Powell River Regional District

Lund Water System Feasibility Study

Final Report
April 2009

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

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KWL File No. 355.008

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STATEMENT OF LIMITATIONS

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EXECUTIVE SUMMARY

INTRODUCTION

The Lund Water System (LWS) is currently owned and operated by the Lