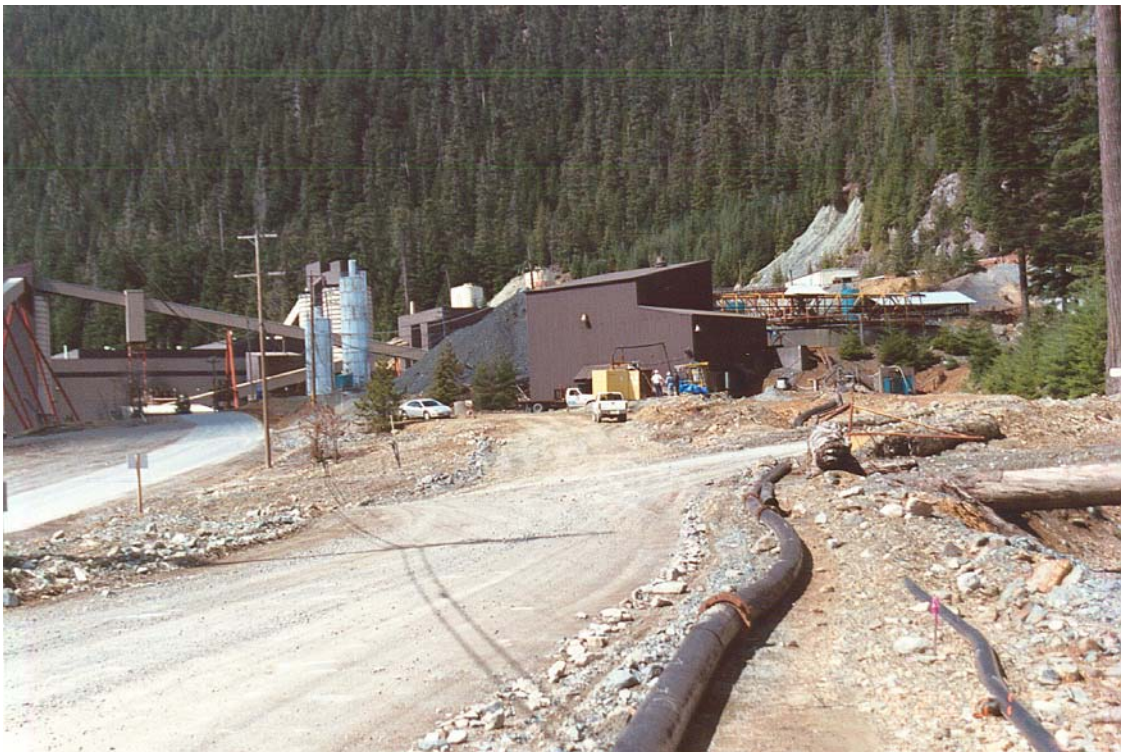


Photo 1 – Boliden Myra Falls Operation – Lynx pipe site mill

Photo 2 – Boliden Myra Falls Operation – Tailings ponds. Under permit with the Ministry of Environment Lands and Parks, the water is treated by lime addition and settling prior to discharge to Myra Creek

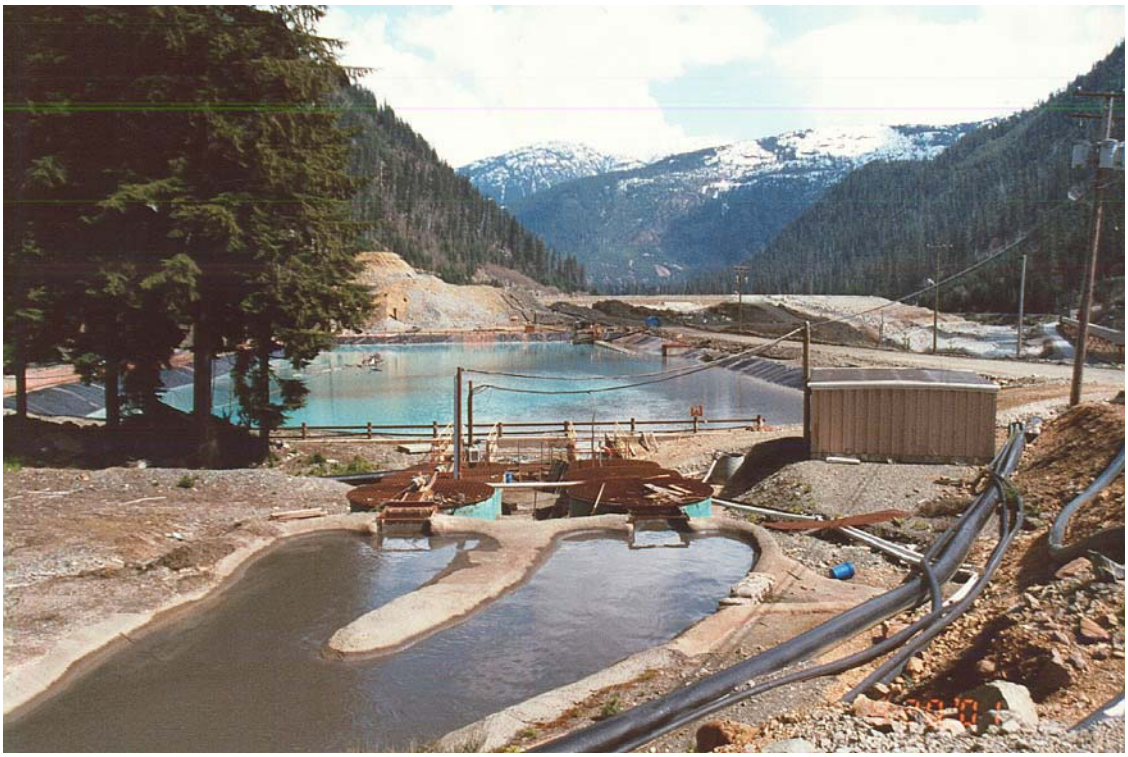


Photo 3 – Boliden Myra Falls operation – Mine drainage and tailings ponds water treatment and super pond

Photo 4 – Boliden Myra Falls – Six Myra solids settling and polishing ponds

Photo 5 – McIvor Lake and recreation area and beach

Photo 6 – Lower Campbell Lake with exposed foreshore area with a low water level

Photo 7 – Informal camping site on lower Campbell Lake

Photo 8 - Recently harvested site under Ministry of Forests woodlot license program

Photo 9 - Recent Ministry of Forests road construction and reseeding prior to harvesting under small Business Forest Enterprise Program

Photo 10 - Demolition storage in the watershed

Photo 11 - Rock crushing operation in the watershed

Photo 12 - Rock crushing operation in the watershed

Photo 13 - Slope failure of unknown origin reseeded by landowner

Photo 14 - Road construction for timber harvesting

Photo 15 – Brewster Lake

Photo 16 – Elk River Estuary

Photo 17 – Household garbage illegally dumped in the watershed

Photo 18 – Household garbage illegally dumped in the watershed

Photo 19 – John Hart Lake

Photo 20 – McIvor Park and recreational area

Photo 21 – Ladore Dam

Photo 22 – Crown Land trespass and illegal occupation

Photo 23 – Upper Campbell Lake

Photo 24 – Upper Campbell Lake at low level

5.0 SURFACE WATER RESOURCES

The District has two intakes drawing water from John Hart Lake. The main water intake is off the B.C. Hydro penstocks below the John Hart Dam while there is a second intake in the lake providing water to the Industrial Park system. The tributary watershed includes the Campbell River watershed above the John Hart Dam. In addition B.C. Hydro diverts water from the watersheds of the Salmon River, Quinsam River and Heber/Crest Creeks into the Campbell River Watershed. The chapter provides an overview of the surface water resources.

5.1 Watershed Description

The Campbell River watershed has an area of approximately 1,460 km^2 and is comprised of 1059 lakes and streams of which 67 lakes and 38 streams are gazetted. The watershed flows in a northeast direction to discharge into the Pacific Ocean near Campbell River and ranges in elevation from sea level to approximately 2200 m. The major water bodies in the Campbell River watershed are Buttle, Campbell, Brewster, Upper Quinsam and John Hart lakes.

The Ministry of Environment, Lands and Parks (MELP) Lake Query Database contains biophysical data for 64 of the lakes in the Campbell River watershed. This information is summarized in Table 5-1. Available bathymetry for 23 lakes in the Campbell River watershed is presented in Appendix A.

TABLE 5-1
LAKE BIOPHYSICAL CHARACTERISTICS
(ADAPTED FROM MELP LAKE QUERY DATABASE)

Lake	Surface Area (ha)	Littoral Area (ha)	Perimeter (m)	Volume (m^3)	Mean Depth (m)	Maximum Depth (m)
Andrew Lake	6.7	-	1141	-	-	-
Arnica Lake	1.3	-	583	-	-	-
Bacon Lake	22.7	-	2432	-	-	-
Beadnell Lake	25.7	-	2806	-	-	-
Beavertail Lake	102.9	32.0	5840	11161000	10.8	28.0
Becher Lake	17.3	-	1869	-	-	-
Boot Lake	92.2	62.7	5913	11003700	11.9	32.0
Brewster Lake	593.3	24.8	16169	189811911	24.5	56.4
Buttle Lake	3094.8	-	74350	1897440000	61.3	120.7
Camp Lake	24.5	18.4	2466	1033630.5	4.2	13.9
Campbell Lake	2693.6	-	89155	458784000	17.1	75.6
Carwithen Lake	22.5	-	2509	-	-	-
Charity Lake	21.2	-	1981	-	-	-
Copper Bush Lake	22.8	-	2328	-	-	-
Cream Lake	15.1	-	1595	-	-	-
Darkis Lake	11.0	11.0	1750	315000	2.9	5.0
Delight Lake	19.8	-	2334	-	-	-
Echo Lake	24.4	10.8	2760	1410000	5.8	14.0
Flume Lake	5.3	4.2	1090	179800	3.4	9.0
Fry Lake	78.1	54.7	9000	-	-	-
Gentian Lake	20.7	-	2904	-	-	-
Gilson Lake	10.8	-	1423	-	-	-
Globe Flower Lake	3.0	-	700	-	-	-
Gooseneck Lake	78.0	6.8	5120	7629980	9.8	38.0
Gosling Lake	62.5	28.1	6400	5000	8.0	40.0
Gray Lake	62.5	10.6	5100	-	-	-
Greenview Lake	26.7	-	2950	-	-	-
Greig Lake	12.4	-	2146	-	-	-
Hawarth Lake	3.8	-	780	-	-	-
Hellebore Lake	8.2	-	1123	-	-	-
Higgins Lake	9.1	-	1637	-	-	-
Hope Lake	8.8	-	1220	-	-	-
Ink Lake	47.9	-	3169	-	-	-
Jim Mitchell Lake	16.2	3.8	2292.5	2735850	24.1	37.9
John Hart Lake	362.6	-	27841	43046400	12.2	22.9
Landslide Lake	26.4	-	1974	-	-	-
Lawson Lake	19.7	-	2176	-	-	-
Limestone Lake	2.4	-	593	-	-	-
Lost Lake	7.3	-	1201	-	-	-
Lower Drum Lake	16.5	4.0	1966	1974821	11.5	24.1
Lukwa Lake	8.0	-	1440	-	-	-

Lake	Surface Area (ha)	Littoral Area (ha)	Perimeter (m)	Volume (m^3)	Mean Depth (m)	Maximum Depth (m)
Marblerock Lake	2.1	-	633	-	-	-
Marsh Marigold Lake	8.9	-	1184	-	-	-
McIvor Lake	123.0	20.9	8500	20800000	16.9	45.5
McNish Lake	14.6	-	1660	-	-	-
Merrill Lake	68.0	25.6	3820	3903332	11.1	29.0
Mia Lake	16.5	-	2331	-	-	-
Middle Quinsam Lake	70.8	-	6584	2824674	4.0	14.6
Milla Lake	66.0	-	4533	-	-	-
Mirror Lake	14.9	6.8	2200	1000000	6.7	16.0
Quinsam Lake	117.4	-	8717	9066093	7.6	21.6
Ralph Lake	16.7	-	2219	-	-	-
Raven Lake	11.7	5.4	1690	791000	6.7	19.5
Reginald Lake	32.3	-	3849	-	-	-
Schjelderup Lake	42.9	-	2584	-	-	-
Snakehead Lake	20.2	15.8	2400	705000	3.5	9.0
Thelwood Lake	34.3	-	6430	3066550	17.8	25.2
Tlools Lake	9.2	-	1384	-	-	-
Upper Campbell Lake	631.9		21726	84110400.0	12.2	39.6
Upper Drum Lake	9.5	4.9	1303.5	456818	4.8	11.6
Upper Quinsam Lake	472.9	-	17850	59393957	12.6	36.0
Upper Thelwood Lake	39.2	-	4258	-	-	-
Volcano Lake	86.6	-	3769	-	-	-
Whymper Lake	10.8	10.7	1438	-	-	-
Wokas Lake	60.8	40.7	4300	8520909	14.0	34.0

5.1.1 Buttle Lake

Buttle Lake is the largest waterbody in the Campbell River watershed. It has a surface area of 3,095 ha and a total volume of 1,897,440,000 m^3. It has a maximum and average depth of 120.7 m and 61.3 m, respectively. Major inlets to Buttle Lake include:

- Myra Creek
- Thelwood Creek
- Price Creek
- Henshaw Creek

- Shepherd Creek
- Ralph River
- Wolf River
- Phillips Creek
- Myra Creek
- Marblerock Creek

Buttle Lake has one outlet (Campbell River) which flows into Upper Campbell Lake. Campbell Lake has a surface area of 2,694 ha and a total volume of 458,784,000 m^3. It has a maximum and average depth of 75.6 m and 17.1 m, respectively. Major inlets to Campbell Lake include Elk River, Tlools Creek, Ranald Creek, Greenstone Creek and Beavertail Creek.

5.1.2 Upper and Lower Campbell Lakes

Upper Campbell Lake has a surface area of 631.9 ha and a volume of 84,110,400 m^3. Its perimeter is 21,726 m. It has a maximum and average depth of 39.6 m and 12.2 m, respectively. Upper Campbell Lake has one permanent outlet, Campbell River, which flows into Campbell River (also known as Lower Campbell Lake). Major inlets include Campbell River, which flows from Buttle Lake, and Elk River.

Campbell Lake has a surface area and a volume of 2,693.6 ha and 458,784,000 m^3, respectively. Its perimeter is 89,155 m. Its maximum and average recorded depths are 75.6 m and 17.1 m, respectively. It has one outlet (Campbell River) and flows into John Hart Lake. Major inlets include Beavertail Creek, Campbell River, Greenstone Creek and an unmanned watercourse which discharges from McIvor Lake. McIvor Lake has a surface area of 123 ha and a volume of 20,800,000 m^3. Its shoal area and perimeter are 20.9 ha and 8,500 m, respectively. Maximum and average measured depths in McIvor Lake are 45.5 m and 16.9 m, respectively.

5.1.3 Brewster Lake

Brewster Lake has a surface area and volume of 593.3 ha and 189,811,911 m^3, respectively. It has a maximum and average depth of 56.4 m and 24.5 m, respectively. Brewster Lake has three permanent inlets (all unnamed) and one outlet and flows south into Gray Lake and eventually into Campbell Lake via Fry Lake.

5.1.4 Upper Quinsam Lake

Upper Quinsam Lake has a surface area of 473 ha and a surface area of 59,393,957 m^3. The maximum and average depths for Upper Quinsam Lake are 36.0 m and 12.6 m, respectively. Major inlets to Upper Quinsam Lake include Hawkins Creek, Sihun Creek and Mine Creek. Upper Quinsam Lake drains north to Wokas Lake via Quinsam River.

5.1.5 John Hart Lake

John Hart Lake has a surface area of 363 ha and a volume of 43,046,400 m^3. The maximum and average depths for John Hart Lake are 22.9 m and 12.2 m, respectively. It has one major inlet, Campbell River, and two outlets due to damming.

5.1.6 Campbell River

The major watercourses in the Campbell River watershed include the Campbell River mainstem, Quinsam River, Elk River and Wolf River. A summary of biophysical characteristics of Campbell River watercourses is presented in Table 5-2.

TABLE 5-2
BIOPHYSICAL CHARACTERISTICS OF
CAMPBELL RIVER WATERCOURSES
(ADAPTED FROM MELP STREAM QUERY DATABASE)

Stream Name	Length (km)	Stream Order	Stream Magnitude
Campbell River	14.54	6	748
Elk River	27.21	5	132
Quinsam River	42.01	4	106
Wolf River	22.43	4	87
Thelwood Creek	13.81	4	53
Myra Creek	14.74	4	38
Ralph River	9.26	4	37
Phillips Creek	12.08	4	35
Tlools Creek	10.59	4	31
Cervus Creek	16.13	4	28
Iron River	16.65	3	25
Henshaw Creek	13.47	3	21
Shepherd Creek	14.11	3	17
Butterwort Creek	6.91	2	14
Price Creek	8.05	3	14
Idsardi Creek	5.86	3	11
Marblerock Creek	6.2	3	10
Filberg Creek	8.6	3	9
Sihun Creek	9.99	3	9
Siokum Creek	3.61	2	7
Nikie Creek	3.08	3	6
Tennent Creek	3.53	3	6
Carwithen Creek	2.46	2	4
Hawkins Creek	6.67	2	4
Ranald Creek	11.02	2	4
Arnica Creek	3.18	2	3
Chute Creek	9.98	2	3
Flintoff Creek	4.3	2	3
Greenstone Creek	13.54	2	3
Mia Creek	4.37	2	2
Mine Creek	4.38	2	2
Volcano Creek	2.68	2	2
Balsam Creek	7.94	1	1
Cream Creek	1.09	1	1
East Tennent Creek	1.08	1	1
Moh Creek	1.48	1	1

The Campbell River mainstem has a total length of 14.54 km and is a sixth order stream. It flows north and then northeast and discharges into the Pacific Ocean. The major tributaries of Campbell River are Elk River, Quinsam River, Wolf River, Thelwood Creek, Myra Creek and Ralph River. A flowchart of the Campbell River watershed is presented in Figure 5-1.

5.1.7 Elk River

Elk River is a fifth order stream, has a total length of 27.21 km and flows east into Upper Campbell Lake. Tributaries to Elk River include Butterwort Creek, Filberg Creek, Idsardi Creek, Cervus Creek and Volcano Creek.

5.1.8 Quinsam River

Quinsam River is a fourth order stream, has a total length of 42.01 km and flows north northeast to confluence with Campbell River approximately 4 km upstream of the Pacific Ocean. Major tributaries to Quinsam River include Flintoff Creek, Hawkins Creek, Iron River, Sihun Creek and Mine Creek.

5.1.9 Wolf River

Wolf River is a fourth order stream and has a total length of 22.43 km. It flows north northeast into the north end of Buttle Lake.

5.1.10 Thelwood Creek

Thelwood Creek is a fourth order stream and has a total length of 13.81 km. It flows east northeast into the south end of Buttle Lake. Tributaries to Thelwood Creek include Carwithen Creek, Price Creek and Cream Creek.

5.1.11 Myra Creek

Myra Creek is a fourth order stream and has a total length of 14.74 km. It flows east into southern Buttle Lake. Tributaries to Myra Creek include Arnica Creek, Tennent Creek and East Tennent Creek. Ralph River is a fourth order stream and has a total length of 9.26 km. It flows west southwest into Buttle Lake. Tributaries include Shepherd and Siokum creeks.

5.2 Hydrology of the Campbell River Watershed

Historical Streamflow Summary data (Environment Canada, 1991) for the Campbell River watershed is available for three sites; on the Campbell River below the Quinsam River confluence (near the City of Campbell River), on the Campbell River mainstem at the outlet of Campbell Lake, and on Quinsam River immediately above the confluence with Campbell River. Average, maximum and minimum monthly flows for the period of record are presented in Table 5-3. Maximum flows occur in Campbell River in November, December and January with the maximum average monthly flow on record (1949 to 1970) of 279 m^3/sec (January 1968). The maximum daily discharge for the period of record is 799 m^3/sec, which occurred on November 15, 1953. Minimum flows occur in July, August and September. The minimum average monthly flow on record was 23.6 m^3/sec (July 1957). The recorded minimum daily discharge, which occurred on September 4, 1957, was 15.9 m^3/sec. Recorded freshet-related high flows range from 174 to 188 m^3/sec and occur in May or June.

TABLE 5-3
CAMPBELL RIVER WATERSHED HYDROLOGY
CAMPBELL RIVER (NEAR CAMPBELL RIVER) - STATION NO. 08HD003 1949-1970
LOCATION: LAT. 50 02 17 N LONG. 125 17 41 W
DRAINAGE AREA 1460 KM^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (m^3/sec)	279.0	183.0	126.0	124.0	174.0	188.0	147.0	108.0	100.0	143.0	277.0	245.0
Min (m^3/sec)	32.3	46.3	34.0	56.2	27.3	60.5	23.6	38.1	29.1	51.8	51.6	31.9
Mean (m^3/sec)	119.0	107.0	83.1	87.3	98.1	112.0	92.3	67.1	66.9	89.3	131.0	132.0

CAMPBELL RIVER (AT OUTLET OF CAMPBELL LAKE) - STATION NO. 08HD001 1910-1949
LOCATION: LAT. 50 00 08 N LONG. 125 23 20 W
DRAINAGE AREA 1400 KM^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (m^3/sec)	258.0	256.0	151.0	147.0	207.0	217.0	187.0	106.0	126.0	227.0	335.0	231.0
Min (m^3/sec)	24.9	16.0	20.1	26.5	50.0	55.2	34.2	21.0	13.7	11.7	30.1	33.4
Mean (m^3/sec)	92.8	79.6	63.6	74.9	114.0	126.0	83.4	41.7	37.6	81.9	115.0	118.0

QUINSAM RIVER (NEAR CAMPBELL RIVER) - STATION NO. 08HD005 1956-1990
LOCATION: LAT. 50 01 45 N LONG. 125 17 55 W
DRAINAGE AREA 280 KM^2

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max (m^3/sec)	48.5	27.8	36.4	17.4	12.3	7.9	4.5	4.0	5.2	16.8	42.6	39.2
Min (m^3/sec)	4.3	5.9	5.4	4.2	3.6	2.2	1.5	1.2	1.3	2.5	3.9	5.4
Mean (m^3/sec)	14.2	13.1	11.9	8.1	6.1	4.2	2.6	2.2	3.3	6.4	12.9	17.1

Maximum flows occur in Quinsam River in December and January with the maximum average monthly flow on record (1956 to 1990) of 48.5 m^3/sec (January 1968). The maximum daily discharge for the period of record is 218 m^3/sec, which occurred on January 19, 1968. Minimum flows occur in July, August and September. The minimum average monthly flow on record was 1.2 m^3/sec (August 1963). The recorded minimum daily discharge, which occurred on September 21, 1956, was 0.89 m^3/sec.

5.3 Surface Water Use

Licensed water users hold 45 water licenses that allow water withdrawal or storage on 12 waterbodies. Two of the water licenses allow the use of more than one water source. The streams and lakes licensed for water use are shown in Table 5-4.

TABLE 5-4
WATER LICENSES ISSUED
FOR THE CAMPBELL RIVER WATERSHED

Waterbody Name	Number of Licenses
Arnica Creek	1
Campbell Lake	4
Campbell River	20
Flintoff Creek	2
John Hart Lake	5
McNish Lake	1
Middle Quinsam Lake	1
Myra Creek	3
Quinsam River	5
Tennent Creek	2
Tennent Lake	1
Thelwood Creek	2
Total	**47**

The purposes for which water licenses have been issued include conservation, domestic, dust control, frost protection, irrigation, mining (processing ore), power (general and storage), pulpmills, river improvement, storage, waterworks and work camps. Major water users include:

- BC Hydro water licenses on John Hart Lake/Campbell River for the John Hart Dam and diversions to their penstocks.
- BC Hydro water licenses to divert water from Salmon River, Quinsam River and Heber Crest Creeks to the Campbell River watershed.
- BC Hydro, which operates the Strathcona Dam on the Campbell River and also holds water licenses on the Quinsam River;
- District of Campbell River, which is the local waterworks authority licensed to use the Campbell River and John Hart Lake;
- The Campbell River Forest District, licensed to use John Hart Lake for irrigation and domestic purposes;
- Boliden Westmin Mines, which holds water licenses for Arnica Creek, Myra Creek, Tennent Creek, Thelwood Creek, McNish Lake and Tennent Lake;

There are several other licensed water users, including private citizens who hold licenses for domestic use of Campbell Lake and John Hart Lake. Appendix B provides details of the water licenses.

5.4 Surface Water Quality

Water quality data for the Campbell River watershed is available from the following sources:

- Ministry of Environment, Lands and Parks (MELP) Water Quality Database;
- MELP Lake Query Database;
- MELP Water Management Branch, 1989. *Campbell River Area, Middle Quinsam Lake Sub-basin Water Quality Assessment and Objectives*.
- Environment Canada and MELP, 2000. *Water Quality Trends in Selected British Columbia Waterbodies*.
- Environment Canada and MELP, 1996. *British Columbia Water Quality Status Report*.

- Kangasniemi, B.J. 1989. *Campbell River Area. Middle Quinsam Lake Sub-Basin. Water Quality Assessment and Objectives* (Executive Summary and Technical Appendix).

The MELP Lake Query Database contains a limited amount of water quality data collected during the Fisheries Branch's Lake Survey Program. Parameters measured generally were limited to pH, transparency (Secchi disc readings) and sometimes total dissolved solids. Lake survey chemistry data are available for 30 lakes (Table 5-5). The data shows a range of lake pH from mildly acidic Jim Mitchell Lake (pH 6.6) to somewhat alkaline Mirror Lake (pH 7.8).

TABLE 5-5
LAKE SURVEY CHEMICAL CHARACTERISTICS
(ADAPTED FROM MELP LAKE QUERY DATABASE)

Lake	PH	Total Dissolved Solids (mg/L)	Secchi Disk (m)
Garrett Lake	7.2	-	6.3
Gray Lake	7.0	-	9.5
Boot Lake	-	-	11
Brewster Lake	7.0	34.0	11
Buttle Lake	-	40.0	13
Camp Lake	7.1	29.0	7.5
Upper Campbell Lake	-	47.7	
Lower Campbell Lake	7.4	37.0	7.6
Darkis Lake	7.2	18.0	5
Echo Lake	6.9	28.0	6.5
Beavertail Lake	-	-	-
Wokas Lake	-	-	-
Thelwood Lake	-	-	-
Upper Drum Lake	7.4	38.0	7.6
Lower Drum Lake	7.6	18.0	10
Quinsam Lake	6.8	35.5	4.5
Upper Quinsam Lake	-	-	-
Middle Quinsam Lake	6.9	39.0	-
Whymper Lake	-	-	-
Merrill Lake	-	-	7.7
Mirror Lake	7.8	28.0	7
Raven Lake	7.5	22.0	7.9
Snakehead Lake	7.6	26.0	7.3
Gosling Lake	-	-	10.3
Jim Mitchell Lake	6.6	6.0	8.8
John Hart Lake	-	68.0	-

Lake	PH	Total Dissolved Solids (mg/L)	Secchi Disk (m)
McIvor Lake	7.3	32.0	-
Flume Lake	7.2	33.0	8.3
Fry Lake	7.0	-	7.5
Gooseneck Lake			

5.4.1 Quinsam Lake

Much of the water quality sampling in the drainage basin has been completed to assess the effects of discharges from the Westmin and Quinsam mines. Appendix C summarizes the results of permit monitoring samples and MELP water quality samples collected to verify permit monitoring data from the Westmin and Quinsam mines. Prior to the commencement of coal mining in the Quinsam watershed baseline water quality was determined (Kangasniemi 1981). Water quality throughout the Quinsam watershed was characterized as soft, exceptionally clear and oligotrophic (Kangasniemi 1981). The pH tended to be slightly acidic (6.0 to 7.0), presumably during periods of rain or snowfall. The Quinsam watershed water had low concentrations of dissolved substances and little buffering capacity. Phytoplankton and periphyton productivity were very low due to nutrient limitation; phosphorous and nitrogen were co-limiting. Hypolimnetic oxygen depletion occurred in Long, Middle Quinsam and Quinsam lakes at the end of the growing season prior to destratification. Suspended sediment concentrations rarely exceeded 5 mg/L even during high flow periods.

Water quality data from Middle Quinsam Lake collected from 1990 to 1998 during the operation of Quinsam Coal Ltd. indicated that pH ranged from 7.12 to 11.9 (possible erroneous reading) with an average value of 7.6. Turbidity ranged from 0.1 to 2.0 NTU with an average of 0.2 NTU. Hardness (total dissolved) ranged from 30.6 to 50.6 mg/L and averaged 41.8 NTU. Sulphates ranged from 10.8 to 67.0 mg/L and averaged 44.2 mg/L. Ammonia ranged from below detection (<0.002 mg/L) to 0.019 and averaged 0.008 mg/L. Nitrate and nitrite nitrogen ranged from below detection (<0.02 mg/L) to 0.04 mg/L.

Metal levels were as follows:

- total and dissolved silver (<0.005 mg/L), arsenic (<0.06 mg/L), cadmium (<0.01 mg/L) and antimony (<0.05 mg/L) were below detection in all samples.
- total aluminum ranged from below detection to 2.57; dissolved aluminum ranged from below detection (<0.02 mg/L) to 0.03 mg/L
- total chromium ranged from below detection (<0.002 mg/L) to 0.003 mg/L; dissolved chromium was below detection in all samples.
- total copper ranged from below detection (<0.006 mg/L) to 0.008 mg/L; dissolved copper ranged from below detection (<0.001 mg/L) to 0.0021 mg/L
- total iron ranged from 0.02 to 2.74 mg/L and averaged 0.17 mg/L; dissolved iron ranged from 0.01 to 0.08 mg/L and averaged 0.05 mg/L
- total mercury in all samples were all below detection (<0.00005 mg/L)
- total lead ranges from below detection (<0.001mg/L) to 0.0034 mg/L; dissolved lead ranges from below detection (<0.001mg/L) to 0.0013 mg/L
- total zinc ranged from below detection (<0.002mg/L) to 0.08 mg/L; dissolved zinc ranged from below detection to 0.005 mg/L.

5.4.2 Quinsam River

Water was also collected from Quinsam River, downstream of Quinsam Lake intermittently in 1991, 1996 and 1997. The pH ranged from 7.5 to 7.72. Water hardness (total dissolved) ranged from 19.8 to 22.8 mg/L and averaged 21.46 mg/L. Sulphates ranged from 13 to 15 mg/L. Two samples collected for ammonia were both 0.007 mg/L. Nitrate and nitrite nitrogen ranged from 0.03 to 0.071 mg/L.

Metal levels were as follows:

- total and dissolved silver (<0.01 mg/L), arsenic (<0.06 mg/L), cadmium (<0.005 mg/L), chromium (<0.005 mg/L), lead (<0.5 mg/L) and antimony (<0.05 mg/L) were below detection in all samples

- total aluminum ranged from 0.048 to 0.18 mg/L; dissolved aluminum ranged from 0.048 to 0.08 mg/L
- total copper ranged from below detection to 0.0017 mg/L; dissolved copper ranged from below detection to 0.0012 mg/L
- total iron ranged from 0.02 to 2.74 mg/L and averaged 0.17 mg/L; dissolved iron ranged from 0.01 to 0.08 mg/L and averaged 0.05 mg/L
- total zinc ranged from below detection 0.003 to 0.01 mg/L; dissolved zinc ranged from below detection to 0.003 mg/L.

The 1996 British Columbia Water Status Report (Environment Canada/MELP 1996) assessed the quality of Middle Quinsam Lake and Quinsam River. To rate the water quality of the bodies of water reviewed in the document five index categories were created:

- Excellent (0-3) indicates that all uses of water are protected and none are threatened or impaired
- Good (4-17) means all uses are protected with only a minor degree of threat or impairment
- Fair (18-43) means that most uses are protected but a few are threatened or impaired
- Borderline (44-59) means several uses are threatened or impaired
- Poor (60-100) means most uses are threatened, impaired or even lost

According to the 1996 British Columbia Water Status Report Middle Quinsam Lake water quality is excellent and is rated as a 3 on the quality index. Due to the presence of a coal mining operation with pits north and south of Middle Quinsam Lake water quality objectives including suspended solids, nutrients, pH, dissolved oxygen and metals were set. From 1991 to 1993, all objectives were met with the exception of one occasion when lead was elevated.

The 1996 British Columbia Water Status Report indicates that the Quinsam River is rated as good (index = 8). Water quality objectives set for Quinsam River include suspended

solids, nutrients, pH, turbidity and metals. From 1989 to 1993 all water quality objectives were met except for zinc on three occasions and for nickel once.
The report titled "Water Quality Trends in Selected British Columbia Waterbodies" (Environment Canada/MELP, 2000) indicated that the Quinsam River is showing a deteriorating trend due to coal mining at Middle Quinsam Lake. Major ions such as sulphate, calcium, magnesium, sodium and strontrium, and the related indicators for hardness and conductivity increased at the mouth of the Quinsam River starting in 1989 to 1992. Although the increasing levels of the above mentioned ions at the mouth of the Quinsam River were well below the safe levels for all water uses the sulphate levels upstream near the coal mine were much higher and may pose a risk to aquatic life (although no effects have been observed). To address concerns regarding water quality downstream of coal mining operations monitoring is continuing near the mine and at the Quinsam River mouth. Quinsam Coal Ltd. has been advised to identify and control sulphate discharges from the mine.

5.4.3 Buttle Lake

As part of the environmental monitoring program for Westmin Mines' operation at Myra Falls, water quality in Buttle Lake is monitored regularly. Samples from 1990 to 1998 were collected from Buttle Lake at three sites: 3 km north of Thelwood Creek, at Gold River Bridge and at the Ralph River boat launch. This data indicates that the lake water is slightly alkaline (pH ranges from 6.9 to 8.1) and soft (hardness (total dissolved) ranges from 20.7 to 32.6 mg/L). The water has low alkalinity (22.8 to 25.9 mg/L). Sulphates range from 4.4 to 12.4 mg/L and ammonia ranges 0.005 to 0.016 mg/L. Nitrate and nitrite nitrogen range 0.02 to 0.11 mg/L. Chlorophyll "a" levels range from 0.0005 0.0042 mg/L.

Metal levels were as follows:

- total aluminum ranged from 0.018 to 0.32 mg/L; dissolved aluminum ranged from 0.018 to 0.16 mg/L

- total and dissolved arsenic ranged from 0.0001 to 0.0002 mg/L
- total and dissolved cadmium ranged from 0.00005 to 0.01 mg/L
- total cadmium ranged from 0.00008 to 0.0013 mg/L and dissolved cadmium ranged from 0.00008 to 0.007 mg/L
- total chromium ranged from 0.0001 to 0.003 mg/L; dissolved chromium ranged from 0.0002 to 0.002 mg/L
- total copper ranged from 0.001 to 0.17 mg/L; dissolved copper ranged from 0.0002 to 0.005 mg/L
- total iron ranged from 0.01 to 0.21 mg/L; dissolved iron ranged from 0.003 to 0.07 mg/L
- total lead ranged from 0.00008 mg/L to 0.004 mg/L; dissolved lead ranged from 0.00007 mg/L to 0.001 mg/L
- total antimony in all samples was 0.00005 mg/L; and
- total zinc ranged from 0.014 to 0.52 mg/L; dissolved zinc ranged from 0.01 to 0.08 mg/L

Due to mining discharge metal levels increased in the lake and peaked sometime between 1980 and 1981 (Deniseger and Erickson, 1991). Maximum concentrations of copper (40 ug/L) and lead (25 ug/L) occurred in the south basin of Buttle Lake. The metal concentrations in the south Buttle Lake basin at the times exceeded criteria for drinking water and for aquatic biota (Nordin et al., 1985). Bioassays conducted using rainbow trout found that at 21^{o}C the concentration of metals in the south basin of Buttle Lake was approximately 50% of the lethal concentration. The highest concentration of cadmium (3.6 ug/L) occurred in central Buttle Lake.

As the metals levels in the water increased, levels of metals also increased in sediments, salmonid muscle and liver tissues. Declines in phytoplankton, periphyton and zooplankton species diversity and population were also observed.

Sediments collected from the south basin of Buttle Lake showed the highest levels of metals with elevated levels of cadmium (0.021 mg/g dry), copper (0.67 mg/g dry), lead

(0.2 mg/g dry) and zinc (5.7 mg/g dry). Metal concentrations in these sediments were similar to those in tailings from the mine (Nordin et al., 1985). To determine the bioavailability of metals in sediments samples were leached. It was found that significant amounts of trace elements were released from samples during whatever extract procedure or reagents were used. In particular aluminum, copper, lead, manganese and zinc may potentially be released in a fair quantity (Nordin et al., 1985). The data suggests that deposited tailings on the lake bottom might potentially be a major source of toxic metals should there be any flow-through of groundwater.

Since 1981, improved treatment and collection systems at the mine site have resulted in a steady decrease in metal levels in the lake. By late 1985 some species of metal sensitive phytoplankton and zooplankton began to reappear in the lake. Also, levels of metals in rainbow trout muscle tissue had decreased significantly, while only copper and cadmium levels in liver tissue remained higher than those of fish inhabiting control lakes such as John Hart Reservoir and Upper Quinsam Lake. Since 1986 cadmium has decreased below background levels with only copper remaining elevated. Concurrently, angler success and catch statistics also improved.

According to the Ministry of Environment, Lands and Parks' Working and Approved Water Quality Guidelines for British Columbia (MELP 2000) water quality in Buttle Lake meets all the criteria for drinking water. However, on occasion it exceeds limits for chromium, copper, and zinc for the protection of aquatic life.

5.5 Fisheries Resources

The Campbell River drainage basin supports at least 15 fish species including:

- coho salmon (*Oncorhynchus kisutch*)
- chinook salmon (*Oncorhynchus tshawytscha*)
- chum salmon (*Oncorhynchus keta*)
- sockeye salmon (and kokanee) (*Oncorhynchus nerka*)

- pink salmon (*Oncorhychus gorbuscha*)
- cutthroat trout (*Oncorhynchus clarki clarki*)
- dolly varden (*Salvelinus malma*)
- rainbow trout (and steelhead) (*Oncorhynchus mykiss*)
- Pacific lamprey (*Lampetra tridentatus*)
- threespine stickleback (*Gasterosteus aculeatus*)
- Aleutian sculpin (*Cottus aleuticus*)
- prickly sculpin (*Cottus asper*)

A brief summary of the life histories of the above mentioned fish species is presented in Appendix D-1. Tables 5-6 and 5-7 summarize the known distributions of fish in the lakes and rivers of the watershed. Distribution of anadromous Pacific salmon species within the Campbell River watershed is limited by the availability of suitable habitat and the existence of obstructions which act as partial or full migration barriers. Obstructions include dams, culverts, waterfalls and cascades. Available habitat for chum and sockeye salmon within the Campbell River mainstem is limited to several kilometres downstream of the confluence with the Quinsam River. Coho, pink and chinook occur as far as the powerhouse at km 5 (one kilometre upstream of the Quinsam River). Based on MELP's FishWizard database the distribution of anadromous salmon species in Quinsam River is as follows:

- coho occur as far as Middle Quinsam Lake
- pink occur as far as 2 km downstream of Quinsam Lake
- chinook occur as far as 2.5 km upstream of Campbell River
- chum and sockeye occur near the confluence with Campbell River
- kokanee occur in Middle Quinsam and Quinsam lakes.

The occurrence of sport fish such as rainbow trout, steelhead and cutthroat trout is largely due to numerous and repeated stockings that have occurred over the last 80 years. Table 5-8 provides a summary of fish stocking within the Campbell River watershed.

According to FishWizard the occurrence of Dolly Varden char has been documented throughout both the Campbell River and Quinsam River systems.

TABLE 5-6
FISH DISTRIBUTION IN CAMPBELL RIVER WATERBODIES

	cutthroat trout	dolly varden	rainbow trout	steelhead	coho salmon	kokanee	threespine stickleback	Aleutian sculpin	prickly sculpin	stickleback species	trout species	sculpin species
Beavertail Lake	✔	✔	✔									
Becher Lake			✔									
Boot Lake	✔	✔	✔									
Brewster Lake	✔	✔	✔									
Buttle Lake	✔	✔	✔				✔		✔			✔
Camp Lake			✔									
Campbell Lake	✔	✔	✔	✔			✔		✔			
Darkis Lake	✔											
Echo Lake	✔	✔	✔									
Flume Lake	✔											
Fry Lake	✔	✔	✔									
Garrett Lake	✔											
Gooseneck Lake	✔											
Gosling Lake	✔											
Gray Lake	✔	✔	✔									
Higgins Lake	✔											
Jim Mitchell Lake	✔											
John Hart Lake	✔	✔	✔							✔		✔
Landslide Lake			✔									
Lawson Lake	✔			✔							✔	
Lost Lake	✔											
Lower Drum Lake	✔	✔	✔						✔			
McIvor Lake	✔	✔		✔			✔	✔				✔
Merrill Lake	✔		✔	✔						✔		
Middle Quinsam Lake	✔	✔	✔	✔	✔	✔				✔		✔
Mirror Lake	✔	✔										
Quinsam Lake	✔	✔	✔	✔	✔	✔	✔		✔			
Ralph Lake											✔	
Raven Lake			✔									
Reginald Lake				✔								
Snakehead Lake	✔											
Thelwood Lake	✔											
Upper Campbell Lake	✔	✔	✔				✔		✔			
Upper Drum Lake		✔										
Upper Quinsam Lake	✔									✔		✔
Whymper Lake	✔		✔									
Wokas Lake	✔							✔				

TABLE 5-7
FISH DISTRIBUTION IN CAMPBELL RIVER WATERCOURSES

	cutthroat trout	dolly varden	rainbow trout	steelhead	chinook salmon	coho salmon	chum salmon	pink salmon	sockeye salmon	kokanee	Pacific lamprey	threespine stickleback	Aleutian sculpin	prickly sculpin	stickleback species	sculpin species
Campbell River	✔	✔	✔	✔	✔	✔		✔	✔		✔	✔		✔		
Cervus Creek		✔	✔													
Elk River	✔	✔	✔													
Filberg Creek		✔	✔													✔
Greenstone Creek	✔															
Haig-Brown Kingfisher Creek						✔										
Henshaw Creek			✔													
Iron River		✔	✔	✔		✔										
Quinsam River	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔						
Thelwood Creek	✔	✔	✔													
Tlools Creek		✔	✔													

TABLE 5-8
FISH STOCKING RECORDS FOR THE CAMPBELL RIVER WATERSHED

Waterbody	Fish Species	Life Cycle Stage	Release Dates	No. of Stock Records
Beavertail Lake	rainbow trout	yearling	1979 to 2000	21
Becher Lake	rainbow trout	fry	1964	1
Boot Lake	rainbow trout	yearling and fingerling	1946 to 2000	18
Brewster Lake	rainbow trout	yearling	1988 to 2000	8
Brewster Lake	cutthroat trout	yearling	1986 to 2000	12
Camp Lake	rainbow trout	yearling and fry	1965 to 1999	7
Chute Creek	rainbow trout	eyed egg	1934 & 1935	2
Gooseneck Lake	cutthroat trout	fingerling and yearling	1987 to 2000	16
Gosling Lake	cutthroat trout	yearling	1978 to 2000	15
Gosling Lake	rainbow trout	fingerling	1945	1
Gray Lake	cutthroat trout	yearling	1986 to 2000	12
Iron River	Steelhead	fry and parr	1979 to 1990	4
Landslide Lake	rainbow trout	fry	1988	1
McIvor Lake	Steelhead	parr and fry	1989 to 1998	12
Merrill Lake	rainbow trout	yearling	1988 to 1999	14
Merrill Lake	cutthroat trout	unknown	1987	1
Miller Creek	cutthroat trout	parr	1982	1
Miller Creek	rainbow trout	eyed egg	1933 & 1934	2
Quinsam River	Steelhead	parr, fry and smolt	1976 to 1999	75
Quinsam River	cutthroat trout	parr, fry and smolt	1941 to 1999	16
Quinsam River	rainbow trout	fingerling	1941 to 1949	11
Reginald Lake	Steelhead	fry and parr	1988 to 1997	5
Sihun Creek	brook trout	yearling and fry	1911 to 1930	5
Sihun Creek	Steelhead	fry	1916 & 1929	2
Sihun Creek	atlantic salmon	fry	1916 & 1922	2
Sihun Creek	cutthroat trout	fry	1911 to 1918	3
Snakehead Lake	cutthroat trout	fingerling and yearling	1986 to 1992	6
Wolf River	rainbow trout	fingerling	1935 to 1940	4

Non-sport species such as three-spine stickleback, aleutian sculpin and prickly sculpin occur throughout the Campbell River watershed. Pacific lamprey are limited to the lower reach of the Campbell River mainstem. Pacific lamprey are an anadromous species that spawn in freshwater. The larval stage remains in freshwater for several years before the fish migrate to sea.

5.6 Hatchery Facilities

The Quinsam River Hatchery is the only government-run hatchery operating in the Campbell River watershed. The hatchery was opened in 1973 and the first collection of eggs took place in 1974. The hatchery is located on the Quinsam River approximately 3 km upstream of the Campbell River confluence. Typically, Quinsam River hatchery releases the following on an annual basis:

- 3.5 million chinook salmon smolts
- 3.5 million coho salmon smolts
- 6 million pink fry
- 20,000 steelhead smolts
- 6,000 cutthroat trout smolts

5.7 Rare and Endangered Species

Rare vertebrates occurring within the Campbell River Forest District listed by the Conservation Data Center (CDC) are shown in Appendix D-2. The CDC categorizes rare and endangered vertebrate species into 'red' and 'blue' lists. Red listed species include species that are extirpated in British Columbia or in danger of becoming extirpated, or threatened. Blue listed species are species that are sensitive or vulnerable to human activity or habitat encroachment. Currently, only one fish species and one amphibian species (tailed frog, blue-listed) are present on the CDC list. The western brook lamprey (*Lampetra richardsoni* var. *marifuga*) is currently red-listed for the Campbell River Forest District. The western brook lamprey is a non-predaceous species. Spawning takes place in the spring and nests are usually constructed among small stones mixed with sand at the head of a riffle, in comparatively quiet water. After hatching the larvae burrow in silt accumulated in back eddies and filter feed on microscopic material. After approximately four years they transform to the adult stage, spawn and then die.

A rare element occurrence report (EOR) for the Campbell River watershed was compiled by the Conservation Data Centre (Appendix D-3). The EOR report outlines those species of red and blue listed vascular plants, vertebrate animals and plant communities that have been documented in the area. In response to an EOR request made on December 5, 2000, the Conservation Data Centre indicated that there has been no reported occurrences of western brook lamprey (var. *marifuga*) or tailed frog in the Campbell River watershed.

6.0 SIGNIFICANT PAST EVENTS

There are a number of activities occurring in the watershed. The significant past event affecting the watershed was a large forest fire in the Sayward Forest which occurred in 1938. The fire reached as far south as the middle of Upper Campbell Lake, as well as a portion of Salmon River. Since the 1950's there have not been any significant forest fires. (Pers Comm, John Andres, MoF)

7.0 LEGISLATION

The Campbell River Water Use Plan is subject to the requirements of both Federal, Provincial and Local Government legislation. This section identifies the more significant applicable Acts and discusses their implications for the plan. This information has been prepared based on a review of these Acts and/or on consultation with representatives of the following agencies:

- Ministry of Environment, Lands and Parks
- Ministry of Fisheries and Food
- Ministry of Forests
- Ministry of Small Business, Tourism and Culture
- Ministry of Aboriginal Affairs
- Campbell River Regional District
- Land Commission
- Department of Fisheries and Oceans
- Environmental Assessment Office

7.1 Federal Legislation[1]

7.1.1 Fisheries Act and Fish Habitat Management Policy

Water control facilities are subject to the federal Fisheries Act, which governs the protection of fish and fish habitat in Canada. The Act empowers the Department of Fisheries and Oceans (DFO) to set requirements for minimum water flows, the construction of fishways, fish guards or screens, pollution prevention, fish habitat protection, and other matters.

[1] Much of the information in this section was drawn from the B.C. Water Use Plan Guidelines (December 1998)

For example, under Section 22(3) of the Act, DFO can issue an order to ensure the availability of sufficient water flow from water control structures for the safety of fish and spawning grounds.

> ***Section 22(3): Sufficient water for river-bed below dam***. *The owner or occupier of any obstruction shall permit the escape into the river-bed below the obstruction such quantity of water, at all times, as will, in the opinion of the Minister, be sufficient for the safety of fish and for the flooding of the spawning grounds to such depth, as will, in the opinion of the Minister, be necessary for the safety of the ova deposited thereon.*

In addition, Section 35(1) ensures that fish habitat is not harmfully altered, disrupted, or destroyed unless authorized by the Ministry of Fisheries and Oceans under Section 35(2).

> ***Section 35(1): Harmful alteration, etc., of fish habitat.*** *No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.*

> ***Section 35(2): Alteration, etc., authorized.*** *No person contravenes subsection (1) by causing the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor-in-Council under this Act.*

DFO's Policy for the Management of Fish Habitat identifies a long-term policy objective of achieving an overall net gain in the productive capacity of fish habitat. This objective is to be realized through active conservation, restoration, and development of fish habitat. In addition, integrated resource planning with all resource sectors (forestry, mining, hydro generation, etc.) is recognized as a means to ensure that the fisheries resource is maintained in Canada.

In May, 1997, an Interim Campbell River flow agreement was signed by the former BC Hydro/Fisheries Advisory Committee, which included the DFO, the BC Ministry of Environment, Lands and Parks, the District of Campbell River, BC Hydro and the Campbell River Gravel Committee. This former committee's agreement, to mimic river flows before construction of the dams on the system, is now included within the Campbell River Water Use Planning process.

7.1.2 Navigable Waters Protection Act

The Navigable Waters Protection Act of Transport Canada governs activities that occur in and around navigable waters. From the perspective of the Campbell River system, the key section is Section 5(1) which reads as follows:

> *5(1) No work shall be built or placed in, on, over, under, through or across any navigable water unless*
> *(a) the work and the site and plans thereof have been approved by the Minister, on such terms and conditions as the Minister deems fit, prior to commencement of construction;*

If it is decided that any such works are required as part of the final Water Use Plan, a trigger of the Navigable Waters Protection Act will result in the need for a Canadian Environmental Assessment Act (CEAA) review of the works.

7.1.3 Canadian Environmental Assessment Act

The Canadian Environmental Assessment Act (CEAA) requires that all federal authorities conduct an environmental assessment prior to exercising a power, duty, or function. The Act applies to projects for which the Canadian Government has decision-making authority, as a proponent, land manager, regulator, or source of funding.

Under the Act, an environmental assessment is required or triggered when a federal department or agency is asked to provide a license, permit, certificate, or other regulatory authorization for a Plan that is listed on the CEAA Law List regulation. Of course, not every federal regulatory decision is likely to result in environmental effects. The Law List defines the scope of the Act by identifying those federal statutory and regulatory approvals that will be counted as triggers for an environmental assessment.

It is important to note that in 1997 steps were taken to coordinate federal and provincial environmental assessment processes for major projects in B.C. with the establishment of a federal-provincial cooperation agreement. Where both federal and provincial reviews are required for a project, the two governments have agreed that federal authorities will follow British Columbia's review process. The federal government will, however, participate actively in this process to ensure its own assessment requirements are met.

7.1.4 Summary – Federal Government

The Federal legislation impacts activities that could affect water quality. The Fisheries Act addresses damage to fish habitat and pollution prevention that would directly ensure maintenance of watershed water quality. The Canadian Environmental Assessment Act requires an environmental assessment and an open public process when a project approval by permit, certificate or other regulatory authorization is required for activities listed in the Act. For any new projects in the watershed that come under the Act, the District's interests in maintaining watershed water quality would presumably be recognized.

7.2 Provincial Legislation[2]

7.2.1 Water Act and Water Use Plans

The Water Act governs the construction, operation, and maintenance of works to ensure the beneficial use of provincial water resources. The Act confers on the Comptroller of Water Rights certain powers and responsibilities with respect to flood control, public safety, and environment. The exercise of this authority has evolved over time and must consider the rights of the licensee, as well as the public interest. Section 31 of the Act, for example, allows the Comptroller to order an inquiry to resolve a water use conflict. Wherever possible, the intent will be to conduct such an inquiry in a less formal manner, by having the licensee or proponent develop a draft Water Use Plan (WUP) in accordance with these guidelines.

The development of WUPs for water control facilities are required as part of the licensing procedures of the Water Act. This planning process was established in 1996. Water Use Plans are means to clarify how rights to provincial water resources should be exercised, and to recognize other social and environmental values associated with those resources. WUPs will specify the operating conditions relating to water licenses issued under the Water Act. Licenses grant a right to construct and operate works, and to store, divert, or use a specified maximum amount of water for particular purposes.

A WUP will define the operating parameters to be imposed on a specific works or water control facility. These parameters will be designed to recognize multiple water use objectives. Key objectives from the provincial government's perspective are the protection of fish and aquatic habitat, flood control, power generation, and First Nations issues. However, the plan may also need to consider other uses, including industrial and municipal development, drinking water supply, recreation and tourism, forestry, irrigation, navigation, and other cultural and heritage values.

[2] Much of the information in this section was drawn from the BC Water Use Plan Guidelines (December 1998).

7.2.2 B.C. Environmental Assessment Act (BCEAA)

The British Columbia Environmental Assessment Act (BCEAA) and associated regulations came into effect in June 1995. BCEAA applies to all new power plants and water management containment/diversion plans, as well as to modifications to existing facilities above certain size thresholds. Under the legislation, the actions of Plan proponents are regulated through the terms and conditions of a Project Approval Certificate (PAC). The PAC provides the general terms of reference and approval-in-principle for construction, operation, and abandonment. Once a PAC has been awarded, the proponents still need to apply for applicable permits and licenses.
Section 35 of the Environmental Assessment Reviewable Plans Regulation states the following with regard to water diversion Plans:

> *35 (1) The construction of a new facility constitutes a reviewable Plan for the purposes of the Act if*
> *(a) the facility is a works for the diversion of water, and*
> *(b) the maximum rate of diversion of water permitted under the Water Act is, or when the construction phase is completed will be, 10 million m^3 or more of water per year.*
> *(2) The review of a facility described in subsection (1) includes a review of the operations phase but does not include a review of the dismantling or abandonment phases of the facility.*

Should there be any significant proposals for diversion of water as a result of the Water Use Planning process, they may be reviewable under the Act. Under the BCEAA, any reviewable project must submit an *Application* to the Environmental Assessment Office to obtain a Project Approval Certificate.

7.2.3 Fish Protection Act

The Province's Fish Protection Act is a comprehensive piece of legislation designed to ensure the protection of fish stocks and habitat, particularly on sensitive streams where fish are most threatened. For streams so designated, recovery plans must be developed with stakeholder involvement. Although none of the streams within the Campbell River watershed have been designated a sensitive stream under this Act (G. Robinson, MELP, pers. comm.), in applying for a water license for the river, the CRWC will be subject to the fish and fish habitat considerations outlined in the Act. The two most applicable sections of this Act include 5(1) and (2) and 6(8):

5(1) Subject to the regulations, in making a decision on an application for a license, an approval or an amendment to a license or an approval, the comptroller or regional water manager may

(a) consider impact on fish and fish habitat, and

(b) include conditions respecting fish and fish habitat in the license, approval or amendment.

(2) Without limited subsection (1), for the purposes of

(a) monitoring the impact of water use or diversion by the licensee on fish and fish habitat, or

(b) verifying the information in relation to fish and fish habitat used in determining whether to issue the license, approval or amendment,

a license, approval or amendment may include conditions that the holder of the license or approval construct, install, operate, maintain and provide data from a streamflow measuring device in accordance with the directions of the comptroller or regional water manager.

6(8) If the comptroller or regional water manager considers that the proposal is likely to have a significant adverse impact on fish or fish habitat that

(a) cannot be addressed by mitigation measures referred to in subsection (7), or

(b) cannot be fully addressed by mitigation measures referred to in subsection (7),

the controller or regional water manager may only issue the license, approval or amendment if satisfied that compensation measures, in place of or supplemental to the mitigation measures, will enhance or enable the enhancement of fish or fish habitat elsewhere to fully compensate for the significant adverse impact of the proposal.

Minimum instream flows to protect fish and fish habitat have already been set under the Interim Campbell River Flow Agreement (1997) and may be adjusted as part of the Water Use Planning process.

7.2.4 Heritage Conservation Act

This Act will apply if there are any existing designated heritage sites located within the watershed. The Act is intended to protect such sites from damage due to construction, vandalism and other activities. The most applicable section is Section 13 (2a) which addresses heritage protection:

13 (2) Except as authorized by a permit issued under section 12 or 14, or an order issued under section 14, a person must not do any of the following:

(a) damage, desecrate or alter a Provincial heritage site or a Provincial heritage object or removed from a Provincial heritage site or Provincial heritage object any heritage object or material that constitutes part of the site or object;

7.2.5 Land Reserve Act

The Agricultural Land Reserve Act governs provincial land designated as Agricultural Land Reserve (ALR). The Act is administered by the Agricultural Land Commission (now called the Land Reserve Commission) whose goal is to preserve agricultural land. The Act limits the use of ALR land as follows:

> *17(3) A person must not use agricultural land for a purpose other than farm use, except as permitted by this Act, the regulations, or an order of the commission, on terms the commission may impose.*
> *18(a) A municipality or regional district, or an authority, board or other agency established by it or a person designated under the Local Services Act may permit agricultural land to be used for other than far use, or permit a building to be erected on the land except for farm use or for residences necessary to farm use or as permitted by regulation.*

Section 22 of the Act indicates that the Commission can decide on applications from persons who wish to use agricultural land for purposes other than farming for a number of activities as identified in Section 34(2) of the Agricultural Land Reserve Procedure Regulation.

7.2.6 Forest Act

The Forest Act is the defining legislation for the management of timber on Crown Land. Within it, Crown timber is defined and classified, various licensing and leasing arrangements for the disposal of Crown timber are defined, a variety of plans are prepared, and the Chief Forester establishes a rate of cut.

Payments to the Crown for timber are defined, along with log scaling and penalties. The Act also allows the Minister to create regulations which further define the Forest Act. None of the regulations specifically discusses community watersheds.

The following are the Forest Act Regulations:

- Administrative Review and Appeal Procedure (Forest Act/Forest Practices Code of BC Act)
- Regulation
- Advertising, Deposits and Disposition Regulation
- Allowable Annual Cut Proportionate Reduction Regulation
- Annual Rent Regulation
- Christmas Tree Regulation
- Credit to Stumpage Regulation
- Cut Control Regulation
- Duu Guusd Designated Area
- Effective Director Regulation
- Forest Accounts Receivable Interest Regulation
- Forest Regions and Districts Regulation
- Free Use Permit Regulation
- Innovative Forestry Practices Regulation
- Log Salvage Regulation for the Vancouver Log Salvage District
- Minimum Stumpage Rate Regulation
- Performance Based Harvesting Regulation
- Scaling Regulation
- Small Business Forest Enterprise Regulation
- Special Forest Products Regulation
- Specifying Designated Areas:
- Brooks-Klaskish-Nasparti Designated Area, Published in BC Gazzete
- Nootka Island's West Coast Designated Area, Published in BC Gazzete
- Tahsish-Kwois Designated Area, Published in BC Gazzete
- Clayoquot Sound Designate Area No. 1, Published in BC Gazzete
- Clayoquot Sound Designated Area No. 2, Published in BC Gazzete
- Timber Definition Regulation

- Timber Harvesting Contracts and Subcontracts Regulation
- Timber Marking and Transportation Regulation
- Woodlot License Regulation

7.2.7 Local Government Act

The Local Government Act has limited information with respect to watersheds, focussing more on drainage and stream related issues, and providing enabling legislation with respect to the exercise of local government authority. The Local Government Act has enabling legislation relevant to both the municipality and the regional district. The more pertinent sections are referred to below.

Watercourse may be included in drainage systems.

> 541. A council may, by bylaw, make a watercourse part of the municipal drainage system, whether the watercourse is on a highway or municipal or private land.

Intermunicipal watercourses

> 548. (1) A council may make agreements with adjoining municipalities, and also with the owner of any land, through, on or in which runs a natural stream or watercourse, for one or more of the following:
>
> (a) constructing, enlarging or maintaining a culvert, ditch, flume, embankment or other work;
>
> (b) removing obstructions from the stream or watercourse to lessen or prevent the danger of flooding from it;
>
> (c) the granting, expending or accepting of money for the purposes referred to in paragraphs (a) and (b), even though the work may not be located in the municipality granting, expending or accepting the money or entering into the agreement.

The authority of a municipality under the following provisions is subject to the applicable provisions of the *Water Act*:

section 529 [works to protect highways from water damage];
section 541 [watercourse may be included in drainage system];
section 542 [requirements respecting drainage works];
section 543 [appropriation of stream channel or bed];
section 544 [control of drainage];
section 548 [intermunicipal watercourses];
section 549 [district municipality drainage works];
section 725.1 [protection of waterways].

(2) In addition, the following authorities of a municipality are subject to the applicable provisions of the *Water Act*:

(a) the authority to acquire, manage, extend and remove

(i) works to maintain the proper flow of water in a stream as defined in the *Water Act*, ditch, drain or sewer in the municipality,

(ii) dikes, or

(iii) works to reclaim or to protect part of the land mass of the municipality from erosion by action of the sea or a stream as defined in the Water Act, or any other cause;

(b) the authority to regulate a wharf, dock, warehouse or ship owned, held or managed by the municipality.

Other legislation of note is section 725.1 referring to Sundry Powers which provides for:

725.1 A council may, by bylaw, prohibit a person from:

(a) polluting, or

(b) obstructing or impeding the flow of a stream, creek, waterway, watercourse, waterworks, ditch, drain or sewer, whether or not it is located on private property.

It should also be noted that authority exists to include objectives to "protect the quality and quantity of ground water and surface water" as part of the regional district's authority to adopt a regional growth strategy. This is provided for under section 849 of the Local Government Act. Similar provisions are available to local government under the Development Permit system.

7.2.8 Various Mineral and Mining Acts

The Provincial Mineral and Mining Act deals with all mining, energy and industrial projects in British Columbia.

7.2.8.1 Environmental Assessment Act

All mining, energy and industrial projects that would be developed within the Campbell River watershed would have to be reviewed under the Environmental Assessment Act.

British Columbia's Environmental Assessment Act became law in 1995 and established a process for assessing the impacts, both positive and negative, of large-scale development proposals. The purpose of the environmental assessment process is to ensure that new developments or major modifications to existing projects support goals in British Columbia.

The environmental assessment process provides a consistent review that balances economic, environmental and social issues, and addresses cultural, heritage and health issues.

The process provides for a thorough, timely and integrated assessment of any foreseeable adverse impacts throughout the life cycle of a project construction, start-up, operation and shut-down. The intent of the process is to determine whether or not there are ways to eliminate, minimize or mitigate those impacts, or to compensate for them.

The environmental assessment process is open and accountable by a neutral agency, the Environmental Assessment Office. At every stage of the review, the process provides opportunities for and meaningful participation by the proponent, the public, First Nations and any relevant government agencies, including those neighbouring jurisdictions.

The process can take up to three stages. At the end of the first stage, a report with recommendations is prepared for the Ministry of Environment, Lands and Parks and one other appropriate minister. The ministers can either approve the project, reject the project, or require that the project proceed to the next stage. If a project proceeds to the third stage, the findings of that stage are forwarded to the full Cabinet for a decision.

Types Of Projects Reviewed

The Reviewable Projects Regulation defines the types and sizes of projects that are automatically subject to an environmental assessment. The review takes into account facilities at the main site and may consider offsite facilities or related activities that could have an impact. For example, the review of a proposed pulp mill would consider the impact of transporting material to and from the mill.

The Environmental Assessment Act does not generally apply to urban housing developments because authority for land use planning and control of development on private lands lies with local governments in B.C.. Similarly, the Act does not apply to stand-alone forestry activities, as these are covered under the Forest Practices Code. The Act does apply to certain wood processing facilities at or above a specified size threshold. The Act also applies to forestry activities related to a project under review, such as site clearing for a hydroelectric dam.

The Minister of Environment, Lands and Parks has the power under the Act to order an environmental assessment for a project that does not fit under any of the specified categories in the Reviewable Projects Regulation. Such a decision is only made if the Minister is convinced the project has potential for a significant adverse effect and a review under the Act is in the public interest.

Proponents are responsible for knowing if their projects meet or exceed the thresholds set out in the Reviewable Projects Regulation, and are therefore reviewable under the Act. Projects subject to review include:

Mines

- Coal mines
- Mineral mines
- Sand and gravel pits
- Placer mines
- Construction stone and industrial mineral quarries
- Offshore mines

Containment and Diversion

- Dams and reservoirs
- Dykes
- Diversions
- Groundwater extraction
- Shoreline modification

Food Processing

- Fish processing
- Meat packing and poultry processing

Tourism and Recreational

- Large destination resorts (and their associated facilities, such as Ski hills, marinas, and golf courses)

Key features of review process:

Single and Consistent

The Act offers a single, consistent process for conducting project assessments. Depending on the completeness of the initial application, reviews range from one to three stages. The second and third stages deal with issues not resolved at previous stages. Decisions are made at the end of each stage and public and First Nation input is encouraged throughout.

Balanced Decision Making

For one- or two-stage reviews, the Act requires joint decision making by the Minister of Environment, Lands and Parks and a second appropriate minister. For example, the Minister of Energy and Mines is responsible for mining and energy projects. After a third stage, Cabinet would make the decision. Participation is encouraged from all levels of government, First Nations, and the public. Proponents are required to consult with the public and First Nations.

Clear Timelines

Specific timelines are defined for the government-controlled part of the process. Clear timelines mean participants can plan their activities with greater certainty.

Other Permit and Licence Reviews

Proponents have the option of requesting that the environmental assessment review be conducted concurrently with the review of other permits or licences. If the proponent's plans are sufficiently well developed to take advantage of this, it can result in a more timely issuing of permits. During an environmental assessment, the Environmental Assessment Office compiles preliminary information requirements for various permits for the project. If a certificate is issued, an appropriate agency is selected to coordinate permitting and other activities.

Canada-British Columbia Co-operation

When a project triggers both federal and provincial environmental assessment legislation, governments have agreed to co-operate in a joint review. A single window reduces duplication and overlap and avoids unnecessary costs, delays and uncertainty. At the end of a joint review, each government makes a separate decision on the project.

Stages of the Review Process

There are potentially three formal stages in any environmental assessment: application review, project report review, and public hearing. Project reviews may conclude at the end of Stage 1 or 2 if all issues have been resolved. Projects requiring a public hearing to assist in the resolution of outstanding concerns go through all three stages.

Final Decision

For projects that go through either the first or the first and second stages of the environmental assessment process, final project approval decisions are made by two provincial Cabinet Ministers: the Minister of Environment, Lands and Parks and the appropriate minister responsible for a particular category of reviewable project. Projects

that require a public hearing (Stage 3) are submitted to Cabinet for a final decision to approve or reject the project.

Once a project approval certificate has been issued, along with any necessary operational permits and licences, then the project may proceed.

Length of Review Process

Timelines for the government controlled portion of each stage of the review are set out in the Prescribed Time Limits Regulation. The timelines are intended to accommodate projects of differing scope and complexity. The timelines for public comment have a stipulated range to guarantee adequate notification while ensuring the review process proceeds in an efficient manner. Ministerial approval is required for extension of any time limits.

No time limits are specified for proponent activities. The length of the review process depends on the complexity of the issues raised by a project and could range from as little as three months to more than three years, if a public hearing is required.

Environmental Assessment Office

The Environmental Assessment Office is responsible for the overall administration of project reviews. The office receives applications and project reports, establishes and chairs project committees, ensures timelines are met, and maintains the Project Registry.

7.2.8.2 Mines Act

The Mines Act is the overview legislation that allows for the operation a mine in B.C.. It makes for the requirement that permitting must be carried out and that a Mine Reclamation Fund must be established.

It is primarily aimed at the establishment and operation of a mine with emphasis on the health and safety of the workers.

7.2.8.3 Mineral Exploration Code

The purpose of the mineral exploration code:

(1) Establish province-wide standards for mineral and coal exploration and development activities.

(2) Administer and manage exploration and development activities to ensure maximum extraction with a minimum of environmental disturbance, taking into account sound engineering practice and prevailing economic conditions.

The MX Code does not apply, nor is an Exploration Activities and Reclamation Permit required, for exploration work that is excluded under the definition of exploration activities in Part 11 of the Code. Work that is excluded from the definition is generally that which does not involve mechanical disturbance of the surface and includes:

- *prospecting using hand-held tools;*
- *geological and geochemical surveying;*
- *airborne geophysical surveying;*
- *ground geophysical surveying without the use of exposed, energized electrodes;*
- *hand trenching without the use of explosives;*
- *establishment of grid lines that do not require the felling of trees unless permitted under the definition.*

Exploration activities that do require permitting and to which the MX Code applies are:

- *drilling, trenching and excavating using machinery;*
- *blasting;*

- *disturbance of the ground by mechanical means;*
- *construction, modification, deactivation and reclamation of an exploration access;*
- *induced polarization surveys using exposed electrodes; and*
- *site reclam*ation.

The code does not apply to aggregate operations.

7.2.8.4 Mineral Tenure Act

Tenure to mineral and coal resources may presently be acquired on approximately 80% of British Columbia's land area. The remaining lands are in parks, lands where sub-surface rights are reserved to the Crown and lands which are excluded by provisions of the tenure statutes. Title for exploration and development purposes is available from the Crown through the locating and recording of mineral claims in accordance with the Mineral Tenure Act and Regulations, and through application for coal licenses under the Coal Act. Title may also be acquired from recorded holders of tenures. The person acquiring title becomes the recorded holder of that particular mineral or coal tenure.

7.2.8.5 Coal Act

The Coal Act is the overview legislation regarding the development and operation of a coal mine in BC. It defines how licences and leases are granted and the rights granted by those licences and leases.

The Act allows the Lieutenant Governor in Council to make regulations.

7.2.9 Forest Practices Code

The Forest Practices Code and Regulations adopted in 1995 define the manner in which forestry is practiced in B.C.. The following preamble from the Forest Practices Code, shows that the protection of water quality is a primary objective to the Code.

WHEREAS British Columbians desire sustainable use of the forests they hold in trust for future generations;

AND WHEREAS sustainable use includes:

a) managing forests to meet present needs without compromising the needs of future generations,
b) providing stewardship of forests based on an ethic of respect for the land,
c) balancing economic, productive, spiritual, ecological and recreational values of forests to meet the economic, social and cultural needs of peoples and communities, including First Nations,
d) conserving biological diversity, soil, water, fish, wildlife, scenic diversity and other forest resources, and
e) restoring damaged ecologies;

7.2.10 Private Land Forest Practices Regulations

The Private Land Forest Practices Regulations adopted by the Province in 1999 apply to private timberland lands within the Forest Land Reserve or private timberland under the Managed Forest Tax Class. The objectives of the regulation is the protection of the following resources:

Water Quality and Fish Habitat

Landowners will conduct their harvesting, silviculture and road building so as not to harm water quality and fish habitat. Enough streamside vegetation, including mature trees, will be retained to manage some important elements of fish habitat, such as shading, nutrient contribution, large woody debris and streambank stability.

Landowners will work to address water quality concerns. Fertilizer use is controlled by ensuring that fertilizer is not applied within a 10 m buffer of visible streams and pesticide use is controlled by the Pesticide Control Act and regulations.

Soil Quality

The conversion of productive forest land to permanent roads, landings and other uses must be kept within specified limits in order to minimize the loss of productive forest land. Other regulations aim to prevent soil erosion and ensure slope stability.

Critical Wildlife Habitat

Landowners will provide opportunities for the study of critical wildlife habitat on their lands. Necessary habitat features that cannot be provided on Crown Land may be protected through an agreement between government and the landowner.

Reforestation

If landowners subject to these regulations wish to maintain the managed forest classification of their lands, all of their forest lands must be promptly regenerated with a healthy, commercially valuable stand of trees after logging. This continues the existing incentive-based commitment to reforestation.

7.2.11 Community Watershed Guidebook

The Ministry of Forests is applying for a Community Watershed designation to cover the lower reaches of the watershed including John Hart Lake and the surrounding draining lands. The effect of creating the Community Watershed designation is to revise the planning objectives to “maintaining water quality, quantity and timing of flow”.

At the strategic planning level, an increased level of planning is required, with restrictions being placed on planned harvest blocks. Harvest blocks cannot be proposed for areas with high hazard for landslides, very high surface erosion hazard and a moderate to very high risk of sediment delivery.

The rate of cut within the watershed is determined after a Watershed Assessment is completed.

At the operational level, harvesting layout must consider the location of domestic water intakes and no harvesting is allowed within 100 m upstream of an intake. Contingency plans in case of an emergency are not mandatory under the Forest Practices Code but are recommended. The contingency plan helps provide for supplying emergency water and rehabilitating the water system should damage occur.

Water quality monitoring is necessary to ensure the protection of water quality as referred to in the Forest Practices Code. The Ministry of Environment Water Quality Program is responsible for developing a strategy and implementation program for water quality monitoring, and for data management. Responsibility for funding and data collection is negotiated.

The Community Watershed Guidebook provides guidelines for riparian management, road construction, timber harvesting, fertilization, herbicide use and recreation within the watershed.

The Guidebook also gives target conditions for several attributes within a watershed. For Equivalent Clearcut Area (ECA), the target is 30% on any subbasin greater than 250 ha. Average cutblock size should be less than 20 ha with no clearcuts on high erosion hazard sites. On the coast, cutblocks should not be concentrated in the rain-on-snow zone.

7.2.12 Park Act

The Park Act is the overriding legislation that defines provincial parks and their uses within the province. Within the Act there are three designations of park, Class A, Class B and Class C. Strathcona Park has been designated at a Class A park, with the objective of preserving the natural environment for the inspiration, use and enjoyment of the public.

Within a park, 'resource use permits' may be issued, which is a license authorizing an activity or course of behaviour or conduct or the occupancy, use, development, exploitation or extraction of a natural resource.

The Act restricts the alienation of interests within a park, and sets as a primary objective the protection of natural resources.

Strathcona Westmin Class B Provincial Park covers the area permitted for Boliden Westmin resources to carry out mining operations. The land was given special designation because of mineral values and the decision by the provincial government to allow exploration and mining in this area. This park was separated out of Strathcona Park in 1965 and designated as a Class B provincial park. Mining began in 1966 and will continue dependant on reserves and commodity prices.

Strathcona Park Westmin Master Plan

The Strathcona-Westmin Provincial Park is a 3,328 ha Class B Provincial Park established to recognize an operating mine, the Myra Falls Operation of Westmin Resources Ltd. The Park is geographically contained within the boundaries of Strathcona Provincial Park. The following are highlights from the Strathcona Park Westmin Master Plan:

- The Class B Park is an interim status and will remain only as long as the mine is in operation. As portions of the Park are no longer needed for mining activities, they will be added progressively to Strathcona Provincial Park.
- The goal of this Master Plan is to accommodate the mine and, at the same time, protect the natural resources and provide recreation opportunities within the Park.
- Park zoning has been modified to reflect the unique purpose of this Class B Park. A Non-Conforming Use Area was included as well as an Intensive Recreation Zone, a Natural Environment Zone and a Special Feature Zone.
- Several branches of government have authority to issue orders to Westmin Resources Ltd. There is a potential for conflicting orders to be given. The plan recommends formation of a field level working group, composed of local representatives of agencies and coordinated by BC parks, to ensure clear direction is given to Westmin Resources Ltd.
- The plan recommends extension of the Strathcona Advisory Committee's mandate to include Strathcona-Westmin for the purposes of public consultation.
- A herd of elk reside in the lower Thelwood Valley. This represents the only known herd entirely resident in Strathcona and Strathcona-Westmin Provincial Parks. All human activities, including industrial, will be monitored to ensure that the presence of elk is not threatened.
- The park has some moderately significant recreational features. However, key backcountry opportunities in adjacent Strathcona provincial Park are accessed from the Park. BC Parks and Westmin Resources Ltd. will work together to ensure that mine operations do not inhibit this access.
- Recreational facilities will be upgraded to the same standard as those of adjacent Strathcona Provincial Park. New facilities are recommended, including: parking at the Price/Cream Trailhead, a backcountry campsite at Arnica Lake, portions of a loop trail and trailhead connecting Bedwell Lake to Cream Lake and the lower Thelwood Valley, and if supported by an impact assessment, a self-guided interpretive trail in the lower Thelwood Valley.
- Overall direction for management will be to protect the Park's recreation and conservation values while not imposing undue restrictions on the mine's operation.

One objective of the approved Strathcona Provincial Park Master Plan is "To eliminate the existing reservoirs at Jim Mitchell, Thelwood and Tennent Lakes once these are no longer needed by Westmin…". Through a review of reclamation and decommissioning plans, this Plan will ensure that this objective is achieved by returning the Strathcona-Westmin lands to a condition representative of their state prior to flooding.

Strathcona Park Master Plan – Issues Analysis

In 1993, a Master Plan was adopted for Strathcona Park. In 1999, a review of the master plan was implemented which lead to an update of the master plan and a reconfirmation of the vision for the Park.

An Issues Analysis document was published in December 1999, and a number of issues related to water quality.

Issue #4 – Industrial Structures within Strathcona Park

There are several concerns discussed within this issue, however in terms of water quality the primary concern was the damming of Buttle Lake and the use of the Heber Creek diversion. A proposal was implemented to work with BC Hydro and the Water Use Planning process to minimize the seasonal water level fluctuations of Upper Campbell and Buttle Lake and stabilize the channel of Elk River. In addition, the concept of removing the Heber/Crest Diversion was put forward.

Issue #11 – Education and Information

The 1993 Master Plan recommended constructing a headquarter facility at Buttle Narrows and developing a full communication plan with facilities, signs and interpretive strategies. The feedback in the Issues document was to follow this direction.

Issue #14 and #15 – Recreation Opportunities and Impacts of Recreation Use

The 1993 Master Plan encourages a wide variety of recreational activities of which boating, camping and horse use could impact water quality. The diversity of recreation opportunities was deemed as an important feature of the park that should be maintained.

The concern of impacts of recreation use was more limited to the more sensitive ecosystems. Dogs were a major concern. There is no mention in the master plan on the potential impact on water quality from horses or dogs (if the dogs are leased).

Issue #16 – Motor Boating

The proposal is to maintain motor boating as an acceptable activity in Upper Campbell and Buttle Lake.

7.2.13 Greenbelt Act

This act allows the Government to enter into agreement to acquire and maintain land as a greenbelt.

7.2.14 Ministry of Environment Lands and Parks Water Management Branch

In 1999, Ministry of Environment Lands and Parks, Water Management Branch published an Action Plan for "Tackling Non-Point Source Water Pollution in B.C.". In it, a series of causes of non-point pollution were identified:

- Land development
- Agricultural
- Stormwater Runoff
- On-site sewage systems
- Forestry and Range activities

- Atmospheric Deposition
- Boating and Marine Activities

Around these causes, a series of action plans were developed.

Education and Training

To increase awareness of NPS pollution prevention and promote non-polluting behavior.

1. Implement a public awareness strategy for NPS pollution.
2. Promote prevention of NPS pollution through industry associations.

Prevention at the Site

To provide specific voluntary tools and Best Management Practices to direct or guide environmentally responsible behaviour and stewardship actions at the source.

1. Support development and implementation of Best Management Practices.
2. Promote water conservation.

Land Use Planning, Coordination and Local Action

To provide proactive planning tools to address the need for coordination of action across all agencies responsible for managing NPS pollution, and for local understanding and commitment to action.

1. Incorporate water resource management objectives into land-use plans.
2. Promote NPS pollution prevention in waste management planning initiatives.
3. Lead development of water management plans or liquid waste management plans in critical areas.
4. Support government coordination

5. Support community-based waterbody protection initiatives.

Assessment and Reporting

To evaluate the effectiveness of the action Plan in preventing NPS pollution and improving the quality of surface and groundwater, and to guide ongoing Non-Point Source Action Plan development.

1. Evaluate performance of NPS pollution actions.
2. Assess key NPS pollution cases.
3. Continue reporting to the public.

Economic Incentives

To provide an opportunity for influencing behaviour and generating revenue to address NPS prevention.

1. Assess the potential for using economic incentives to encourage NPS pollution prevention.

Legislation and Regulation

To provide the broad government framework for development of program assignments of government resources and enforcement of actions.

1. Implement the water quality provisions of the new Fish Protection Act and Local Government Statutes Amendment Act.
2. Enhance agricultural waste management.
3. Enhance on-site sewage management.
4. Manage boat sewage.
5. Address forestry and range NPS impacts through the Forest Practices Code.

6. Propose new legislation to fill gaps.

7.2.15 Pesticide Control Act

The Pesticide Control Act regulates the use and application of pesticides in BC.

7.2.16 Summary-Provincial Government

As discussed in this section the Provincial Government has a number of legislative authorities that will impact on water quality in the watershed as follows:

- **Drinking Water Protection Act- The 2001 Drinking Water Protection Act provides the Provincial Government with the ability to protect watershed water quality by requiring that the Medical Health Officer and local government are consulted on statutory decisions affecting water quality such as mining, range and water management permits and logging plans. The Act also strengthens the inspection powers and establishes new prohibitions and penalties against contaminating a water supply and a water system. The Act creates the position and role for a Drinking Water Officer with the legal ability to deal with imminent or actual threats to the watershed water quality including abatement and restoration.**

- **Water Act- The removal, diversion or storage of water must have the approval of the Provincial Government. The granting of a new water license within the watershed would have to recognize multi-use water objectives and protection of the environment which would assist the District in protecting the watershed water quality.**

- **BC Environmental Assessment Act- This act became law in 1995 and requires new projects and modifications to existing facilities covered by the Act to complete an Environmental Assessment. The District should be consulted if an**

environmental assessment is required in the watershed. The process would allow the District the opportunity to ensure that the water quality is addressed.

- **The Fish Protection Act is legislation intended to protect fish habitat which should ensure the protection of the watershed water quality. On streams where fish are threatened the Act allows development of a recovery plan.**
- **Local Government Act- The Act focuses on drainage and stream related issues principally related to flooding and flood prevention. This would assist in a program to minimize the water quality impacts from residential development.**
- **Various Mineral and Mining Acts- The Mine Act deals with all mining, energy and industrial projects in B.C. Any projects in the Campbell River watershed covered by this Act would also be reviewed under the Environmental Assessment Act. The process would allow the District the opportunity to ensure that the water quality is addressed. The Mine Act also requires permitting of the operation including a reclamation fund to restore the site after completion of mining.**
- **Forest Practices Code- Introduced in 1995 regulates the forestry practices in BC with the primary objective of the Code being protection of water quality.**
- **Waste Disposal Regulations- These regulations pertain to the discharge of liquid wastes. The regulations identify waste discharge criteria and treatment standards. The protection of receiving water quality is the principal goal.**

7.3 Local Government Bylaws

The watershed study area spans the District of Campbell River municipal boundary and Electoral Areas D and H of the Regional District of Comox - Strathcona (RDCS). The majority of the study area, however, falls within the Regional District.

As part of this study, the Official Community Plans (OCPs) and Zoning Bylaws of both jurisdictions for their respective boundaries within the study area were reviewed. OCPs and Zoning Bylaws are the primary land use regulatory tools of local governments in British Columbia. An OCP is a document adopted by a local government (either

municipality or regional district) which outlines a broad set of objectives and policies to guide land use planning within a specified area. A Zoning Bylaw is more detailed and provides regulations that specify permitted uses as well as such parameters as lot size, density, and building envelope. The contents of an OCP and Zoning Bylaw are established by provincial legislation contained within the British Columbia Local Government Act. Local government actions are bound by the provisions of these documents, however, upon application, amendments to the OCP and Zoning Bylaws can take place.

While generally local governments have land use planning jurisdiction within their boundaries through implementation of OCPs and Zoning Bylaws, certain provincial legislation, including the Land Reserve Commission Act, supercede local government bylaws.

Through the Land Reserve Commission Act, the Land Reserve Commission (LRC) oversees privately held lands found within the Agricultural Land Reserve (ALR) and Forest Land Reserve (FLR). Much of the land within the study area found in the Regional District is FLR. The purpose of the LRC is to preserve and protect BC's farmland and help maintain BC's working forest. Specifically, the LRC is responsible for the administration of forest practices on private land in the FLR, which include consideration for the protection for fish habitat, water quality, soil conservation and critical wildlife habitat. In addition, reforestation is required.

A summary of the contents of the OCPs and Zoning Bylaws of Campbell River and the Regional District, as they relate to municipal/regional land use regulation within the study area, are outlined below.

7.3.1 District of Campbell River, Official Community Plan Bylaw No. 2555

Adopted in May, 1997 by Council bylaw, the District of Campbell River's OCP covers land use and development policies over the entire area of the District, encompassing

some 13,700 hectares of land. The OCP outlines the three key elements upon which all policies are shaped: protecting the environment, managing growth, and strengthening neighbourhoods (OCP, page 16).

The OCP clearly focuses on environmental considerations by:

- Establishing an Urban Residential containment boundary which confines all residential development, with the exception or rural subdivision, to within the boundary
- Stating that goal number 2 is to "protect water resources, maintain or restore high quality in both surface and ground water" (OCP, page 18)
- Identifying the watershed protection area of Campbell Lakes (OCP Map 12-3) and stating that the District will seek to have the watershed designated as a "sensitive Watershed under the Environment Management Act" Policy 12-4 (OCP, page 96)

The entire watershed study area falls outside the urban containment boundary. Within the study area and District boundaries there are three OCP designations. These include: Greenways, Resource Industrial, and Rural 2 units/hectare.

7.3.2 Greenways Designation

Much of the land within the study area is designated Greenways in the District's OCP. The OCP states that the designation of "greenway" is intended to identify that an environmental concern is present (OCP, page 21).

The Campbell River Greenway Vision is about "…how land use is implemented, managed, and maintained and is a vision of sustainable use…."(OCP, page 151). The OCP clearly states, however, that the greenway vision is not a demand to prohibit land use in much of the Campbell River watershed. Instead, the Plan states that the greenway vision will designate land into land use classes (possibly as many as seven different classes) from conservation corridors, and sensitive areas to trails. These different

greenway land-use classifications will allow for varying levels of tolerance for human disturbance. A comprehensive Greenway Plan is currently under development.

7.3.3 Resource Industrial Designation

Within the study area, a Resource Industrial designation has been applied to the Gold River Highway/Argonaut Road area, located east of McIvor Lake. The Resource Industrial designation is designed for those activities which require locations to be distanced from higher density development because they must be in close proximity to a particular resource or may be a potential nuisance due to noise, dust, etc.. The OCP states specifically that the Gold River/Argonaut Road area is reserved for the primary purpose of aggregate extraction.

7.3.4 Rural 2 units per hectare Designation

Generally, the District's OCP does not support rural residential development within District boundaries suggesting that this form of low density residential land use is more appropriate within the Regional District. However, the OCP does acknowledge existing rural residential development and a Rural 2 units/hectare designation is found west of Gold River Highway, south of John Hart Lake.

7.3.5 Oyster Bay – Buttle Lake Official Community Plan Bylaw No. 1857, Regional District of Comox - Strathcona

The Oyster Bay – Buttle Lake OCP of the Regional District provides land use policy direction for Electoral Area D and a small portion of Electoral Area H. The plan area includes all of the watershed study area from the District of Campbell River boundaries to Strathcona Provincial Park. The Plan was adopted in April, 1997.

With one exception, the Oyster Bay – Buttle Lake OCP designates the entire area within the watershed study area as Upland Resource. The Upland Resource designation limits

land use to resource dependent activities and industries and includes activities which require isolated sites such as the storage and manufacturing of explosives. Policies also acknowledge the need to integrate land and water management and to protect water quality within water source areas. In addition, policies restrict parcel size to a 400 hectare minimum within the study area.

The only exception to the Upland Resource designation is a Tourist Commercial designation for Strathcona Park Lodge. However, the OCP also states that Tourist Commercial uses ("New campgrounds and other tourist facilities…") may be permitted in any portion of the plan area without OCP amendment subject to specific conditions which include compatibility with adjacent uses and natural resource areas, provision of adequate buffering, and inclusion of systems for sewage disposal, stormwater management, and water supply/distribution. While Tourist Commercial designations are also subject to development permit area regulations, as established by the Regional District, to regulate form and character of the development, Strathcona Park Lodge is not subject to development permit regulations.

7.3.6 District of Campbell River, Zoning Bylaw No. 2700

The Campbell River zoning designations found within the Watershed Management Plan study area are outlined below:

Zoning Designation	Short Form	Permitted Use/Minimum Lot Size
Lake shore one	LS1	Single family residential, designed to manage land use along lake shores to protect the watershed, minimum lot size 8 hectares – clustering of bare land strata development is permitted within the overall permitted density
Lake shore two	LS2	Intended to manage resort, motel use along lake shores to protect the watershed, minimum lot size 100 hectares
Rural two	RU2	Uses, including residential, requiring large rural properties, minimum lot size 4 hectares

Zoning Designation	Short Form	Permitted Use/Minimum Lot Size
Greenways one	G1	Protection/enhancement of the natural environment, and includes passive recreational uses, no minimum lot size
Public Assembly one	PA1	Uses that provide social, educational, recreational, and other public services to the community, includes parks, recreation centers, and public utilities
Industrial three	I3	Resource industrial for industries removed from more intensive development due to proximity to resources or potential to create nuisances, minimum lot size 4 hectares

7.3.7 Campbell River Area Zoning Bylaw, 1991, Bylaw No. 1404, Regional District of Comox - Strathcona

All land within the study area boundaries of the Regional District is zoned Upland Resource, with the exception of Strathcona Park Lodge. The Upland Resource zone allows single family dwellings as well as, forestry, agriculture and park use. In addition, explosives sales, storage, manufacturing and firearm ranges are permitted. Low impact recreation use is also permitted, which could include camping. Only one dwelling is permitted per lot, with minimum lot size within the study area restricted to 400 hectares.

Strathcona Park Lodge is zoned Commercial Five (C-5). The C-5 zones permits hotels, campgrounds and recreation facilities, as well as park and agricultural uses.

Given the location of Forest Land Reserve areas within the study area and the application of the Land Reserve Commission Act, Regional District bylaw regulations, contained in both the Official Community Plan and Zoning Bylaw, have limited application. These documents must comply with the Land Reserve Commission Act, all amendments and regulations.

Official Community Plan and Zoning Bylaw designations for the District of Campbell River and Regional District are shown on Figures 7-1 and 7-2.

7.3.8 Summary – Local Government

As discussed in this section the Municipal Governments have a number of legislative authorities principally in the area of land use planning that can influence activities that could impact on water quality in the watershed principally the Official Community Plan/Zoning Bylaws. The District and the Regional District of Comox - Strathcona have adopted Official Community Plans and Zoning Bylaws for land within the Campbell River watershed. The role is created under the Provincial Local Government Act. The OCP outlines a broad set of objectives for land use while the zoning bylaws specify permitted land uses. The shaping of land use and conditions of development under Municipal Government jurisdiction to influence water quality impacts fall within this area.

7.4 Summary

The following is a summary of the present federal and provincial legislation and local government bylaws that regulate land use and land use activities that could impact water quality in the Campbell River Watershed.

TABLE 7-1
SUMMARY OF LEGISLATION INFLUENCING WATER QUALITY

Jurisdiction	Regulation Act	Focus	Consequence to Water Quality
Federal	Fisheries Act	Protection of fish and fish habitat • Protects stream beds from disruption • Prohibits introduction of deleterious substance to water that could harm fish.	The consequence is that water quality is protected.
	Navigable Water Protection Act	Permission is required to build or place works in any navigable water. Any works in the water and covered by this act require permitting and may fall within Environmental Assessment Act.	The District would have to be consulted.

Jurisdiction	Regulation Act	Focus	Consequence to Water Quality
	Environmental Assessment Act	Environmental Assessment required where the Federal Government has jurisdiction and would be triggered for authorization of project types on the listed in regulations.	The focus of the assessment is on sustantiability including protection of water quality.
Provincial	Water Act	Governs construction, operation and maintenance of works to ensure beneficial use of provincial water resources. Licencing of diversion and storage of water. Objectives include protection of fish and aquatic habitat, flood control and drinking water supply.	As a water licence holder in the Campbell Systems the District would need to be consulted on new licence applications.
	Environmental Assessment Act (June 1995)	New and modifications to existing power plants and water management containment/diversion plants.	
	Fish Protection Act	Protection of fish stocks and habitat on sensitive streams habitat on sensitive streams.	There are no streams designated within the Campbell River Watershed.
	Forest Acts	A number of regulations to manager timber on Crown Land.	
	Local Government Act	Delegated responsibility to municipalities and Regional District governments for drainage and stream related issues.	Allow for bylaws to prohibit polluting and affecting a stream.
	Mining Acts	Cover all mining, energy and industrial projects. Covers exploration, land tenure.	Environmental Assessment Act would be triggered for new projects the Campbell River watershed. Established conditions of operation and reclamation on existing mining operations.
	Forest Practice Code (1995)	Details the manner in which forestry is practiced in BC. Primary objective is water quality protection.	Minimizes the impact of forestry practices on water quality.
	Private Land Forest Practices Regulations (1999)	Applies to private timber land within the Forest Land Reserve or private timberland under the managed forest tax class. The objectives are projection of water quality and Fish Habitat.	Minimize the impact of Forestry practices on water quality.

Jurisdiction	Regulation Act	Focus	Consequence to Water Quality
	Greenbelt Act	Acquire and maintain land as a greenbelt.	
	Ministry of Environment Lands and Parks Water Discharge Regulation	Focus in on liquid waste discharges and treatment goals within the context of the receiving environment.	Permit condition should recognize the use of the Campbell River as a direct water source.
	Pesticide Control Act	Regulates the use and application of pesticides.	Minimize any unintended impacts with the use of pesticides.
Local Government	Official Community Plan Zoning Bylaw	Planning and approval of land use. Certain provincial government legislation supercedes local government bylaws.	Land use and conditions of land development to reduce the risk to water quality.

8.0 DRINKING WATER PROTECTION ACT

The regulatory authority for drinking water quality in British Columbia rests with the Ministry of Health through the Upper Island/Central Coast Community Health Services Society. This chapter reviews the regulatory approach and issues.

8.1 BC Drinking Water Protection Act

The BC Drinking Water Protection Act (Bill 20) was adopted by the Province in April 2001. The Act establishes a lead authority on drinking water in BC. A provincial drinking water co-coordinator from each of the ministries of Health and Environment will provide central direction on drinking water issues and support regional drinking water programs. Community based drinking water officers will be responsible for drinking water issues in each health region of B.C.

The Act establishes that a water supplier must provide potable water, which is defined in the Safe Drinking Water Regulations, and receive a "Construction Permit" to undertake any changes to a water system. Every water supplier must hold a "Permit to Operate" a water system and qualified persons must operate the water system. The qualifications will be identified by Provincial regulations. Each water supplier must have a written approved emergency response plan detailing plans to be implemented in an emergency. The Act also identifies water quality sampling and prescribed methods to report the results to the drinking water officer. The water supplier must report any threats to the drinking water system. All water suppliers must make the emergency response plan and water quality results available to the public.

If required by the drinking water officer a water system may have to undertake a water source and system assessment. The assessment process, public notice and assessment response plans are identified in the act.

The act prohibits the contamination of drinking water or tampering with a water system. No person shall introduce or cause to introduce anything that will result in a health hazard. A drinking water officer has broad powers to deal with the actual or imminent drinking water health hazards which include powers to order abatement, repairs or a remediation plan. The act provides broad powers to recover reasonable costs if an order is in default.

The act also allows for the preparation of a drinking water protection plan if the minister considers that a plan will assist in addressing or preventing threats to drinking water. The plan development process, approval for the plan and plan implementation are outlined. Key to the plan is that the plan must be considered by persons making a decision under a specified enactment, restrict issuance or amendments of licenses, approvals or permits and provide a higher-level plan for purposes of the Forest Practices Code.
The act also allows that the drinking water officer may enter a property to conduct an inspection.

In summary the Drinking Water Protection Act:

- Provides a higher standard of care for regulation of water systems and protection of water sources.
- Ensure that local governments, the medical health officers and the drinking water officers are consulted on senior land use decisions affecting drinking water quality such as forestry plans and waste management permits.
- Requires water quality monitoring and identifies procedures for reporting the results.
- Prohibits the contamination of drinking water or tampering with a water system.
- Allows for the development of drinking water protection plans to address and manage any threats to drinking water quality.

- Establishes training and qualification for water system operators.
- Sets water quality standards.
- Affirms the public's right to know about their drinking water system.
- Establishes obligations on the part of the water supplier to report threats to drinking water supplies.

8.2 British Columbia Safe Drinking Water Regulation

The British Columbia Safe Drinking Water Regulation came into effect October 1, 1992. The Regulation was amended in April 2001. A copy is provided as Appendix 3. The regulation provides a framework for the construction and operation of a domestic water system to ensure that potable water is supplied to all users of a waterworks system. A water purveyor must have a "Permit to Operate" a water system, receive permission to construct changes to the water system in the form of a "Construction Permit" and have written an Emergency Response Plan to be implemented in the event of an emergency affecting the water system. The water purveyor must notify all users on the water system if there is a potential health hazard. The manner, wording, time period for notification and frequency of repeat notices will be agreed to with the medical health officer.

Water supplied through a water system must be potable. Potable water means water that meets the standards established by Schedule A of the Regulations and is safe to drink and fit for domestic purposes without further treatment. Schedule A of the Regulations specifically identifies the microbiological standards to be met (Table 8-1). Failure to meet the B.C. standards can result in a fine of not more than $2,000 or imprisonment of not more than 6 months in jail or both.

Table 8-1 B.C. SAFE DRINKING WATER REGULATION MICROBIOLOGICAL STANDARD (SCHEDULE A)	
For a waterworks system to meet the standard, sample tests must meet the following criteria:	
Fecal coliform Escherichia Coli Total coliform:	Less than 1 fecal coliform/100 mL Less than 1 Escherichia Coli per 100 mL
i One sample within a 30-day period.	0 total coliform/100 mL
ii. More than one sample in a consecutive 30-day period.	90% or more of the samples must have 0 total coliform/100 mL and no sample must have more than 10 total coliform/100 mL.

The Regulations also state that water systems serving 15 or more service connections must meet the standard established in Schedule B of the Regulations. The medical health officer may order improvements to the water system to reduce or eliminate the health risk posed by the failure to meet the water quality standards identified in Schedule B. The criteria adopted by the Ministry of Health in Schedule 3 of the Regulations are from the "Guidelines for Canadian Drinking Water Quality". In the guidelines, Maximum Acceptable Concentrations (MAC) have been established for certain substances that are known or suspected to cause adverse effects on health. They have been derived to safeguard health on the basis of lifelong consumption. To the extent possible, the use of drinking water for all usual domestic purposes, including personal hygiene, has been considered in the derivation of the Guidelines.

The guidelines are the result of a cooperative Federal/Provincial process and are used as targets for drinking water quality. Health Canada provides the leadership in determining what guidelines need review. The sixth edition of the Guidelines contains guidelines on biological water quality, aesthetic water quality, chemical and physical characteristics and radiological characteristics. At the present time, there are 54 maximum or interim MAC for chemicals and 25 aesthetic objectives. About 28 parameters have no guidelines as there is either no data indicating a health risk, or may be harmful but not registered for use in Canada or not likely to occur in drinking water.

The need to review or develop a new guideline is determined on a priority basis by Health Canada. The initiation of a review could be triggered for a number of reasons, but is usually the result of a review of recent scientific information. The provinces and territories all have appointed representatives to the Federal/Provincial Subcommittee on Drinking Water. It is this group which is responsible to provide a technical review of the proposed changes and establish a provincial or territorial position.

8.3 Safe Drinking Water Act

The Ministry of Health and Ministry of Municipal Affairs, in approving recent treatment construction plans for British Columbia municipalities improving their treatment methods, has directed that the work be done to the United States Environmental Protection Agency (USEPA) Safe Drinking Water Act (SDWA), principally for the treatment goals.

Under the SDWA there are drinking water standards. There are 92 contaminants including turbidity, 8 microorganisms, 4 radionuclides, 19 inorganic contaminants and 60 organic contaminants. Maximum contaminant levels have been set for 83 contaminants and 9 contaminants have treatment requirements. The latter includes cryptosporidium, fecal coliforms, giardia, heterotrophic bacteria, legionella and viruses.

There are several drinking water regulation rules that accompany the SDWA as follows:

- Surface Water Treatment Rule,
- Disinfection Byproduct Rule,
- Inorganic Contaminant,
- Total Coliform Rule,
- Lead and Copper Rule,
- Consumer Confidence Rule,
- Nitrate/Nitrite Rule,

- Organic Contaminant Rule,
- Maximum Disinfectant Residual Concentration Rule.

8.4 Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) mandates filtration and disinfection for all water utilities in the U.S. using surface water as a source unless the raw water is of high enough quality that disinfection alone is suitable. The United States Environmental Protection Agency has assumed that all surface water supplies are at risk of contamination from Giardia lamblia, viruses and pathogenic bacteria. Treatment (disinfection with or without filtration) must achieve at least as a minimum 99.9 percent (referred to as 3 log) removal or inactivation of Giardia lamblia cysts and 99.99 percent (referred to as 4 log) removal or inactivation of viruses.

8.4.1 Filtration

Operating criteria are established for systems that must install filtration. At no time must the filtered water turbidity exceed 5 nephelometric turbidity units (NTU) and 95 percent of the measurements taken must meet the following turbidity limits:

- slow sand filtration - 1 NTU
- conventional or direct filtration - 0.5 NTU; and
- diatomaceous earth - 1 NTU

The residual disinfectant in treated water entering the distribution system must not be less than 0.2 mg/L and must be detectable anywhere in the distribution system.

8.4.2 Filtration Variance

A utility using a surface water source must use filtration unless it can meet the following key source water quality criteria conditions:

- **Turbidity limits** - the raw water turbidity must not exceed 5 NTU.

- **Disinfection** - the system must employ disinfection to achieve a 99.9 and 99.99 percent inactivation of Giardia cysts and viruses respectively. The minimum CT (C is the disinfectant residual, mg/L while T is the disinfectant contact time, minutes) values as established in the rules must be achieved each day. Typically the CT will vary between 150 and as high as 400-500. Duplicate independent disinfection equipment must be in place.

- The system must not have been identified as a previous source of waterborne giardiasis.

- The system must comply with the total trihalomethane limit of 80 micrograms/L.

- The system must undertake a watershed sanitary survey and maintain an effective watershed control program.

- The fecal coliform count in the raw water must be less than 20/100 mL and the total coliform count must be less than 100/100 mL. (Both levels must be met in 90% of the samples in any consecutive 6 month period.)

- **Disinfection Byproduct Rule -** This rule establishes the contaminant standards for a number of disinfection byproducts. The principal byproducts associated with the use of chlorine include total trihalomethanes (0.080 mg/l) and haloacetic acid (0.060 mg/l).

- **Maximum Disinfectant Residual Concentration Rule -** This rule establishes the maximum disinfectant residual in a water distribution systems as 4 mg/l for free chlorine and chloramines and 0.8 mg/l residual for chlorine dioxide. The District relies on a free chlorine residual and the "Water Quality Study" identified the typical chlorine residual as ranging between 0.25 mg/l and 0.75 mg/l.

8.5 Water Quality and Issues

a) Microbiological

The risk to a waterborne disease outbreak comes from bacteria, viruses and parasites.

Giardiasis: *Giardia lamblia* (Protozoa) is an intestinal parasite which is transmitted by most warmblooded animals and can affect humans. It is the parasite that has in the last twenty years changed the way water utilities and regulators in North America approach water treatment.

Morphology. The existence of Giardia lamblia was first noted by Van Leeuwenhoek in 1681. The life cycle of the microorganism involves two stages, the inactive cyst stage and the active, reproductive and disease causing trophozoite stage. The cyst is ovoid in shape, consists of four nuclei and possesses a thick hyaline wall. The trophozoite, is pear-shaped, includes two anterior nuclei and four pair of flagella. The microorganism measures from 10-15 microns in length and 7-12 microns in width. The cyst is about the same size as a silt particle and larger than bacteria.

Life Cycle. The Giardia lamblia cyst lives in the duodenum, jejunum and upper ileum of the digestive tract. In general, when the inactive cyst is swallowed by a host it undergoes a process of excystation, or breakdown of the hyaline wall, in the upper portion of the small intestine. Within 30 minutes of ingestion a cyst hatches out two trophozoite. An infecting dose can be as little as 1 to 10 cysts with 10 to 1 million cysts producing a 100

percent infection. The cyst wall breaks down and the newly formed trophozoite attaches its large sucking disc to the wall of the intestinal tract. The sucking disc fits over the epithelial cells with every cell being covered in a severe infection. The trophozoite reproduces by simple fission. The trophozoite and cyst forms are released to the environment through the host fecal wastes.

It has been calculated that between 300 million and 14 billion cysts could be contained in a human stool sample. The thick wall permits the cyst to survive up to two weeks in a moist environment outside the host's intestinal tract. In cold water (8ºC) cysts can remain viable for two or more months and in warm water (21ºC) cysts can survive about one month. Boiling water will immediately destroy the cyst. The cycle is repeated when an individual ingests water or foods, which are contaminated with cysts.

Transmission. Infection occurs by ingestion of the cysts in contaminated water or food. The cysts from humans, dogs, cats and beavers have been found not to be host specific so that cysts from humans infect dogs, cats, and beaver and it is assumed that Giardia from dogs, cats and beaver can infect humans.

Symptoms/Treatment. The Giardia lamblia trophozoite attaches to the intestinal wall in a dense coating and feeds off mucous secretions. This interferes with the absorption processes in the intestine and irritation or inflammation of the mucosa. The typical consequence is acute or chronic diarrhoea including water, greasy, foul smelly stools. Symptoms include weakness, weight loss, cramps, nausea and vomiting. The typical treatment for giardiasis are the drugs quinacrine, metronidazole (Flagyl) and Furazolidone (Furoxone).

Detection in Water. The detection of the Giardia lamblia cyst in ambient water sources is difficult because of the typically low concentrations and variability with time. The standard method of detection includes concentration of a water sample through filtration, separation of the trapped material from the cartridge and microscopic examination. The problem with the procedure includes the cost of analysis, length of time required for

results, low recovery efficiency, and the high volume of samples needed to overcome the typically low cyst concentration in ambient water.

Occurrence of Giardia Lamblia Cyst. Giardia lamblia occurs world-wide. On the basis of stool examination the prevalence of Giardia lamblia in the United States was from 4 to 22 percent present in children and 2 to 15 percent present in adults.

In British Columbia, a survey for Giardia Duodenalis was carried out between April 1985 to July 1986 on feces from 388 fur-bearing animals trapped throughout the province. On 299 beaver specimens examined, 44 or 14.7% were positive for Giardia. A positive rate of 19.50% was found for muskrat. Thirty-one beavers positive for Giardia were trapped in the central area of British Columbia (Cariboo, Northern Interior, South Okanagan, South Central Health Units) while nine were trapped in the southeast of British Columbia (East and Central Kootenay and North Okanagan Health Units). The study confirmed that Giardia is found in both beaver and muskrat in all parts of British Columbia studied. Waterborne disease outbreaks in British Columbia have occurred at such locations as 100 Mile House, Penticton, Creston and Revelstoke.

Cryptosporidium:

Cryptosporidium is a pathogen that is and will further change the approach to water treatment in North America.

Background. Cryptosporidium is a parasite. It has a two stage life cycle with infection occurring in the form of an "oocyst" - a microorganism protected by a tough outer shell which invades intestinal epithelial cells. This may cause cryptosporidiosis, a gastrointestinal illness. According to the USEPA, the oral infectious dose for man is thought to be less than 10 oocysts, but further studies are needed to confirm this.

The epidemiology and transmission of Cryptosporidium is similar to Giardia. It's hardier, smaller (3-5 micron), and more resistant to disinfectants than Giardia. It is

suspected of having more potential for animal-to-human transmission than Giardia. Cryptosporidium is known to infect most mammals; young animals are most susceptible. Anywhere animals defecate can become a contamination source.

History. Cryptosporidium was first recognized as a pathogen during an outbreak of diarrhoea in a turkey flock in 1955 and was first identified in people with weakened immune systems in about 1980. Waterborne outbreaks of cryptosporidium in British Columbia were identified in the City of Cranbrook and the City of Kelowna while in the United States at Milwaukee (1993) affecting 300,000 people and Carrollton, Georgia (1987) affecting 13,000 people.

According to the USEPA, Cryptosporidium is normally not found in groundwater because of natural soil filtration. Cryptosporidium in the Carrollton outbreak survived routine disinfection procedures in the community water supply system. A filtration problem in the water system contributed to the outbreak.

Symptoms. Typically, symptoms start 8-10 days after oocysts have been ingested. Cryptosporidiosis symptoms include diarrhoea, abdominal pain, nausea and vomiting, and low-grade fever. Some people appear to be asymptomatic (i.e., no symptoms although oocysts are present in stool samples).

People with compromised immune systems are very susceptible to cryptosporidiosis. These include AIDS patients, cancer patients undergoing chemotherapy (which supresses the immune system), those suffering from certain viral illnesses such as chicken pox or measles, and malnourished children. Symptoms disappear and the immune system returns to normal.

In otherwise healthy people, the illness generally lasts no longer than 30 days. Symptoms may wax and wane. Diarrhoea may be followed by 7-10 days with no symptoms, than a second or even third episode of diarrhoea may occur. Illness duration may be as short as 8-10 days or as long as 25-26 days. Symptoms typically last 10-14 days in children.

Water Treatment Impact. A properly operated treatment plant is thought to remove 85 to 99 percent of cryptosporidium oocysts. A study showed that slow sand filters may achieve greater than a 3-log (99.9 percent) reduction of Giardia and Crytosporidium. Another study evaluated diatomaceous earth filtration for removal of Giardia and Crytosporidium from surface water. Essentially all of the Giardia and Cryptosporidium were removed from waters containing approximately 2,000 cysts/L. Removal of cryptosporidium was further improved by using alum during treatment prior to rapid rate filtration. Chlorine is not very effective in killing the organism but ozone studies have shown promise. Waterborne cryptosporidiosis outbreaks in British Columbia have occurred at Kelowna and Cranbrook.

iii) Total and Fecal Coliforms. A number of organisms have been considered as indicators of health risk for consumption of drinking water. These include the fecal coliform which have been used for a number of years as the legal water quality indicator. Coliform bacteria occur naturally in the soil and on vegetation, whereas fecal coliforms are restricted to the gastro-intestinal tract of warm-blooded animals such as birds and mammals, including humans. Because the number of pathogenic organisms present in water are few and difficult to isolate, the coliform organisms which are more numerous (each person discharges 100 to 400 billion coliform organisms per day) and more easily tested for, are used as an indicator organism. The presence of coliform organisms is taken as an indication that pathogenic organisms may also be present and the absence of coliform organisms is taken as an indication that the water is free from disease producing organisms. According to the Ministry of Health the objective coliform level for domestic water is "no organisms detectable per 100 mL". However, in practice this level is not always attainable.

The following maximum acceptable level is adopted for all drinking water sampled at the consumer's tap.

1. No sample should contain more than 10 total coliform organisms per 100 mL; and
2. Not more than 10 percent of the samples taken in a 30-day period should show the presence of coliform organisms; and
3. Not more than two consecutive samples from the same site should show the presence of coliform organisms; and
4. None of the coliform organisms detected should be fecal coliform.

b) **Turbidity:** Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a liquid sample. Turbidity in water is caused by any suspended matter which interferes with the clarity of the water. This may include clay or silt, algae, and other organic or inorganic compounds.

Typical sources of turbidity in drinking water include runoff from disturbed or eroding watersheds, algae or aquatic weeds and products of their breakdown in water reservoirs, rivers or lakes and humic acids and other organic compounds resulting from decay of plants and leaves in water sources.

Excessive turbidity in drinking water is not only unsightly, but also may be a health concern, since the turbidity-causing particles can interfere with the disinfection process. In effect, the particles of turbidity provide "shelter" for microbes by reducing their exposure to the action of the disinfectant. Turbidity also reacts with disinfectants directly, causing quick depletion of disinfecting power, possibly allowing disease causing pathogens to survive and be passed into the distribution system. Turbidity causing particles can provide food for microbes, promoting their regrowth in the distribution system. The Health and Welfare Canada maximum turbidity level is 1 NTU with a provision that a maximum of 5 NTU at the users tap.

c) **pH:** The pH value is a measure of the hydrogen iron concentration in the water and it indicates the balance between acids and bases. The Health and Welfare Canada Guidelines recommend a pH for drinking water of between 6.5 and 8.3. A pH greater than 8.3 interferes with disinfection while a pH less than 6.5 indicates a corrosive water.

d) **Alkalinity/Hardness:** Alkalinity is a measure of the water's capacity to neutralize an acid while hardness is a measure of the divalent cations, especially magnesium and calcium. Alkalinity standards have been set as a guide to chemical balance with water for treatment processes involving chemical addition, to avoid corrosion and encrusting properties and to minimize gastro-intestinal problems. Hardness can have a positive effects on human health but may have a detrimental effect on piping due to scaling. According to the Health and Welfare Canada guidelines, the acceptable alkalinity range is 30 to 500 mg/L as calcium carbonate while the hardness should be less than or equal to 120 mg/L as $CaCO_3$.

e) **Colour:** The Health and Welfare Canada recommended maximum and objective level is less than 15 alpha (colour units). While the standard is set for aesthetic considerations, the presence of colour is viewed as an indicator of levels of complex natural organic matter (humic substance) resistant to microbial degradation. Organic content is a problem for a number of reasons:

1. Certain organics contribute to taste and odour problems.
2. The presence of organic matter may lead to problems with biological quality changes in the distribution system.
3. The presence of organic matter may aggravate corrosion problems.
4. Organic compounds have been shown to interfere with oxidation and removal of iron and manganese.
5. Haloforms and other halogenated organic compounds can be formed on addition of chlorine.
6. Certain organic compounds are harmful.

7. Organic matter can shield waterborne pathogens from disinfection treatment and can lead to water quality problems in the distribution system.
8. May adversely affect some industrial processes.

Colour could also be arrived from natural mineral components such as iron and manganese.

f) **Total Organic Carbon:** The Total Organic Carbon (TOC) is a direct expression of the total organic carbon in the water such as humic substances, which have the potential to create Disinfection By-Products (DBP's). The TOC measures the amount of carbon associated with organic compounds in a sample. The lower the TOC the lower the organic compounds present and the lower the DBP in reaction with disinfectants such as chlorine.

There are no standards for the TOC levels in drinking water but according to the Water Quality Sourcebook (Environment Canada) a level of "less than 3.0 mg/L has been observed to be relatively clean".

g) **Disinfectant Byproducts:** Disinfection by-products form a by-product when a disinfectant is added to water. The resulting reaction of the disinfectant with organics in the water forms disinfection by-products. These by-products are a concern because some are suspected carcinogens (cancer causing). As a result of this concern, trihalomethanes (THMs), a disinfection by-product, are presently regulated by the Ministry of Health at an average annual limit of 0.1 mg/L based on at least four water samples.

Temperature: A water temperature of less than 15^{o}C is considered acceptable for domestic consumption according to the Health and Welfare Canada Guidelines. Water temperature also affects the efficiency of some unit water treatment processes, influences

the biological growth in distribution lines and may impact on taste and odour characteristics.

8.6 Discussion

It is anticipated that the Ministry of Health will require that British Columbia water purveyors meet the GCDWQ and have treatment that will provide a 3 to 4 log giardia removal and 4 to 5 log viruses removal. If the turbidity is less than 1 NTU and the organics are low then the treatment could be achieved by disinfection. If the turbidity is greater than 1 NTU then filtration would be required. The goal of the WMP is to ensure a John Hart Lake quality that meets the GCDWQ, the turbidity is less than 1 NTU and the microbiological threat from bacteria viruses and parasite cysts is minimized.

9.0 DESCRIPTION OF RISK

Under the BC Drinking Water Protection Act (2001) British Columbia water utilities must meet the "Guidelines for Canadian Drinking Water Quality" (GCDWQ). The guidelines identify Maximum Acceptable Concentrations for a number of water quality parameters. The first step in the watershed management plan is to identify the activities in the Campbell River system that could affect the District's drinking water quality at the John Hart intake. As identified earlier, historically the District's water has been judged to be excellent with the only identified issue being the corrosive nature of the water, a characteristic of most surface water sources in coastal British Columbia.

This chapter provides a summary of those present activities that could possibly impact the District's drinking water quality. The activities identified at the Watershed Planning Committee Meeting Number 1 and the Public Open House Number 1 are discussed in this Chapter.

The District has both an intake system off the BC Hydro penstocks below John Hart Dam and an intake located in John Hart Lake. The latter intake is the water source for the Industrial Park area of the District while the former serves the remainder of the District. Given the large area of the watershed and the nature of the watershed in terms of the high annual runoff, for purposes of this analysis, it was decided to segregate the watershed into four geographic zones and three subzones (Table 9-1). The subzones are buffers around the lower lakes and reflect the higher concentration of activity and closer proximity to the main water flow.

TABLE 9-1
WATERSHED ZONE DEFINITION

Zone Identifier	Description	Comments
A	John Hart Lake watershed below Ladore Dam	The intake is within this watershed and activities will likely have a higher risk of affecting the District's water quality.
A1	100 m buffer strip around John Hart Lake	This subzone has the closest proximity to the water intake, so activities can pose the highest risk.
B	Lower Campbell Lake watershed below Strathcona Dam, to the first order stream	
B1	100 m buffer strip around Lower Campbell Lake	This subzone has a high concentration of recreational activity.
B2	100 m buffer strip around McIvor Lake	This subzone has the highest concentration of residential properties.
C	Upper Campbell Lake watershed and, the Lower Campbell Lake watershed above the first order streams.	
D	BC Hydro Diverted Watersheds.	These watersheds are the most remote from the intake.

The Figure 9-1 identifies the boundary of the four zones.

The risk posed by the various activities can be categorized into key water quality categories as follows:

- Turbidity/Sedimentation - Turbidity is typically clay and silt particles in water and is a direct measure of the light reflected through water with the more light reflected indicating more particles in the water column. It is a water quality measurement used by regulators to determine the type of water treatment process required. It is used for water treatment process control and treatment efficiency measurement, and affects the efficiency of disinfection. Minimizing the turbidity levels is a very important goal of this watershed management plan in that if greater than 1 NTU it could force the District into water filtration.

- Chemicals - The GCDWQ identify a number of chemicals, that if present in the drinking water and consumed in high enough concentration over the long term (50 to 70 years), can affect human health.

- Microbiological - Drinking water is a common pathway for transmission of waterborne diseases from bacteria, viruses and parasitic organisms. The giardia lamblia cyst and cryptosporidium oocyst are two parasitic organisms that are more common in North American waters to the extent that they are the focus of evolving water treatment regulations.

- Metals - The GCDWQ identify a number of metals, that if present in the drinking water and consumed in high enough concentrations over a long period of time (50 to 70 years), can affect human health.

The following sections identify the activities and possible impacts on the water quality at the District's intake. As will be discussed in the next chapter the actual risk to the District's water quality from the activity depends on the (i) frequency, (ii) duration , (iii) magnitude and (iv) spatial distribution of the activity.

9.1 Forestry

As tabulated in Table 4-2 approximately 33% of the total watershed land area (including diverted watersheds) are under active forestry management including lands owned by the Crown Provincial Forest, TimberWest and Hancock. The activities that could have a potential impact on the District's water quality include timber harvesting, access road construction, deactivation and maintenance and silviculture. All the activities would fall under the provisions of the Forest Practices Code or Private Land Forest Practices Regulation.

9.1.1 Forest Harvesting

Forest harvesting may lead to several types of events (hazard processes) that can reduce water quality. As with most of the hazard processes, the proximity to the water intake has a significance to the consequence or level of damage to water quality.

Forest harvesting can cause sedimentation through alteration of water flow on the hillslope, specifically underground flow, which can cause landslides. The likelihood of landslides increases with the slope gradient, and seldom occurs on slopes under 40%, unless there is a highly erodible soil type such as a lucustrine.

Surficial erosion can occur with soil exposure due to harvesting practices (scraping logs across the ground) or by blowdown of trees remaining along the edge of a cutblock, unaccustomed to the exposed winds. The movement of surface soils in this situation is limited by slash in the cutblock, herbaceous and shrub vegetation, the slope of the ground and the porosity of the soils. Most soils in the Campbell River Watershed are porous and little surface movement of water occurs.

After harvesting, the organic matter on the forest floor is reduced by two processes: accelerated decomposition; and the alteration of inputs to the nutrient cycle.

In a stable forest, there is a cycle of nutrients, similar to the water cycle. Many of these nutrients are banked in the forest floor, where they are released through decomposition of the organic matter and leaching of the nutrient compounds. The trees take up the nutrients through the roots, and then as the tree looses its leaves/needles or dies and falls over it cycles the nutrients back to the forest floor. This is a simplified description as there are several other inputs and outputs to the cycle. After harvesting, the major input component to the cycle is lost and while decomposition continues to occur, and the nutrient compounds remain in the ground water. This process is temporary as the balance returns after herbs, shrubs and ultimately new trees invade the site. The effects are small and the nutrients are soon diluted as the ground water reaches the lake.

Accelerated decomposition is caused by a warming of the soil due to the loss of forest cover.

Water can also be contaminated by oils and greases from the machines and the personal hygiene of the crew. The most likely scenario for this contamination is through the breakage of a hydraulic hose, where the hydraulic fluid is under pressure and is sprayed from the break. New machine designs limit the amount of fluid that is lost in such an event and in highly sensitive areas, vegetable based hydraulic fluids can be used.

Regular machine maintenance, such as oil changes, can now be done in a manner that prevents oil leakage, and spill kits should be utilized. The personal hygiene of the crew is a minor issue.

9.1.2 Roads (Construction, Maintaining, Deactivation)

The issues possibly affecting water quality from roads include:

- Slope failure through failure of existing roads
- Slope failure due to channeling of hillslope water courses
- Slope failure due to current road construction (eg blasting caused failures)
- Erosion of road surface
- Stream sedimentation during bridge and culvert construction
- Water contamination through oils and greases leaking from machines
- Source and placement of blasting materials
- Dust control
- Ditch cleaning

9.1.3 Silviculture

Forest management practices include the selected use of fertilizers to increase tree growth rates and herbicides/pesticides to manage the tree species in areas of reforestation. The issue is the potential to transmit the chemical to the watercourse and the impact on the District's water source.

Use of herbicides is regulated by the Provincial government and requires a permit from the MOELP based on a Pesticide Management Plan. Conditions include a minimum 50 meter buffer from major streams and consultation with affected neighbours.

Whereas the application of fertilizers does not require a permit, the Private Land Forest Practices regulations state that fertilizers must not applied within 10 m of a visible stream.

9.1.4 Protection

Forest fires, pest infestations or tree disease outbreaks can have effects on water quality, however the practice of broadcast burning has been stopped and the occurrence of wildfires is very low. The occurrence of pest and disease outbreaks is also very low.

Forest fires impact water quality directly through sediment input of the ash and soot and by chemical changes made in the ground water. The chemical changes are caused as rainwater leaches various chemical compounds out of the ash on the ground. The chemical leaching does not have a significant impact. Fire retardants, used in fire fighting, have a phosphate base that can cause minor changes in water quality. The effective changes are small and soon diluted as the groundwater reaches the lake.

When trees are killed by fire, mechanical root strength reduces as the roots deteriorate, slightly increasing the risk of landslides. On hot burns, where much of the shrub and

herbaceous vegetation is burnt off, the surface erosion protection provided by these plants is lost and the risk to sedimentation by surface erosion is increased.

Pest infestations and disease outbreaks have minor effects on water quality. When a tree dies the deterioration of roots is similar to fires. There is also an increased risk of tree blowdown, which exposes soil to surface erosion.

Root "stumping" is a silvicultural practice used to control the spread of root rot fungus (Armillaria spp or Phillinus spp), but digging out stumps and exposing the roots to air. This results in soil exposure, which could lead to sedimentation, however the practice is usually carried out on flat or low sloped terrain so the probability of sedimentation is very low.

Other issues of protection possibly affecting water quality include:

- Loss of forest floor
- Change in water chemistry
- Destruction of timber leads to lower mechanical root strength
- Blowdown of burnt timber exposes soil to surface erosion
- Root stumping in root rot areas.

9.2 Roads/Highways

The Campbell River system has many miles of public roads administered by the Ministry of Transportation and Highways. In addition Boliden is responsible for snow removal of the 37 km of road from the Gold River turnoff to the Myra Falls mine site. There are number of issues that could impact the District's water quality.

9.2.1 Road Surfacing/Deicing

There are sections of public roads that are not paved. Dust control is attained using magnesium chloride. There are provincial standards that identify the application rates and methods and the MOTH reportedly adhere to these standards.

The de-icing of the road surface in the winter by both MOTH and Westmin is done with sand chemically using sodium chloride. There are provincial standards that identify the applications and methods and both organizations reportedly adhere to these standards. The MOTH requires material certification prior to the product being used.

9.2.2 Traffic Accidents

Traffic accidents have the potential for the release of gasoline or diesel fuels as well as engine chemicals and any cargo being transported. The MOTH maintenance contractors maintain spill kits absorbing oils and liquid products. These kits are utilized in the event of motor vehicle accidents. If the situation arises, the MOELP will deal with hazardous products released during an accident. The MOTH also has an Emergency Response Plan detailing a response to, amongst a number of scenarios, a "Dangerous Goods Spill at Highway". The immediate action is to contact the MOTH Regional Community Centre, Provincial Emergency Program (PEP), the police and fire department. The procedures for spills is outlined in the procedures of the Transport Canada Emergency Response Centre (CANUSEC).

The issue is the potential movement of the materials to the watercourses that lead to John Hart Lake.

The MOTH via an Engineering Warrant system has evaluated all the curves on Highway 28. The probability of vehicles hitting the lake is a significant component of whether or not roadside barriers are installed. Barriers have been installed on all curves and tangents

where the evaluation suggest there is a medium to high risk of vehicles ending up in the lake.

The MOTH undertook this work because there was high risk to the drivers and passengers if they crashed into the lake. In the last six years (1994 – 2000) there was only one vehicle that found a weakness in the system. That vehicle made it to the edge of the lake and was only partially submerged.

9.2.3 Drainage/Slope Failure

In some areas the public roads and road right-of-ways are located in steep terrain and experience high intense rainfall patterns. While the roads are designed for these features it is possible that there will be slope or road failures that would result in the release of sediments to the watershed watercourses.

9.3 Mining

As discussed earlier there are several active and inactive mines in the watershed as well as several rock/gravel extraction operations with the principal operation being the Boliden/Westmin Mine at the end of Buttle Lake.

9.3.1 Westmin

The Boliden Myra Creek operation is the largest mine in the watershed. The life expectancy with the present known ore reserves is about 10 years. The main ores are copper and zinc with some gold.

The mine is in Strathcona Park administered by the Provincial Parks. It also has Provincial Government permits related to various aspects of the operation including the Ministry of Environment, Lands and Parks, Ministry of Energy and Mines and the Ministry of Health. The MOELP permits include PE 6858 (Tailings Management and

Water Treatment Systems), PR 2561 (Refuse Permit) PA 2408 (Air Emissions Permit). The PE 6858 permit identifies sample locations on Myra Creek upstream of the influence of the mine, downstream of the mine at Myra Falls and at the outfall from the tailings ponds. They also have two sites on Buttle Lake where water samples are taken with depth every 2 months for a range of chemical, physical and biological parameters. The mine prepares and submits an annual environmental audit to MOELP, BC Parks, Ministry of Energy and Mines and Environment Canada.

The mine has a Ministry of Energy and Mines Reclamation Permit M26. The permit stipulates the conditions and requirements that the mine must comply with. These include site, watercourse, waste dump, open pit and access road reclamation as well as a mine closure plan and acid generating material control, monitoring and remediation plan. The mine has to provide bonding to the Provincial Government that covers the cost of the closure plan currently about $10M.

Tailings were discharged to Buttle Lake up to 1983. Since 1983 the tailings have been placed into two tailings ponds with the water from the tailings ponds put through a treatment process. The tailings pond water is pumped into a lined super pond where lime is added through coagulation process. The water is then transferred to six settling ponds operated in series before discharging to Myra Creek. The estimated detention time through the ponds is 2 days. The settled solids are land filled. Westmin is preparing a design of a new tailings pond wall/containment around the ponds. This will include a slurry wall to prevent underground seepage reaching Myra Creek and the ability to collect and treat the seepage water.

Another issue is acid leaching from waste rock. The mine is at about elevation 1000 m and gets about 2 to 3 meters of rainfall per year. The mine has a number of programs in place to reduce the impact. There are systems of diversion ditches above the mine site to divert water away from the mine site. Where they can be identified the flows from on-site underground seepage and drainage channels are collected and treated through the water treatment system.

Westmin has prepared a site closure plan identifying steps and costs to close the mine. The plan was completed in 1995 and due to be revised by Westmin in 2002. Westmin has the responsibility to not only return the site back to "park like conditions" but to maintain the site and water treatment plant after completion of mining until the impacts have stopped. The Province will eventually take back responsibility for the mine site. At the moment the closure costs are about $10.2 M of which the mine has to supply bonding to the Province for 100% of the costs.

The principal access to the mine from Campbell River is by road. There is a potential for a vehicle accident and the spillage of the mined product. Westmin's trucks transport the concentrate from the mine site to Campbell River for shipping. The major mine deliveries include diesel fuel for electrical generation, cement, lime and ore concentrator process chemicals and others. The deliveries are FOB the mine site. The trucking companies are responsible for any problems in transit. The mine has a spill response plan and a spill response team. Westmin also cooperates with like teams from the Elk Falls plant.

Quarry Operation

There is a quarry operation operated by Hecate Excavation Ltd. in the watershed on Crown Land and licenced by the BCAL. The MOELP has jurisdiction over water quality impacts on pollution control measures that may arise from this type of operation.

9.4 Urban Development/Agriculture

9.4.1 House Construction

Residential development requires site services (roads, water, power, sewage system). There are no municipal water or sewage systems provided for either existing or new developments located within the watershed. The RDCS Development Permit Act for protection of Aquatic Habitat extends 30 m from the natural boundary of lakes and

streams. In addition the RDCS has flood proofing setbacks that regulate the distance and elevation from a watercourse and waterbody. Site servicing and building construction create exposed soil surfaces while building construction results in some waste of construction materials.

9.4.2 On-Site Sewage Treatment and Disposal

Existing residential development in the watershed uses onsite sewage treatment and disposal to handle domestic wastes. The effectiveness of this system to remove bacteria, viruses and parasitic organisms depends on the design, construction, operation and management. The principal issue is failure of the drain field and release of pathogenic organisms to the watershed waterbodies and possible release of nutrients.

The Upper Island Central Coast Community Health Services Society (UI/CCCHSS) has enforcement powers under the Sewage Regulations requiring the permitting of sewage systems for these uses. The permit allows them to ensure proper sizing, location and suitability of a proposed system to ensure that it has no negative impact on the area as far as sewage contamination is concerned. Once the system is installed, there are limited resources to monitor these systems. It is up to the system owner to ensure it is properly maintained and to seek out a new permit should the existing system fail.

An onsite sewage disposal system has a finite life span that depends on many variables. It is impossible to predict how long a system will function. It is a legislated requirement for the owner to obtain a new permit to repair/replace the failing system. The only other means of being made aware of these failures is on a compliant basis.

Any sewage ponding on the surface of the ground or draining directly or indirectly into any watercourse is a violation of the Sewage Regulations. How much of an impact this would make on the water quality would depend on many factors such as dilution, rainfall and distance to intakes etc.

The main item for reducing these risks would be public education. If property owners and the general public had a better understanding of the risks associated with the improper disposal of human wastes, they would potentially take greater care in ensuring that bodily wastes were handled properly.

9.4.3 Human Activity/Vehicle

With development there is the potential for the use of chemicals such as lawn fertilizers, herbicides and pesticides, as well as the impacts of hydrocarbons from vehicles.

The illegal dumping of household waste has occurred on a very limited scale in the watershed. Given the close proximity and easy vehicle access to some areas of the Campbell River watershed this will continue to be an issue. The impact on water quality will depend on the nature and location to water courses of the waste material that was deposited.

9.4.4 Domestic Animals

The two most common parasitic organisms, (giardia lamblia and cryptosporidium) and other pathogenic organism require a warm blooded host as part of the organisms life cycle. If the domestic animal is a host to such organisms then it can be transmitted to other animals or watershed waterbodies through fecal matter.

9.4.5 Sea Gulls/Canada Geese

The RDCS Landfill is outside the watershed boundaries. Seagulls, however, have been observed to feed off the solid waste in the landfill prior to the material being covered over and then are known to use McIvor Lake as a resting area. The concern is that the seagulls will carry pathogenic organisms from the landfill to the water body.

9.4.6 Rearing of Cattle and Horses

Agricultural use is a permitted use in the RDCS Upland Resource zone and as such this activity is regulated under the Right to Farm Act. Works in and around a stream (not the lakes) are regulated under the Provincial Water Act and damage to fisheries habitat is regulated under the Federal Fisheries Act. Guidelines are being developed by Ministry of Agricultural, Fisheries and Food or other partnerships that will work toward voluntary compliance guidelines for farmers for protection of riparian habitat, leachates, etc..

Horses and cattle, especially young calves, are known to act as hosts for parasitic organisms such as giardia lamblia cysts and cryptosporidium oocyts. In addition, the fecal matter will also contain bacteria and viruses. The origin of the cryptosporidium oocyst in several recent North American waterborne cryptosporidiosis outbreaks has been traced to cattle.

9.4.7 Float Plane Operation

The use of float planes for transportation within the watershed is common. The concern is an accident and the resulting release of fuel and engine oils.

9.5 Natural Processes

9.5.1 Slope Failure/Stream Bed Erosion

The Campbell River system is a large watershed with areas of steep terrain and heavy rainfall. Slope failures, mass wasting and streambed erosion are natural processes typically associated with rainfall events. The natural processes lead to sediment transport and turbidity in the watercourses.

9.5.2 Wildlife

Wildlife can be carriers of pathogenic disease causing microorganisms that can be transmitted through fecal matter to the water intake and can lead to a waterborne disease outbreak. Most of the waterborne giardiasis and cryptosporidiosis outbreaks affecting British Columbia water systems originate with wildlife in the watershed. The cysts or oocysts are carried to the intake by water currents.

9.5.3 Catastrophic Failure

As illustrated on Figure 9-2 between the Campbell Lake and John Hart Lake is a narrow land mass that divides the two lakes. There are indications of substantial ground water movement between the lakes at the narrow land mass. The issue is the risk associated with mass wasting in a major earthquake.

9.6 Recreation

The Campbell River watershed Crown Land is open to the public and includes Strathcona Park. Many types of recreational pursuits are undertaken in the watershed. For purposes of this report, recreation uses are categorized as Recreation Day Use (motorized, non-motorized and picnicing) and Overnight Use (regulated and unregulated camping).

9.6.1 Recreation Day Use

The day use recreation activities include the use of motorized vehicles such as dirt bikes, dune buggies and boats. The issues include creating erosion that results in the release of sediment to the receiving waters as well as fuel and engine oil spills. Non-motorized activities include hiking, mountain biking, mushroom picking, hunting, canoeing, kayaking and salal harvesting. The principal issue aside from erosion related trail building and disposal of solid waste (eg. containers, packing, food wastes) is the potential for passage of bacteria, viruses and cysts from fecal matter of humans or domestic dogs

to wild animals that in turn could pose a threat to the water source. There are many developed picnic sites and many informal picnic sites in the watershed. The distinguishing feature is that the former have toilet and garbage facilities while the latter do not. The issue is the risk associated with fecal matter and garbage contaminating the watercourses.

9.6.2 Recreation Overnight Use

There are both regulated and unregulated overnight camping sites within the watershed. The principal difference is that the former have toilet and garbage facilities while the latter do not. There are several very popular unregulated camping sites located on the foreshore of the watershed lakes on private property owned by TimberWest. They are occupied from around April to September of each year. The issue is the direct contamination of the adjacent waterbody by fecal matter as well as the impact from garbage not removed.

9.6.3 Gun Range

The gun range in the watershed is a Crown Land tenure (File 1408482 Upper Campbell Lake) from BC Assets and Lands, and is a permitted use in the RDCS Uplands Resource Zoning (Firearm ranges). While there is a gun range in the watershed, the impact of gun powder (or lead) would be localized and negligible within the watershed.

9.7 Power Generation

BC Hydro relies on the Campbell River system to generate a substantial percentage of electrical power for Vancouver Island. The power system includes the John Hart, Ladore and Strathcona dams as well as dams on several watershed diversion systems. The nature of the system is that the lakes provide storage capacity to store the winter precipitation volumes for use in generating power during the low runoff periods experienced during the late summer and early fall.

9.7.1 Exposure of Lake Bottom

The result of the system operation is that the lake levels are at or close to a maximum elevation in the later winter and spring period and at lower levels during the late summer and fall period. At low lake levels there are miles of exposed lake bottom that is a source of sediment and turbidity that can be transported to the water column during rainfall events.

9.7.2 Dam Failure

The BC Hydro dams are designed to handle the design earthquake for the Campbell River area and the Campbell River system watershed flood flows. There is a very remote possibility of dam failure.

9.7.3 Operations

BC Hydro has an active operations program that is to some extent located in the watershed; including vegetation control and vehicle operation with the potential for release of gas/diesel and hydrocarbons such as oil and grease.

9.7.4 Damage to the Penstocks

The District's water source is from the penstocks between the John Hart Dam and the powerhouse. Any interruptions to the penstocks will affect the water supply to the District. BC Hydro and the District have made changes as needed to the operation of both systems to ensure an uninterrupted water supply to the District. The concern is loss of water in the event that all the penstocks are taken out of service due to damage such as failure of the highway bridge over the penstocks or a vehicle accident that impacts the penstocks.

9.8 Summary

The recognized activities in the Campbell River system that have the potential to affect the District's John Hart Lake water source are summarized in Table 9-2.

TABLE 9-2
SUMMARY OF ISSUES

Number	Activity	Risk Description
	Forestry	
1	Forestry Harvesting	• Harvesting methods (highlead, ground skidding), • Change in hydrology and runoff pattern, • Change in chemical composition of water.
2,3,9	Forestry road building & deactivation	• Exposed earth surfaces and soil erosion, • Cut and fill, • Rock quarries, • Ballast material, • Bridge and culvert installation/removed
4	Silviculture	• Application of fertilizer, • Application of pesticide/herbicides.
5	Road Maintenance	• Grading, • Dust Control, • Bridge and culvert repair and replacement, • Ditch cleaning.
6, 15	Forest Protection	• Residuals from controlled post harvesting debris burns, • Pest and disease stumping in root rot area.
7	Personal hygiene	Disposal of body wastes from staff working in the watershed
10	Vehicle/Equipment Operations	Liquid and solid debris associated with vehicle/equipment accidents and operation.
	Natural Processes	
14	Slope failure	• Slope failure creating open soil surfaces and erosion.
16	Stream bed erosion	• Bed load movement under stream flow conditions.
17	Wildlife	• Carriers of pathogenic organisms
18	Catastrophic failure	• During major earthquake possible failure of barrier between Campbell Lake and John Hart Lake.
	Recreation	
19,22	Regulated Sites (with facilities)	• Sewage/solid waste disposal with formal picnic and camping sites, • Domestic animal wastes.
13,20, 24, 25, 28, 29	Informal Recreation (hiking, mountain biking, hunting, mushroom picking, motorized vehicles, trail construction)	• Sewage/solid waste disposal with informal uses, • Domestic animal wastes.
21	Motorized Boating	• Gasoline/Oil spills

Number	Activity	Risk Description
23	Unregulated Sites (no facilities)	• Sewage/solid waste disposal with formal picnic and camping sites, • Domestic animal wastes.
26,27	Kayaking/Canoeing	• Sewage/solid waste disposal with formal picnic and camping sites, • Domestic animal wastes.
30	Gun Target practice	• Impact of gun powder
31	Swimming beaches	• Personal hygiene in the water.
	Land Development	
32	Construction	• Construction of municipal services, • Buildings creating soil erosion, • Construction debris (paints, waterproofing agents, gyproc, etc)
33,41,42	Onsite treatment and Disposal systems	• Long term on site tile field effectiveness with microbiological and nutrient removal efficiency.
34	Human activity	• Impact from fertilizers/urban wash/domestic animals
35,36	Vehicle	• Impacts of vehicles
37	Float Plane Operation	• Fuel or hydrocarbon spill
38	Rearing of Cattle and Horses	• Impact of animal waste
39	Seagulls/Canada Geese	Seagulls attracted to landfill resting in McIvor Lake. Fecal matter.
40	Landfill Debris	Debris carried by the wind from the landfill to McIvor Lake.
	Highways	
43	Road surfacing	• Material used to surface public roads including dust control and possible leaching to water system. (MOTH uses magnesium chloride for dust control)
44, 49	Drainage	• Impact on natural drainage pattern, • Road failure from flooding and restoration
45	Traffic accidents	• Vehicle accidents and associated liquid (oil, gas, diesel, cargo) reaching the source water.
46	Deicing materials	• Chemical agents used to de-ice roads. (MOTH and DCR use sodium chloride).
48	Slope failure	• Erosion from slope failure and restoration.
	Mining	
50	Tailings ponds	• Quality of drainage from tailings ponds and mining operation.
51	Tailing ponds	• Dam failure
52	Traffic to and from Mining Site.	• Transportation of mined product and materials used in the mining activity through the watershed and impact from vehicle accident.
53	Gravel/Rock Extraction	• Gravel extraction operations

Number	Activity	Risk Description
	Power Generation	
54	Exposure of lake bottom	• Erosion and transportation of the lake bottom soils to the lakes in the Campbell River system when exposed by a draw down of the lakes during power generation activities.
55	Vegetation control	• Use of herbicides.
56	Structural capacity of the highway bridge over John Hart Dam penstocks.	• Bridge failure and damage to the penstocks from where the DCR draws water.
58	Main Stem Dam Failure	• Failure of the main stem dams
59	Diversion Dam Failure	• Failure of diversion dams.
60	Operations	• Hydrocarbons such as oil and grease
61	Traffic Accident	• Damage to the Penstocks
	Power Distribution	
62	Vegetation Control	• Method to control vegetation growth under power lines within the watershed.
63	Power pole preservatives	• Method to preserve power poles.
64	Substation	• Transformer Oil
	Invasive Species	
65	Zebra Mussel/Eurasia Milfoil	• Inadvertent addition of foreign species to the lake environment such as zebra mussels and milfoil.
66	Fish	• Inadvertent addition of foreign fish species to the lake environment affecting water quality.

10.0 RISK ANALYSIS

Risk analysis looks at the probability of an event occurring in relation to the effect that the event will have on a resource or value. The purpose of risk analysis is to provide managers with the knowledge to make decisions and define priorities to reducing the risk. All activities carry some level of risk against a value, although the level of risk may vary according to the value measured against. Most activities are considered acceptable risk, that is below the threshold which people are willing to accept.

Risk mitigation or reduction are a series of actions that can reduce probability of the event occurring or reducing the effect (consequence) should the event occur. Residual risk is the risk that remains after mitigation has taken place.

Risk management is the collective decisions and actions taken by people, based on risk analysis, considering the level of acceptable risk, the level of residual risk and funding availability. This chapter overviews the risk framework adopted for the watershed management plan and details the analysis of the risk rating associated with the watershed activities.

10.1 Risk Definition

The Risk Framework is a decision support tool designed to identify areas of higher risk and allow decision makers to develop action plans and funding priorities. The assessments provided are based on relative scales as opposed to absolute values. This allows activities that have no metrics to be assessed equally with other activities.

For this framework, drinking water quality at the District's John Hart Lake intake is the sole value or resource that risk is being assessed for, and the following terms are listed

and defined:

- **Consequence** is the effect of a potential event on the water quality, and for this analysis is related to the level of response that the District of Campbell River will have to impose if an event were to occur. The rating ranges from Very Low to Catastrophic. Although this is described in terms of sedimentation, other damage processes such as chemicals or pathogens can be substituted.

Consequence		
Rating	Description	Example Action
VL	Existing	• Turbidity less than 1 NTU • No Action Required
L	Minor monitored increase in turbidity	• Turbidity less than 1 NTU • No Action Required
M	Monitored increase in turbidity noted	Public Notification – Turbidity between 1 and 5 NTU
H	Potential Contamination or monitored increase in turbidity noted	Monitoring has detected pathogenic microbiological in the distribution system; Turbidity is greater than 5 NTU.
VH	Disease Outbreak	Actions such as a boil water advisory is required.
Catastrophic		The water supply from Campbell River is unusable, such as an intake failure or very serious chemical spill; the use of alternate water source is required.

- **Duration** is defined as the length of time that the activity will impact water quality. They are established as ranges of time periods;
  - Hour is an extremely short term event;
  - Day is an event where the impacts persist for a short period of time up to a couple of weeks;
  - Month is a longer term impact where there is persistence but the impact still has a finite life span;

- Continual is an event where there is no foreseeable end to the impact. An example of this would be leaking of a chemical with the concentration higher than the GCDWQ MAC at the District's intake.

Duration	
1	Hour
2	Day
3	Month
4	Continual

- **Frequency** is defined as how often the event occurs:

  - Single event is one that happens once and is unlikely to be repeated.
  - Occasional event are events that happen without regularity.
  - Frequent event are ones that happen with a high degree of regularity.
  - Continual events are ones that constantly occur.

Frequency	
1	Single Event
2	Occasional Event
3	Frequent Event
4	Continual

- **Hazard** is defined in this analysis as the frequency of the event, duration of the event, magnitude of the event and the probability of the event occuring. Each item is given a numerical value based on the descriptions given below item. The ratings are summarized and hazard ratings defined. Each item is rated between 1-4 and a hazard rating is set as:

Hazard Rating	
1-4	Very Low
5-8	Low
9-12	Medium
13-16	High
17-20	Very High

- **Magnitude** is defined as the relative size of the event. Magnitude is best described through a series of examples:

  - Low
    - Road maintenance, such as grading leading to surface erosion,
    - Mountain biking erosion on flat ground.

  - Medium
    - Sedimentation caused through culvert construction in the lower risk zones,
    - Road failure with sediment not reaching the lake in the upper risk zones.
  - High
    - Concentrate truck accident ending in the lake,
    - Large wildfire leading to surface erosion.
  - Very High
    - Earthquake induced failure of Campbell Lake barrier.

Magnitude	
1	Low
2	Med
3	High
4	Very High

- **Probability** is the relative estimate of the probability of the event occuring. This again is just a relative judgement rather than a true statistical probability.

Probability
Nil – Very Low
Low
Med
High

  - Nil – Very Low – for example earthquake induced events.

- Low – Unregulated camping the back country risk zones.
- Med – Erosion of trails by non-motorized (hiking) recreational use.
- High – Swimming in John Hart or Lower Campbell lakes and introduction of fecal matter with people urinating in the water.

- **Risk** is the product of the hazard and consequence. In other words, Risk=Hazard X Consequence. A 5x5 risk matrix was used to define risk to water quality.

Hazard	Consequence					
	VL	L	M	H	VH	C
VL	VL	VL	L	M	M	M
L	VL	VL	L	M	M	M
M	L	L	M	H	H	H
H	M	M	M	VH	VH	VH
VH	H	H	H	VH	VH	VH

- Very Low – Likely an existing situation. Mitigation measures are of low priority or are currently being undertaken as a matter of business.
- Low – Likely an existing situation. Mitigation measures are of low priority or are currently being undertaken as a matter of business. These events may be considered in low priority emergency planning.
- Medium – Mitigation measures should be considered and/or developing emergency action plans given medium priority.
- High – Mitigation measures have to be considered and undertaken and/or emergency action plans developed.
- Very High – Mitigation measures have to be undertaken and/or emergency action plans developed.

10.2 Risk Analysis

A series of approximately 65 activities were defined as having a potential impact on water quality in the Campbell River watershed. Risk was determined by subdividing these activities into damage processes and risk zones.

The damage processes were identified in the Best Management Practices paper (BCLSS) as non-point pollution sources:

- Sedimentation
- Chemicals
- Acids
- Nutrients
- Pathogens
- Heavy Metals

An additional damage process, intake failure, was added to account for a penstock failure. This damage process was defined as an interruption of the supply to the District.

Each activity was divided into four risk zones and three sub zones. The risk zones relate to anecdotal observations, that events that occur further away from the water intake have less effect on the quality of water experienced at the intake. This is due to dilution, settlement capacity of the lakes, flushing action of the lakes or the chemical buffering in the soils and lake water.

The sub zones are related to activities that occur on the lakeshore or directly adjacent to the lakes.

The four risk zones are:

A John Hart Lake watershed below Ladore Dam

B Lower Campbell Lake watershed below Strathcona Dam, to the first order stream

C Upper Campbell Lake watershed and, the Lower Campbell Lake watershed above the first order streams.

D BC Hydro Diverted Watersheds.

The risk sub-zones are:

A1 A 100 m buffer surrounding John Hart Lake

B1 A 100 m buffer surrounding Lower Campbell Lake

B2 The landbase surrounding McIvor Lake outside the MoF Community Watershed application and east of the main river channel.

Table 10-1 shows the risk ratings for the identified activities as related to damage process and Risk Zone.

11.0 RISK REDUCTION

This chapter discusses the activities that pose the greatest risk to water quality in the watershed. A range of risk reduction measures are identified and those that can be used to reduce risk associated with those activities categorized in Chapter 10 as very high, high and medium risks.

11.1 Risk Reduction Measures

The Campbell River watershed encompasses a large land area with the principal land ownership resting with the Crown and, to a lesser extent, two private corporations with a forestry mandate. The remaining private land holdings are minor in the context of the overall watershed area but are located in the general area of John Hart Lake where the District's intake is located. The Crown Lands are either classified by the Province as Provincial Forests, Provincial Parks or nonforest reserve.

The principal land use control, planning, management and regulatory approvals within the watershed rests with the Province through a number of Provincial Government ministries. Various Provincial acts and regulations as detailed earlier provide the legislative framework under which the land use decisions are made by the Province. The local government control under provisions of the Local Government Act mainly land use planning, rests principally with the Regional District of Comox - Strathcona and to a very minor extent the District around the John Hart Lake.

The watershed is a multi-use watershed with divergent land use activities from mining and forestry to day use recreation and including an important BC Hydro infrastructure system for hydro power production. The BC Hydro generating system is a major source of electricity for Vancouver Island. There is an extensive public road network in the

watershed that allows ease of vehicle access to most areas. It is likely that the public use of the watershed will continue to increase with an increasing population.

The protection and enhancement of the John Hart water quality will have to rely on a series of initiatives. A series of risk mitigation and reduction strategies and measures are identified in this chapter and then categorized as Action Items, Planning and Regulation Items, Referral and Notification Items and Education Items.

Action Items are defined as measures where a distinct action would be taken and are considered reactive after the event has occurred. Planning and Regulation Items can be considered proactive items that take place before the events occur and include bylaws and regulations and developing emergency action plans. Referral and Notification Items relate to informing other agency and stakeholders before an event occurs. For example, plans for road construction on unstable terrain may be referred to the District who may institute a higher level of sampling or disinfection preparedness during the time of the road construction. Notification is the informing of other agencies after an event occurs, thereby allowing other agencies to take appropriate actions. For example, a natural landslide into a lake, District would be notified allowing them to take appropriate action. Education Items are defined as activities aimed at reducing public caused events in the long term through a heightened awareness of problems that might be occuring.

Table 11-1 summarizes a list of risk reduction and mitigation measures that have been developed for the Campbell River watershed.

11.2 Discussion of Risk Activities

The tables within Chapter 10 develop risk levels for a variety of activities within several risk zones in the watershed. The following table summarizes the number of activity/risk zone combinations that rated as medium risk or greater.

Risk Rating	Number of activity/risk zone
Medium	128
High	37
Very High	19
Total	184

While there are 56 activities/risk zone combinations that rate as high or very high risk to water quality within the watershed, they must be considered as relative only to activities in the Campbell River watershed.

Very High Risk Ratings

Four damage processes are identified in the very high risk ratings, which include pathogens, fuel spills, intake failure and sedimentation. In general, they are related to activities occuring in risk zones A1, B1 and B2, which are lands immediately surrounding John Hart Lake, Lower Campbell Lake and McIvor Lake.

The pathogen generation has been associated with activities such as unregulated camping, wildlife (seagulls, Canada geese and mammals), failed onsite treatment and disposal systems (septic tanks) and defecation by domestic animals. Fuel spills are primarily associated with traffic accidents, with trucking activity to the mine being considered a higher risk due to the volume and the fact they travel in all weather conditions. Intake failure is associated with vehicles having an accident at the bridge over the penstocks and having a vehicle landing on and destroying the penstocks.

High Risk Ratings

Activities associated within the high risk ratings are also primarily located in the A1, B1 and B2 risk zones. A wider range of damage processes are identified in the high risk categories with the two primary processes being sedimentation and pathogens.

Activities that cause sedimentation include wildfires, bridge installations and natural failures (ie landslides or earthquakes). The activities associated with pathogens include unregulated human activities including camping, swimming or boating.

Other high risk activities include dam failures, fuel spills from float planes, traffic accidents involving mine concentrate trucks, domestic animals and seagulls.

Medium Risk Ratings

Activities associated with the medium risk ratings are also located in A1, B1 and B2 risk zones, although there are more activities located in the A, B and C risk zones.

The full range of damage processes described in Section 9.0 are associated with the medium risk.

In general, most of activities/risk zone combinations that show a medium risk rating have a consequence rating of medium. The consequence is defined as the potential effect on water quality and is related to the level of response required by the District of Campbell River. The example action for a medium consequence was a public notification with a turbidity between 1 and 5 NTU.

A summary of the risk ratings that are moderate or greater are provided on Table 11-2.

12.0 RECOMMENDATIONS

The District's water supply service area population is presently about 32,253 and expected to increase to over 65,600 users in 2030. The principal aim of the watershed management plan must be to ensure that over the long term the District has access to the highest quality water and as a result treated water to the District's customers meets the Safe Drinking Water Regulations and the Guidelines for Canadian Drinking Water Quality in a cost effective manner.

The North American regulatory approach to drinking water regulations has been to focus on microbiological risks, principally protection against waterborne disease outbreaks from bacteria, viruses and giardia cysts. From a treatment point of view, the giardia cyst is the most problematic given its resistance to disinfectants. If the John Hart Lake turbidity remains less than 1 NTU year round, and the compounds created when the naturally occurring organic compounds react with disinfectants such as chlorine are not determined to be a health risk, then an unfiltered water treatment approach may meet the treatment goals. As a consequence, the minimization of the turbidity levels in John Hart Lake is fundamental to the outcome. In addition, water treatment processes depend on the concentration of the microbiological organisms and efforts must be made to ensure they remain as low as possible at the John Hart Lake intake. The plan must recognize and address the risk, although low under current conditions, from introducing chemicals at levels that would exceed the GCDWQ.

The District has a statutory responsibility in operating the water system to meet the Drinking Water Protection Act and the Safe Drinking Water Regulations. Land in the Campbell River watershed is principally owned by the Crown and two privately held forestry companies. The Crown Land designations include park, forest reserve and non-forest reserve. Outside of an area around John Hart Lake within the District boundary, regulation of land and water-use activities in the watershed rests with senior governments and the Regional District. Significant activities include the Boliden mine, BC Hydro's electrical generation system and forestry. In addition

public access is allowed on Crown Land and all waterbodies. Given the proximity to a major urban center, outdoor recreation is a significant activity in the watershed. The senior government land use regulations recognize and, in most cases, have water quality protection as a primary goal. There has been very little consultation in the past with the District on decisions in regards to land use activities.

This chapter provides a series of recommendations that recognize the protection of water quality in the Campbell River Watershed Lake to reduce the risk to the District's water quality source.

12.1 General

12.1.1 Request Drinking Water Protection Designation from the Province

Under the Drinking Water Protection Act passed by the Province in April 2001 there is a provision for the Minister of Health to designate an area for development of a Drinking Water Protection Plan. The proposed plan must be reviewed by the Minister and the Provincial Drinking Water Coordinators and approved by the Provincial Government. Under the Act, powers are available in making decisions under specific enactments and issuance of permits, licenses and approvals for activities in the watershed that would increase the protection of the water quality.

Recommendation 1

It is recommended that the District request that the Province, under the Drinking Water Protection Act, adopt this plan as the Drinking Water Protection Plan for the Campbell River watershed.

12.1.2 Establish A Permanent Watershed Management Committee

About 20 percent of the total watershed land is Crown owned in Provincial Forest, about 60 percent of the total watershed is Crown owned in Provincial Park and less than 0.5%

is Crown owned and managed by BCAL. About 12 percent of the total watershed is owned by TimberWest, about 1.5% of the total watershed is owned by Hancock and about 0.06% is owned by B.C. Hydro. The remainder (0.50%) is privately held. The District has very little legislative power to deal with activities in the watershed. This power rests with Provincial and Federal agencies and to some extent the Regional District.

Recommendation 2

It is recommended that a permanent Campbell River Watershed Management Committee (CRWMC) be created as a forum with the responsibility of addressing activities, land use management plans, best management operating procedures, permit applications, coordination of public education and concerns that could affect the District's water quality. The committee should be comprised of the District, the RDCS, resource agencies, Native government, Boliden/Westmin Mine and major property owners.

The very nature of this process will likely require the District and stakeholders to budget staff time to coordinate and respond to the CRWMC process and senior government referrals as they occur. In the proposed watershed management budget, discussed in a later section, an allowance has been identified to allow the District staff, or consultants working on behalf of the District, to review any land use activity plans that would be referred to the District for comment.

12.1.3 Geographic Information System

The majority of the land within the watershed is owned by the Crown (over eighty percent) with the major minority ownership resting with two corporations (about thirteen percent). The District has statutory responsibility for operating a water system in conformance with the Drinking Water Protection Act. Land use activities on both Crown and privately held lands in the Campbell River watershed that are regulated by senior governments and the Regional District influence the water quality at the District's John

Hart Lake intake. Various Provincial Government agencies have responsibility for authorization and regulation of land use activities in the Campbell River watershed. There are also a number of organizations compiling background information on the watershed, including water quality. Individual regulatory bodies regulating land use in the watershed maintain separate record systems on permit/license scope, conditions and procedures.

Recommendation 3

It is recommended that a Campbell River watershed GIS system be developed and maintained over time that includes information relevant to water quality such as permits granted by various levels of government, historical water quality results, physical features (roads, trails, dams, diversions, campsites, resource extraction sites and so on), and on-site sewage treatment and disposal systems. The goal would be to do develop an information system that would assist the CRWPC in ensuring that existing and potential land use activities in the Campbell River watershed will recognize water quality.

12.2 Complete Watershed (Risk Zones A, B, C, D, A1, B1, B2)

12.2.1 Intake – Prevention and Emergency Response Plan

As noted in the previous chapter there are risks associated with a number of activities in the watershed.

Recommendation 4

It is recommended that the District review all the activities in the watershed that have a moderate and higher risk and develop emergency response plans that provide guidance and direction to staff on how to react should the events occur and impact the water availability at the District intakes. To stay current the plans will have to be updated on a semi-annual to annual basis.

12.2.2 Communication Strategy

The Campbell River watershed is open to the public. Land use activities include power production, forestry, mining, residential housing, both day and overnight recreation and limited agriculture. It is important that a permanent ongoing public education program be developed and implemented to increase the awareness of the nature of the watershed seeking public assistance in minimizing impacts on water quality.

Recommendation 5

It is recommended a permanent public education program be developed to raise the awareness such as:

- Road side signs on entry to the watershed.
- Signage and information packages at all formal and informal campsites and start of trails and so on.
- Information packages to land owners in the watershed.
- Information items to water users within the District.

Recommendation 6

It is also recommended that there be the presence of an information person in the watershed especially during the summer to educate watershed users and look for potential or actual problems that may affect water quality.

12.2.3 Prevention and Emergency Response Plans – Others

A risk to water quality at the District's intake is a traffic accident in the watershed particularly with trucks transporting fuel (diesel, gas), chemicals and mine concentrates. The coordination to such an event would rest with the MOELP and PEP. The Campbell

River Emergency Program and Campbell River Fire Department are only mandated to operate within the boundaries of the District of Campbell River.

The responsibility for dealing with spilled product is held by the owner and shipper of the product. All transporters of hazardous goods are required to have a plan in place to deal with accidental release of their product into the environment.

Recommendation 7

It is recommended that the District notify both the MOELP and PEP of the potential risk to the District's water quality from a traffic accident in the Campbell River watershed and seek assurance that the lead agency's emergency response plans are capable of dealing with an accident in a fashion that would minimize the risk to the District's water quality. The plans should include a contact and contact process to notify the District of any threats to the water quality.

12.2.4 Recreation

Recreation opportunities in the Campbell River watershed are many and likely to continue to increase over the next decades.

Recommendation 8

It is recommended that the Campbell River Recreation plan to coordinate any development of recreation opportunities in the Campbell River watershed be periodically updated. The plan participants should include such organizations as BC Parks, Ministry of Forests, Comox-Campbell River Regional District, TimberWest and the District of Campbell River.

Recommendation 9

It is recommended that any recreational planning and recreation development recognize that basic sanitary facilities, including handling of human body wastes and refuse, must be provided in the watershed. This would include toilet and garbage facilities. This should include Best Management Practices for dealing with the quality of stormwater run-off from paved or graveled surfaces such as roads and parking lots. It is further recommended that such facilities at existing recreation sites (trails, beaches, picnic sites, overnight sites and so on) be reviewed and improved as necessary.

There have been instances of illegal squatters constructing and living in temporary shelters on Crown Land. This should continue to be discouraged by the land owner.

12.2.5 BC Hydro Pesticides/Herbicides.

BC Hydro has used herbicides/pesticides in controlling vegetation growth in the vicinity of various facilities in the watershed. The use is regulated under the Pesticide Control Act.

Recommendation 10

It is recommended that BC Hydro review any intended use of herbicide pesticides in the John Hart Lake watershed with the District. This should include the part of the transmission right-of-way to the Gold River Area within the watershed. Any BC Hydro application under the Pesticide Control Act should also be submitted to the District for comments with measures clearly identified (chemical used, timing, application method, application personnel and so on) to ensure there is no impact on the John Hart Lake water quality. This will also allow the District to initiate a short-term water quality-monitoring program to monitor for any impacts. If there are measurable impacts at the District's source as defined by the BC Safe Drinking Water Regulations a review of the role of the

chemicals should be undertaken with BC Hydro and include the Medical Health and Drinking Water Protection Officers.

12.2.6 Best Management Practices

Best Management Practices are defined as "practices or combination of practices, industrial techniques and good housekeeping principles determined to be the most effective and practical known means of preventing or reducing the source pollution". By it's very nature BMPs are moving targets with the advances in technology and practices.

Recommendation 11

It is recommended that BMP practices to protect water quality be adopted by the various responsible organizations for any activities permitted or otherwise in the watershed.

12.2.7 Fire Suppression Plan

A major forest fire occurred in the watershed in 1938. It is believed that the conditions do not exist for a fire of this magnitude to occur at present. A forest fire and the effort to control a forest fire could impact the District's Water Quality.

Recommendation 12

It is recommended that a forest fire suppression plan be developed in conjunction with the Ministry of Forests, Timber West, Hancock and the District of Campbell River. The plan should include items such as response time, use of fire retardants, level of suppression and use of equipment. Also within this plan should be discussion on sedimentation control and revegetation.

12.2.8 Residential Land Use

Residential Land Use Practices can have an impact on water quality. Especially significant could be the impact of agriculture on the watershed water quality. For instance many waterborne cryptosporiodiosis outbreaks have resulted from cattle.

Recommendation 13

It is recommended that any agriculture in the watershed adopt agricultural Best Management Practices.

12.2.9 Boliden/Westmin Mine

The Boliden/Westmin mine is operating under various regulatory permits issued by the Provincial Government with oversight provided by several Federal Government regulatory agencies. These include wastewater discharge permits, water quality permits and air quality permits. It is understood that the mine has been and is currently in compliance with the issued permits. The mine has implemented a water quality monitoring program in the Campbell Lake system in addition to the programs required under the various Provincial Government permits. The water quality information is provided to the Ministry of Environment, Lands and Parks. The mine has prepared and submitted a mine closure plan to the Province with a financial guarantee to cover the estimated current cost of the plan.

Any mine operation in the Campbell River watershed, including Boliden/Westmin, has the potential to impact the chemical characteristics of the watershed water quality and the water environment. The regulatory responsibility to work with the mine to ensure protection of the water quality rests with senior levels of government.

Recommendation 14a

It is recommended that on an ongoing basis the District be provided with all Campbell River watershed water quality results, regulatory reports and historical trend analysis reports related to the Boliden/Westmin mine, both by the Ministry of Environment, Lands and Parks and Boliden/Westmin. It is recommended that District request that any reports prepared for senior government under the conditions of the issued permits include an analysis, interpretation and trending of water quality findings in terms of drinking water quality as defined under the BC Drinking Water Regulations.

Recommendation 14b

It is recommended that emergency response plan scenarios related to any mine operations in the watershed, including Boliden/Westmin, that potentially affects the District's water quality include the District. It is recommended that the District be consulted in development of emergency response plan scenarios affecting water quality in watershed mining operations.

Recommendation 14c

It is recommended that the District be part of the referral process for any amendments to permits issued by senior government for mining operations in the watershed.

12.2.10 Aggregate Operation

The Ministry of Energy and Mines (MEM) has jurisdiction over subsurface mineral and petroleum resources, and geothermal resources on Crown Land and on private land where the subsurface rights remain vested in the Crown. Provincial government authority includes recording and issuance of mineral and energy resource tenures, and management and permitting of related resource development activities. MEM is also responsible for

the regulation of the province's aggregate resources, which are either held as part of the surface rights of property owners or as Crown tenures issued under the Land Act.

It should be noted that staking of mineral claims can occur anywhere that the subsurface rights are vested in the Crown and, according to the Mineral Tenure Act, a mineral tenure holder has the right to access, explore and develop the mineral resources on their tenures. A Crown land permit is not required until the exploration results in changes to the landscape including activities such access road construction and drilling. BC legislation and regulations permit responsible mineral and energy exploration and development on lands outside of parks and other protected areas.

Recommendation 15a

It is recommended that the Ministry of Energy and Mines, as a condition of operating an aggregate operation in the Campbell River watershed, require facilities to monitor and treat stormwater run-off to ensure that there is no long-term impact on water quality. Annual assessment of the outcome should be prepared and submitted to the CRWPC.

Recommendation 15b

There are potential mineral bodies in the watershed. It is recommended that any permit applications received by the Ministry include the District in the review process.

12.2.11 Traffic Safety

The MOTH has undertaken a Highway 28 traffic safety evaluation identifying areas where improvements are needed to improve the road safety .

Recommendation 16

It is recommended that the District appraise the MOTH of the concern with regard to traffic accidents especially with the bulk chemical, concentrate and fuel carriers and support the MOTH in initiatives to implement the high priority improvements identified.

There is a significant potential to affect the watershed water quality during construction of any road improvements, particularly erosion of exposed soil surfaces. Any highway design and construction work undertaken in the watershed should be to the highest standard of care and Best Management Practices to minimize both short and long term impacts on the watershed water quality.

12.3 Risk Zones A and A1

12.3.1 Water Quality Monitoring

It is recommended that the District expand the water quality monitoring and data management program in Risk Zones A and A1 as follows:

Recommendation 17a

Install in-line turbidimeter/pH/temperature equipment to continuously monitor the John Hart raw water quality characteristics. This could be located at the treatment plant or on the lake. A location on the lake would provide an earlier warning of problems.

Recommendation 17b

Increase the frequency of John Hart Lake routine water analysis (chemical and physical parameters including known materials associated with activity in the watershed such as herbicides and pesticides) as well as cryptosporidium oocyst and giardia cysts four to six times per year.

Recommendation 17c

Develop a water quality data management program within the District's Engineering Department to facilitate analysis of the District's water quality database.

Recommendation 17d

Receive access to the water quality databases for the main Campbell River watershed lakes that are maintained and managed by other organizations such as the Ministry of Environment, Lands and Parks, the Ministry of Health and the Ministry of Energy and Mines. The data should be complied in a database to facilitate historical analysis and information retrieval.

Recommendation 17e

To determine baseline conditions of water quality in John Hart Lake and to monitor changes to lake biological, physical and chemical characteristics over the next decades, the following water quality program is recommended. There should be periodic analysis of the data by qualified scientists to evaluate the "health" and the trend in the "health" of the lake.

Samples should be taken at one open water site four times per year for the first three years. Once seasonal water quality trends have been determined, it may be possible to reduce the sampling to twice a year. The following combination of chemical and biological parameters are suggested:

- Nitrates, nitrites, ammonia and phosphates
- pH, (see 17a) temperature (see 17a) and dissolved oxygen (in-situ)
- Turbidity (See 17a)
- Alkalinity

- Colour and clarity (in-situ)
- Quantitative and qualitative phytoplankton and zooplankton
- Coliforms (total, fecal and fecal streptococcus)
- Giardia and Cryptosporidium (see 17b)
- Total and dissolved metals

Inlet systems to John Hart Lake include Campbell River, the Lost Lake tributary and the unnamed system that is located at the northwest end of the lake. These inlets should be tested for total suspended solids, dissolved oxygen, temperature, total and dissolved metals, coliforms and Giardia/Cryptosporidium. Discharge volumes of major inlets should also be determined.

12.3.2 Land Use

Land use and land use activities in the John Hart Lake watershed are a key part in protecting the District's water source over the long term. The District's two water intakes are in John Hart Lake. Given the close proximity, both in terms of time and distance, from any area of the watershed to the intakes, the impact could occur in a very short time frame. Of particular concern is with recreational activities in the John Hart Lake watershed and the potential risk of pathogenic organisms and sediment reaching the water source from human activity. This concern extends to forestry activities and potential land development.

The land on the north side of John Hart Lake is in the Provincial Forest administered by the Ministry of Forests and on the south side of John Hart Lake it is Crown land administered by BCAL except for recreation. Recreation is administered by the Ministry of Forests. The land on the south side is generally within the boundaries of the District while the land on the north side is within the Regional District. Given the status as Crown owned land, public access cannot be denied. The BCAL administered Crown land is subject to sale while any land use would be subject to the District's Official Community Plan, zoning bylaws and rezoning processes.

As discussed in Chapter 1 the process of designating the John Hart Lake watershed as a "Community Watershed" resulting in a higher standard of practice for forestry activities is nearing completion. It applies to Provincial Forest on the north side of John Hart Lake but would not apply to the Crown owned land on the south side of John Hart Lake.

The land use activities in the John Hart Lake watershed could be problematic for any landowner wishing to use the land, given the sensitivity and potential impacts on John Hart Lake water quality.

Recommendation 18a

It is recommended that the District approach BCAL to identify and have them commit to a strategy for management of the lands on the south side of John Hart Lake to protect water quality. Potential longer-term land use strategies along with their implications on John Hart Lake water quality should also be identified. The District should include an option to acquire the land from the Crown if the conclusion is that land use other than park/community forest will negatively impact the John Hart Lake water quality over the long term.

Recommendation 18b

It is recommended that, within scope of the John Hart Lake Community Watershed Designation and the Drinking Water Protection Act, the District reach an agreement with the Ministry of Forests to involve the District in land use and harvesting decisions on the watershed lands on the north side of John Hart Lake. There have been a number of recent initiatives that attempted to increase the duty of care on future forestry activities. The results of these approaches should be monitored as land use activities occur. If the outcome is not satisfactory in terms of water quality protection, the District should consider an option to acquire the land from the Crown for a permanent park.

12.3.3 Recreation

Recommendation 19

It is recommended that permanent camping sites should not be developed in the John Hart Lake watershed. As will be discussed later the use of vehicles, recreational motorized vehicles and overnight camping, both formal and informal, in the John Hart watershed, should be eliminated. Recreation should be restricted to light day use (biking, walking, running) on developed trails and with proper sewage and garbage facilities in place. Any public marshalling areas, including vehicle parking, should be located as far as possible from the lake and designed to deal with water quality runoff problems through such techniques as wetland treatment. The walking of domestic animals such as dogs in this watershed should be discouraged because of issues around disease transmission through fecal matter.

Recommendation 20

Overnight Camping – It is recommended that the Ministry of Forests add Risk Zone A to the John Hart Lake Community Watershed and prohibit all overnight camping on Crown Land within the John Hart Lake Community Watershed as designated by the Forest Practices Code of BC Act.

12.3.4 Land Development

There are areas within the watershed that are zoned for residential development. Any development around McIvor Lake must be done in a manner that avoids any water quality impacts. This includes environmentally oriented land use planning, zoning and development restrictions.

Recommendation 21

It is recommended that Best Management Practices be developed and adopted by bylaw and the OCP that include, but are not be limited to, low density development, minimization of disturbance to the natural site, onsite secondary sewage treatment, conservative design and setback from receiving streams or lakes and a backup area for sewage disposal fields, site storm water management, an active sewage disposal system management by a responsible government agency, removal of construction debris and minimization of pollutant releases.

12.3.5 Brewster Bridge

The Brewster Bridge over the B.C. Hydro penstocks at the John Hart Lake dam is owned by the District. The load limit is 12,000 kg. The concern is failure of the bridge resulting in damage to the BC Hydro penstocks.

Recommendation 22

It is recommended that either the bridge be permanently closed to vehicle traffic or physical barriers be installed to restrict access to the bridge to vehicles that weigh greater than 12,000 kg.

12.3.6 John Hart Lake Level

The Campbell River Watershed is a important system for electrical power production on Vancouver Island. BC Hydro has been mandated by the province to prepare a Water Use Plan to operate the reservoirs in a manner best recognizing the needs of various stakeholders. An issue affecting water quality, particularly turbidity, is the operation of the reservoirs. Low reservoir levels expose 3 to 6 m in a vertical direction and hundreds of kilometers in a horizontal direction of exposed lake bottom. The lake bottom material

can be transported to the lake during high precipitation events. Based on limited turbidity measurements at the District's intake this has not been a historical problem.

Recommendation 23

It is recommended that the District request that BC Hydro maintain the John Hart Lake level as high as possible to avoid exposure of the lake bottom to erosion forces.

It is recommended that BC Hydro review the areas where high siltation and sediment cause elevated levels of turbidity in the Campbell River watershed lakes, especially when the lake levels are drawn done, and develop mitigation plans. These include bank armouring or planting with grasses. The latter was a technique implemented by BC Hydro on Arrow Lake in the vicinity of the City of Revelstoke to control erosion by wind.

12.3.7 Logging Roads

Recommendation 24

The use of logging roads, specifically those within Risk Zone A by motorized and non-motorized recreational users has in some instances resulted in garbage and human wastes left in the watershed. It is recommended that Access Management Plans be prepared and implemented to deactivate roads not required for forest management practices.

12.3.8 Logging Traffic

Recommendation 25

Ministry of Forests redirect industrial logging traffic to alternate routes outside the John Hart Lake Community Watershed as designated by the Forest practices Code of BC Act (i.e. roads other than the Brewster Lake Road) where possible.

12.3.9 Stump Removal Program

BC Hydro has a program to remove stumps from the reservoirs when the lake levels are drawn down. This results in exposure of soils when the roots are removed and from action of the machine traveling to the location of the stump and removing the stump.

Recommendation 26

This work should be done in a manner that minimizes the potential for transport of the soil materials increasing the turbidity in John Hart Lake.

12.3.10 Landfill Operation

The Regional District owns and operates the Campbell River Landfill site under permit from the Ministry of Environment, Lands and Parks to dispose of solid wastes. There have been risks identified associated with wind blown debris reaching the District's intake area and disease transmission by wild fowl moving between the landfill site and intake area.

Recommendation 27

It is recommended that the Regional District be made aware of the risk posed by the landfilling operation and where possible make operation changes that would reduce the risk.

12.3.11 Motorized Water Craft

There are anecdotal observations that there are more motorized recreation boats on Lower Campbell Lake including houseboats and jet boats. Over the next decades there is a potential for a growth in recreational boat use on all the lakes in the Campbell River

watershed. The issue is the potential for the introduction of pathogenic organisms and fuel spills that could impact the District's water quality. The regulation of boats on a lake is within Federal jurisdiction.

Recommendation 28

It is recommended that recreational motorized boats be banned from John Hart Lake.

12.4 Risk Zones A, B, A1, B1 and B2

12.4.1 Formal and Informal Recreation Sites

There are a number of formal and informal recreation sites located on the foreshore of the Campbell River watershed lakes. There are major concerns about the impact of the informal summer campsites that are located in the watershed typically on private land. The issues include disposal of human body wastes and garbage.

Recommendation 29

It is recommended that a more formal microbiological water quality monitoring program be established by the UICCCHSS for active recreation areas on McIvor, John Hart and Lower Campbell Lakes and water quality data be collected on a routine basis particularly during the summer months. The goal would be to evaluate and monitor the impact of the recreation sites, both formal and informal, on the water quality. Sampling should take place weekly during the summer season when recreational activity is at its peak. Water quality parameters tested at these sites should include temperature, dissolved oxygen, turbidity and coliforms.

12.4.2 On-Site Sewage Systems

There are a number of residential on-site sewage treatment and disposal systems in the Campbell River watershed as well as permitted pumped systems particularly at authorized campsites. The design and installation approvals are by the Upper Island – Central Coast Community Health Services Society (UICCCHSS). There are presently limited resources to manage the on-site systems with typical remediation done on a drain field only at failure.

Recommendation 30a

It is recommended that an ongoing education program be developed and implemented to reach each permit holder to make them aware of the issues with sewage disposal in a community watershed.

Recommendation 30b

It is recommended that a formalized program to manage the on-site treatment and disposal systems in the watershed should be developed and implemented. The program should include a detailed and easily accessible registry of all systems, an ongoing performance and monitoring program of all systems, operation and maintenance tasks, correcting systems identified as a risk by the monitoring program and education of users about the potential risks to the District's water quality.

12.4.3 Forest Practices

Under Section 7 of the Operational Planning Regulation – BC Forest Practices Code Act, the Ministry of Forests can require the development of an Operational Plan and have that plan referred to any government agency or person specified by the District Manager. It is recommended that the MoF, in consultation with the DCR, create a set of site specific Standard Operating Procedures (SOP) for any timber sales undertaken within Risk Zones

A and B (including subzones A1, B2 and B2) that reflect the importance of maintaining water quality and have these included in any Operational Plans.

The SOPs will define specific procedures. A partial list of topics to review include:

- Wet weather shut down criteria
- Bridge and culvert construction
- Road and ditch maintenance
- Temporary road access deactivation
- Equipment Fuel Handling
- Emergency Response Procedures

Recommendation 31

Active forest management of both public and private land has been and continues to be a major activity in the watershed. It is important that those responsible for forest management incorporate water quality protection in any Forest Management Plans. It is recommended that the goals, practices and outcomes under the BC Forest Practices Codes or the Private Land Forest Practices Regulation should be the basis for the conduct of all forestry practices in the watershed.

12.4.4 Development and Harvesting Plans

Recommendation 32

The Ministry of Forests should refer all forest development plans and harvesting plans within Risk Zone A and B (including sub zones A1, B1 and B2) to the DCR. These plans should contain references to specific actions and Standard Operating Procedures designed to protect water quality.

Recommendation 33

Harvesting within Risk Subzones A1 and B1 has significant potential to introduce sedimentation. In addition to riparian reserve and management zones required under the FPC, it is recommended that consideration be made in developing harvesting plans which include the use of single tree and group reserves to control potential water movement within the block.

12.4.5 Sub-Landscape Level Planning

The Provincial Forest lands within Risk Zones A and B (including sub zones) are of primary planning importance. The Watershed Assessment Procedure (WAP) and Equivalent Clearcut Area (ECA) calculation are useful tools in managing the rate of cut relative to water quality, however their standard application does not adequately meet the unique situation of the subject area.

Recommendation 34

It is recommended that the MoF, Timber West and Hancock, in consultation with the DCR and the MoF Regional Hydrologist, undertake a modified WAP and ECA for the areas in Risk Zones A and B (including sub zones), which is beyond the area of the proposed community watershed, for the purpose of establishing a rate of cut and desired range of opening sizes. Until the WAP is completed, it is recommended that the ECA for this area be maintained at less than 20%. See Appendix 5.

It is also recommended that any motorized crafts used elsewhere in the watershed with on board toilet facilities be required to have holding tanks with an approved waste discharge facility to accept the wastes in place. It is recommended that there be permanent signage in place identifying the risks to the water quality from boating and requesting the public's assistance.

12.5 Future Studies

12.5.1 Wildlife Health Studies and Animal Inventory

The potential for a pathogen contamination of the water supply caused by wildlife is one of the highest rated events evaluated. A wildlife study to Resource Inventory Committee (RIC) standards will provide a baseline for the numbers of wildlife, specfically beavers, muskrat and otters and where their primary habitat is located. The study would look at the health of these populations to determine the presence of the giardia lamblia and cryptosporidium parasites in the animals. The results of these studies would provide data on wildlife management requirements.

12.5.2 Geotechnical Study of Campbell Lake – John Hart Lake "Barrier"

It is reported that the narrow land mass between Campbell Lake and John Hart Lake is subjected to a substantial groundwater flow. The concern is that in a high magnitude earthquake the land mass could fail with a sudden leakage of water from Campbell Lake to John Hart Lake. BC Hydro is evaluating the situation on an ongoing basis that should provide background information to the District.

12.5.3 Campbell River Watershed Hydraulic Characteristics of the Main Lakes

The impact of an event in the watershed reaching the District's intake depends on the velocity of the water movement through the lakes tributary to the intake. This includes Buttle, Upper and Lower Campbell and John Hart Lakes. The velocity of the water is dependent on the precipitation and the operation of the power plant and overflow structure at John Hart Lake.

It is recommended that the District request BC Hydro undertake a study to identify the travel time of the water to the John Hart Dam from various locations on the lakes for different operating conditions. This would assist all agencies in understanding of the

available time between an event occurring in the watershed and possible impacts on the District's intake.

12.5.4 Long Term Impact of On-site Treatment and Disposal

The UICCCHSS reviews and reports on the setback requirements between a sewage drainfield and the Campbell River watershed receiving water to ensure no long term microbiological impacts from on-site disposal systems.

12.5.5 Debris in the Watershed

There has been a long and historical case of public vehicle access in various areas of the watershed both on public and forestry roads. One of the inevitable consequences is that unwanted garbage and debris has been deposited. It is recommended that a study be undertaken to identify the volume and type of debris in the John Hart Lake watershed, the associated risk to water quality and the estimated cost and responsibility to remove and dispose of the debris. The report should provide guidance on the method and responsibility to deal with future occurrence of illegal dumping in the watershed, particularly the John Hart Lake watershed.

12.5.6 Official Community Plan Admendments

This report provides a number of recommendations intended to protect the Campbell River watershed water quality to the highest standard possible. It is clear that the District and the Regional District have limited land use and regulatory powers in regards to affecting land use decisions in the watershed. It is recommended that both the District and Regional District seek to incorporate the recommendations contained in this report , particularly on land use matters, into their respective Official Community Plans. This will provide the community's direction to both land owners and regulatory bodies with interest in the watershed.

12.6 Implementation Strategy, Budget and Schedule

This section summarizes the recommendations, provides a budget estimate for each recommendation and proposes an implementation schedule.

The recommendations are summarized on Table 12-1. Included with the summary are estimates of the one time startup costs associated with each recommendation, the estimated ongoing District staff time and cost, as well as consultant costs. The consultant effort would be to provide direction to the District on any referrals for comments from senior government ministries and departments.

The Campbell River Watershed Management Committee has been allocated some of the expenditures. It is likely that land use activities and regulators in the watershed should share the funding of initiatives cooperatively. Other recommendations fall to parties other than the District and the ability to fund the recommendations would have to be discussed with these agencies.

An implementation schedule for each of the recommendations is included on Figure 12-1. It is assumed that any District expenditures will have to be included in the 2002 and beyond budget processes.

District of Campbell River- Watershed Management Plan

Table 12-1 Program Summary and Estimated Budget

revision date July 24, 2001

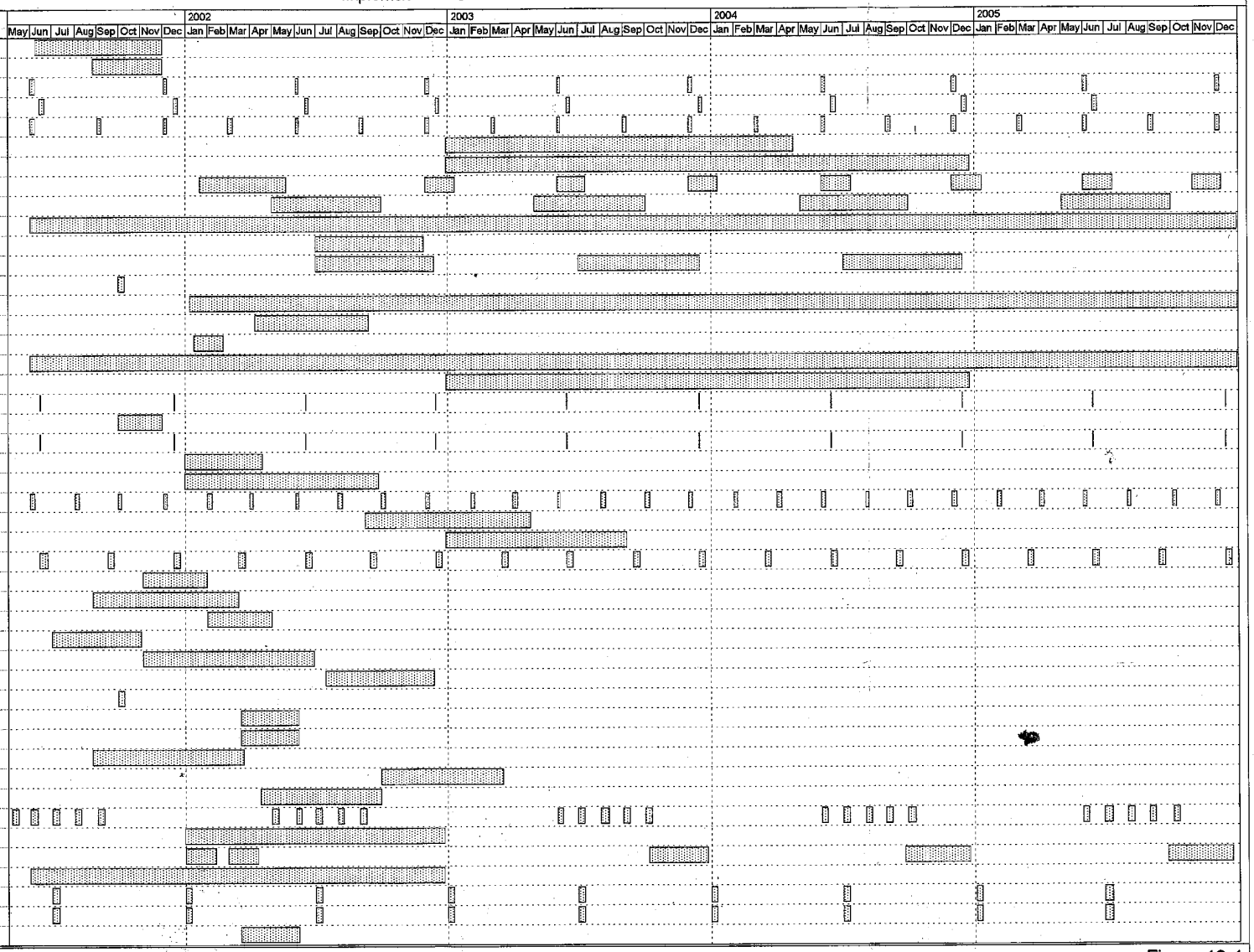
Recommendation Number	Task Description	Responsibility	Estimated Startup Cost	Estimated Annual Budget			Total Annual Budget ($)	Comments
				Staff Time Number of Hours	$/hr	Consultant Cost		
Recommendation 1	Drinking Water Protection Plan	District						Staff time
Recommendation 2	Permanent Watershed Committee	District & Stakeholders		300	$50	$10,000	$25,000	Two meetings per year plus preparation/reporting and administration. Include key stakeholders/regulators. Staff time. Agree on Best Management Practices and Code of Conduct reflecting Water Quality Protection.
Recommendation 3	Geographic Information System	CRWMC	$50,000	200	$30		$6,000	Create GIS System for Watershed, Land Use/Permits MOELP,BCAL,MoH Water Quality Data.
Recommendation 4	Emergency Response Plan - Water Quality	District	$35,000	50	$50		$2,500	Staff time and consultant to prepare plan, update by staff annually.
Recommendation 5	Public Education Program	CRWMC	$5,000	300	$50		$15,000	Ongoing public education
Recommendation 6	Information Person	CRWMC		400	$50		$20,000	Support of a "park ranger"
Recommendation 7	Road Safety	Ministry of Highways		100	$50		$5,000	Reduce Risk of Accidents ERP's for Traffic Accidents
Recommendation 8	Watershed Recreation Plan	CRWMC	$20,000					Develop a coordinated watershed recreation plan and update as necessary
Recommendation 9	Recreation Best Management Practices	CRWMC	$5,000					Develop BMP practices code and bring existing sites into conformance.
Recommendation 10	Pesticide Use	BC Hydro, Regional District		100	$50		$5,000	Advise District on pesticide use.

Recommendation Number	Task Description	Responsibility	Estimated Startup Cost	Estimated Annual Budget			Total Annual Budget ($)	Comments
				Staff Time Number of Hours	$/hr	Consultant Cost		
Recommendation 11	Adoption of Best	CRWMC						Develop BMP in fields of practice.
	Management							
	Practices							
Recommendation 12	Fire Suppression	MoF						Protocol on suppression tactics
Recommendation 13	Agricultural BMP	Regional						Develop and adopt BMP for agricultural
		District						operations in the watershed.
Recommendation 14a	Boliden/Westmin Mine	Boliden/Westmin		100	$50		$5,000	Staff time
		Mine						
Recommendation 14b	Emergency Response	CRWMC						By other organizations operating
	Plans and Update							in the watershed.
Recommendation 14c	Mining Permit and Refferals			100	$50		$5,000	Staff time.
Recommendation 15a	Aggregate Operations -	Ministry of						Storm water runoff monitoring program
	Stormwater Run-off	Energy Mines						
Recommendation 15b	Application Permit	Ministry of		100	$50		$5,000	Stormwater Permit Application, Staff time
		Energy Mines						
Recommendation 16	Road Improvements	MOTH						Effects of construction of any road
								improvements on the watershed
Recommendation 17a	Water Quality	District	$50,000	300	$30		$9,000	Online monitoring, purchase equipment
	Monitoring - Turbidity							collect, analyze and report on data
Recommendation 17b	Water Quality	District		60	$30	$6,000	$7,800	Sample, analysis and reporting
	Monitoring - Detailed							Commercial Laboratory Costs
	Analysis							Comprehensive Chemical and
								Microbiological 6 times per year
Recommendation 17c	Water Quality Data	District	$5,000	70	$30	$8,000	$10,100	Water quality data base management
	Management Program							
Recommendation 17d	Agency Water Quality	District		100	$30		$3,000	Staff time.
	Data Base Integration							
Recommendation 17e	John Hart Lake Water	District				$6,000	$6,000	Biological / Physical / Chemical Water
	Quality Monitoring							Quality Monitoring and Analysis in addition
	Program							to 3a and 3b.

Recommendation Number	Task Description	Responsibility	Estimated Startup Cost	Estimated Annual Budget			Total Annual Budget ($)	Comments
				Staff Time Number of Hours	$/hr	Consultant Cost		
Recommendation 18a	Land Use Strategy	District	$5,000					Land Use Strategy, Staff time.
Recommendation 18b	BCAL Discussions			100	$50		$5,000	Staff time.
Recommendation 19	Recreation Activities	District	$5,000					Staff time.
Recommendation 20	Overnight Camping	MoF						Prohibit overnight camping on John Hart Lake
Recommendation 21	Land Development		$10,000	150	$50		$7,500	
	McIvor Lake							
Recommendation 22	Brewster Bridge Access	District	$5,000					Recommend changes to bridge access.
Recommendation 23	John Hart Lake level	BC Hydro						Recommend that for water quality purposes the lake level be kept high.
Recommendation 24	Zone A Logging Roads Deactivation Plan	MoF						Plan to deactivate logging roads in Zone A. Ministry of Forests.
Recommendation 25	Logging Traffic							Redirect logging traffic to alternate roads in Zone A. Ministry of Forests.
Recommendation 26	Stump Removal	MoF						Ministry of Forests
Recommendation 27	Campbell River Landfill Operation	Regional District						Modify operations plan to reduce the risk to water quality.
Recommendation 28	Motorized Watercraft			100	$50		$5,000	Recommend motorized boats banned
Recommendation 29	Water Quality Monitoring- Recreation Areas	Ministry of Health		30	$30	$10,000	$10,900	Program of Routine (1/week) Monitoring of Water Quality Adjacent to recreational areas May to September at ten sites.
Recommendation 30a	Education Program Onsite Sewage System Owners	Ministry of Health					$5,000	Education program about onsite sewage disposal systems in the Campbell River Watershed.
Recommendation 30b	Onsite Sewage System Management Program	Ministry of Health	$20,000				$3,000	Establish and maintain an on-site sewage disposal system management program.
Recommendation 31	Forest Practices Code	MoF/MOELP						Adopt Forest Practices Code or Private Land Forest Practices Regulations on all forested lands in the Watershed. Ministry of Forests.

Recommendation Number	Task Description	Responsibility	Estimated Startup Cost	Estimated Annual Budget			Total Annual Budget ($)	Comments
				Staff Time Number of Hours	$/hr	Consultant Cost		
Recommendation 32	Referral of Harvesting	MoF						Refer all harvesting plans in Zones A & B to
	Plans in Zone A & B							the District for comment. Ministry of Forests.
Recommendation 33	Referral of Harvesting	MoF						Refer all harvesting plans in Subzones A1 &
	Plans in Subzones A1 & B1							B1 to the District for comment. Ministry of
								Forests.
Recommendation 34	Sub-Landscape Level	MoF, Regional						Develop Sub-Level Landscape Plan.
	Planning	District						Ministry of Forests.

Campbell River Watershed Management Plan
Implementation Schedule



Dayton & Knight Ltd.

Figure 12-1

DOC (10).max

13.0 EXPERIENCES FROM OTHER WATER DISTRICTS

13.1 Greater Vancouver Regional District

The Greater Vancouver Regional District water sources include the Capilano, Coquitlam and Seymour Lakes watersheds. The watersheds are closed to the public. In it's Watershed Management Plan, the Greater Vancouver Regional District identifies three areas of concern regarding water quality. The first of these concerns is erosion control and avoidance of sediment delivery into the water source. Measures prescribed to mitigate erosion are as follows:

- Landslide Deposit – Excavation of landslides that are accessible by road.
- Torrented Gully Treatments – Aerial seeding of gullies
- Landslide Scars – Planting and/or seeding on landslide scars
- Exposed Mineral Soil Protection – Seeding naturally disturbed areas with exposed mineral soil
- Stream Protection – Rip-rap protection of eroding and unstable banks

Forestry and vegetation management was the second issue identified. The use of appropriate silviculture treatments to provide a particular stand structure on target areas is intended to address this issue. Access management is the final point addressed in the Watershed Management Plan, and will be managed through the following measures:

- Road Use – Increased use to support erosion control and silviculture operations, but attempt to minimize use by public
- Road Construction and Improvements – Minimize new construction and upgrades
- Road Decommissioning – Deactivate selected roads

13.2 City of Nanaimo

Water for the City of Nanaimo, Village of South West Extension and No. 1 Indian Reserve is collected under the jurisdiction of the Greater Nanaimo Water District (GNWD), from a watershed located approximately 26 kilometers southwest of Nanaimo. The land is owned by MacMillan Bloedel, but the GNWD holds water licences over an area of 32.6 hectares. The watershed has restricted access to protect water quality.

In 1931 the South Fork Dam was constructed to supply Nanaimo and its surrounding settlements. The dam was taken over by the GNWD in 1953.

In 1974, the Jump Creek Dam was constructed to step up the increasing demand on the water supply, and in 1986, additional storage was added to Jump Creek Dam with the addition of floodgates.

The lands within the Greater Nanaimo Water District's watershed is owned by Weyerhaeuser Company Ltd. The Greater Nanaimo Water District is responsible for maintaining an adequate supply of high quality water to their customers. To accomplish the goals and objectives of both users within the watershed requires the implementation of management strategies that fit and are unique to the watershed. The operation of the watershed is cooperatively managed by the Greater Nanaimo Water District and Weyerhaeuser Company Limited. Pre and post logging plans are reviewed on a yearly basis and active discussion takes place towards the protection and enhancement of water quality. The watershed is actively logged, with sustained growth and water quality as two of the main objectives of the logging plan.

The Greater Nanaimo Water District contracts the operation and maintenance to the City of Nanaimo.

As part of the water quality protection program the access to the watershed is restricted. Authorization for entry is on a limited basis, and only open to individuals or groups that

can demonstrate a need to be in the watershed. Entry to the watershed is controlled by permit, and permit holders are required to attend a video training session.

13.3 Greater Victoria Water District (Capital Regional District)

The Capital Regional District (formerly Greater Victoria Waterworks District) developed a strategic plan in 1999 for water management including a section on watershed management. The CRD owns approximately 98% of the landbase of their watershed, and has strict control on the activities within the watershed including public access.

The strategic plan has been developed to manage the natural watershed processes that have been modified over the past century by transportation, utility corridors, mining, timber harvesting and settlements. Further, a plan was required to focus future management activities on protecting the water supply from both natural and human elements of risk. The plan is also developed to help manage and mitigate the impact of natural processes that are detrimental to water quality.

Watershed Management Goals

Ensure that the quality of the water in the source water bodies within the watershed meets or exceeds the limits stated in the Guidelines for the Protection of Freshwater Aquatic Life.

Ensure that the quality of the source water entering the treatment plant meets or exceeds the limits stated in the Guidelines for Canadian Drinking Water Quality and the USEPA Interim Enhanced Surface Water Treatment Rule as it applies to unfiltered water sources.

Maintain, and enhance ecosystem function and the hydrologic stability of the forest to protect water quality, achieve water supply objectives and support compatible secondary values.

Strategic Policies

The CRD Water Department shall use consolidated land ownership and management of land use activities in the Greater Victoria Water Supply Area as the primary means of source water quality protection.

The CRD Water Department shall continue the policy of a closed watershed.

CRD-owned catchment lands shall be dedicated to the supply of high quality water. Management activities, for the purposes of water quality and supply, shall have priority over secondary values and other management activities.

The CRD Water Department shall pursue land use control through ownership or land use agreements with the owners of non-owned catchment lands.

CRD-owned non-catchment lands under the jurisdiction of the Water Department shall be managed primarily as a buffer between other land use activities and for operational requirements.

The CRD Water Department shall seek co-operative planning and operational agreements with the CRD Parks Department and other adjacent land holders for the purpose of reducing impacts to catchment lands.

The CRD Water Department shall use an ecological based risk assessment process to evaluate watershed management activities and land use activities on adjacent lands as a means of identifying and determining potential risks to water quality and secondary values.

The CRD Water Department shall use an adaptive management approach to continually improve watershed management activities.

The CRD Water Department shall support a collaborative research program that will enhance the understanding of ecological functions and the inter-relationships between terrestrial and aquatic processes for the purpose of water quality and supply. Further, management activities and natural processes within the Greater Victoria Water Supply Area will provide educational opportunities and serve as an outdoor classroom in a manner that supports watershed values.

The CRD Water Department shall conduct ongoing public consultations on major projects, planning initiatives and programs.

The Strategic Plan for Watershed Management describes current watershed management issues and prescribes actions for dealing with existing high priority risks to water quality and secondary resource values. The issues and actions are grouped into seven categories:

1. Aquatic Systems Management
2. Security Management
3. Fire Management
4. Forest Health Management
5. Erosion Management
6. Waterborne Pathogens Management
7. Ecosystem Management

Discussion within each of the several categories includes:

- Identification of key management issues
- Review of existing programs and practices of the Water Department
- Recommendations for operational goals as an overall guide for action
- Recommendations for short and long-term action including needs for further data collection and study.

13.4 City of Seattle

The Cedar River Watershed Habitat Conservation Plan (HCP) has been prepared to allow the City of Seattle to comply with the Endangered Species Act, and to maintain the high quality raw water, that supplies 2/3 of Seattle's demands. In addition to providing a source of drinking water, this watershed is partially managed by Public Utilities to supply nearly 1% of Seattle's electricity consumption.

Because the Cedar River is a surface water supply, the City must meet certain regulatory standards at its raw water intake. The obligations to under the Safe Drinking Water Act have been major constraints in developing the Habitat Conservation Plan, in particular the passage of anadromous salmon and trout above the raw water intake.

The Surface Water Treatment Rule dictates that a filtration system must be installed unless eleven filtration avoidance criteria are met. The Cedar River has generally been able to meet the criteria, but periodically cannot meet individual criterion, usually fecal coliform levels. This has been attributed to increased wild animal activity near the river mainstem.

The City has recommended the development of an ozonation facility to meet the SWTR, with a master plan to include a filtration facility in the future if deemed appropriate and necessary.

To protect the unfiltered surface water source, the watershed has been closed to unsupervised public access and a surveillance program has been implemented.

A number of City policies and ordinances around logging have been implemented since 1989 regarding timber harvesting in the watershed. Since 1989, about 1,650 ha has been harvested, with the last significant harvest occurring in 1994. All harvesting now is restricted to second growth stands, and the concept of "New Forestry" has been utilized.

New Forestry is defined as management designed to create a similar stand structure, with multiple canopy layers and snag component similar to adjacent old growth stands.

Turbidity has been viewed as the primarily concern due to timber harvesting in the watershed. Virtually all recent concerns regarding turbidity levels have been related to storm events, due to stream bank erosion, landslides or the failure of beaver dams (which act as a sediment trap).

The effectiveness of these strategies will be assessed through continued monitoring, and it is anticipated that water quality will be indirectly maintained through the maintenance and enhancement of habitat within the watershed.

13.5 Fraser Valley Regional District - Norrish Creek

Approximately 117 km^2 in size, the Norrish Creek is the primary water source for the District of Mission and City of Abbotsford. The total service area population is about 100,000 persons. The watershed is open to public access through a network of logging roads. Forestry has been and continues to be the predominant activity in the watershed. In 1974, B.C. Hydro constructed a high voltage transmission line through the watershed.

Issues of concerns identified during the creation of the Watershed Management Plan included forestry activities, fisheries values and uncertainty regarding terrain stability. Numerous measures to minimize adverse impacts to the water quality from Norrish Creek were recommended within the Watershed Management Plan. These measures are as follows:

- Monitor the traffic that enters the watershed, by having the gate attended for an unspecified time,
- Increase public awareness of the watershed status of the area; achieved through to posting of informational signs, as well as through oral communication by the gate attendant, when present,

- Plan to manage low flows for fisheries values by reservoir flow release initiated at specific critical levels,
- Establish and revise approval procedures for general resource development guidelines based on terrain hazards,
- Evaluate condition of all inactive roads within the watershed and prescribe remedial procedures.

13.6 District of Squamish

The Integrated Watershed Management Plan created for the Stawamus River and the Mashiter Creek, involved a collaborative effort by numerous stakeholders. The municipality, various provincial and federal government agencies, Squamish Nation, and timber harvesting interests collectively identified management strategies for four issues of concern. Water Quality, Quantity, and Flow; Fish Habitat; Wildlife and Biodiversity, and Forest Management were the identified issues. The management strategies for each were as follows:

13.6.1 Water Quality, Quantity and Flow

- Monitor delivery of water quality through periodic testing
- Prevent the entry of diseases or contaminants by limiting access, provide education/information, establishment of riparian reserves, etc.
- Initiate development of an alternative water supply to ensure minimum flows are maintained
- Minimize peak flows by ensuring that timber harvesting activities employ selection silviculture systems

13.6.2 Fish Habitat

- Evaluate fish habitat values to be protected and opportunities for enhancement by carrying out inventories, restoration projects and riparian management reserves

- Ensure minimum flows are maintained and avoid sedimentation through proper management of timber development activities

13.6.3 Wildlife and Biodiversity

- Identify critical habitat and undertake inventories
- Establish a Forest Ecosystem Network (FEN)
- Define and maintain riparian habitat
- Maintain large organic debris, snags and wildlife trees in reserves, buffers, inoperable areas and partial cut areas

13.6.4 Forest Management

- Harvest at a rate of 1% of the operable timber per year
- Harvest in accordance with the Forest Practices Code of B.C.
- Maintain and enhance forest cover through planned road construction, harvesting, prompt reforestation, intensive silviculture and control of pest/disease agents

13.7 Comox Valley

The Comox Lake watershed has an area of 58,591 hectares. The Regional District of Comox - Strathcona's water source and distribution system services the City of Courtenay, Town of Comox, Comox Valley Local Service Area, Arden LSA, Greaves Crescent LSA, Marsden/Camco LSA and England Road LSA. The source is the Comox Lake Watershed. It is not a controlled watershed and does not have a formal management plan. The Regional District does not own any of the lakeshore.

There are eight sub-catchment areas within the watershed. The watershed is almost entirely zoned Upland Resource with a minimum parcel size of 40 hectares. The permitted uses of the area are: one single family dwelling per parcel, forestry, agriculture, low impact recreation, fish hatcheries and enhancement facilities, public utilities, park

use, explosives sales, manufacture and distribution, fire arm ranges and intensive aquaculture. There are 35 cabins on leased land at the upper end of the lake and a further 20 on leased land near the outlet of the lake. The municipal campground contains 48 camping spaces.

The Regional District accesses the lake from the BC Hydro Penstock. BC Hydro is responsible for managing the level of the lake. There are no Comox Valley Regional District staff who monitor the area. Daily inspections are performed by staff on the master meter and the chlorination system for their incoming water supply. The annual withdrawal for 2000 was 8,140,000 m^3 of water.

13.8 City of Portland

Sources

The Portland water system flows from the Bull Run Watershed to the Bull Run River into two reservoirs before it reaches the Headworks. The average annual water production is 125 million gallons per day. The Bull Run water supply is of such high quality that it meets all of the requirements for non-filtration. Three high turbidity events occurred from December 1977 to January 1978 with turbidities greater than 5 NTU. These events were all caused by the same storm event which was considered an unusual event by the OHD. The Mount Hood National Forest Service and the City of Portland have control over the watershed.

Water Quality

No significant change in water quality has been detected within the last 100 years which is partially due to the strict watershed management practices. However there are periodic high turbidity spikes due to storm events and draw down of reservoirs.

Watershed Control Program

Access is restricted to the Bull Run Watershed. The following objectives are included in the watershed management policy. Commercial logging and related forest management activities that are solely for profit and do not enhance or maintain current water quality are prohibited. Salvage logging is prohibited unless it is consistent with the protection of water quality. Pollution has always been a sensitive issue. The watershed is closed to the public except for prearranged city tours. When a portion of it was logged in 1973, horses wearing diapers were used to haul downed timber.

There is a long range plan for the Little Sandy River to be a long term water supply. The prevention of natural and human influences such as fire, wind, and human entry is an issue. Boundary adjustments to the watershed ensure an adequate buffer zone for water quality.

Chemical Treatment

Chlorination occurs at the Headworks, and Ammoniation at Lusted Hill. The residual disinfectant is chloramine. Chlorination and ammoniation facilities are also located downstream of the Headworks.

13.9 District of Port Alberni

There are two watersheds in the surrounding area of Port Alberni. The China Creek Watershed which has an area of 6,500 hectares and the Bainbridge Lake Watershed which has an area of 1,300 hectares. The City of Port Alberni has a permit to withdraw 24,000 m^3 of water per day from the China Creek Watershed and a permit to withdraw 9,700 m^3 from the Bainbridge Lake Watershed. The population of the City of Port Alberni in 2000 was estimated by Stats BC to be 19,329. The City does not have a formal watershed plan for these watersheds though they may prepare one in the near future.

The current management for the area is governed by a "Logging Plan and Assessment" as forestry is the major activity in the area. The City of Port Alberni monitors all activities within the watersheds, especially hauling activity. TimberWest and Warehauser are the two stakeholders in the watershed. There is an agreement with these stakeholders to not haul logs in wet weather. There has also been a set of "Wet Weather Shutdown Criteria" created to help maintain the area. These criteria include:

- water bars must be constructed on roads after logging is complete for the season, this reduces erosion

- loggers must use and empty porta-potties

- loggers must use waterproof storage cases for all lubricants, (eg. Motor oils)

Besides forestry there are many recreational activities within the watersheds such as: mushroom picking, hiking, biking, walking and swimming.

13.10 City of Rochester

The City of Rochester gets a portion of its drinking water from Hemlock and Candice Lakes and in 1993 adopted a Forest Resource Management Plan to guide the City's 7,100 watershed acres (2873 ha). The primary goal of the plan was to assure the continuance of high quality water.

Recreational activities that are compatible with water supply concerns are allowed on the lake, and a permit system (permits are free) has been instituted. The permits serve as an educational tool. Acceptable activities include fishing, boating, hunting and hiking. Swimming is strictly prohibited. A "no access" zone is maintained.

A Forest Resource Management Plan was implemented in 1993. The plan addressed and offers support to the recommendation of maintaining the status quo in regard to land use

and development while at the same time reveals why no action of forest management on city owned property would bring about long term undesirable environmental changes.

The assurance of high water quality is the primary goal. All other goals and the objectives to reach these goals are weighted against this benchmark.

Forest management is allowed considering future species compositions over the landscape, particularly oak and white pine. Timber harvesting practices are defined but no formal Best Management Practice or Standard Operating Procedure is defined.

13.11 Finger Lakes – Lake Ontario Watershed Protection Alliance (FL-LOWPA)

FL-LOWPA is a coalition of 25 counties in western New York state that are wholly or partially in the Lake Ontario drainage basin. FL-LOWPA fosters coordinated watershed management programs across the Lake Ontario basin based on local needs. FL-LOWPA programs enhance and protect water quality through a combination of nonpoint source pollution control; watershed planning and research and public education. The following list summarizes the programs used by a variety of the counties to ensure drinking water quality:

- Best Management Practices related to Agriculture
    - Barnyard water management systems
    - Nutrient Management Plans
    - Milkhouse water treatment systems
- Lake Weed Growth Management
    - Mechanical harvesting
    - Aquatic moth stocking program
- Septic system inspections
- Public Education
    - Formation of Watershed Committee
    - Public meetings

    - Workshops
    - Demonstration projects
    - Teacher packages
    - Poster contests
    - Newsletters
    - Volunteer water quality water sampling program
- Erosion Control
    - Streambank stabilization
    - Revegetation Programs
    - Tree Planting
    - Hydroseeding
    - Road bank and ditchline stabilization
- Develop GIS data management system
- Water quality monitoring
- Wetland creation
- Stormwater monitoring
- Private Well Testing Program

A complete list of programs used by each county is included as Appendix 4:

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX 1

WATERSHED PLANNING COMMITTEE
AND OPEN HOUSE MINUTES

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX 2

RISK REDUCTION STRATEGY
(ALL RISKS)

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX 3

B.C. SAFE DRINKING WATER REGULATION

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX 4

FINGER LAKES – LAKE ONTARIO WATERSHED PROTECTION ALLIANCE (FL-LOWPA) SUMMARY

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX 5

FOREST PRACTICES CODE WATERSHED ASSESSMENT PROCEDURE

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

VOLUME II

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX II

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX A

Bathymetry for 23 Lakes in the Campbell River Watershed

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDIX D

D1 – Life Histories of Fish Species in the Campbell River Watershed
D2 – Rare Vertebrates Occurring in the Campbell River Forest District
D3 – Rare Element Occurrence Report

DISTRICT OF CAMPBELL RIVER
WATERSHED MANAGEMENT PLAN

APPENDICES

VOLUME II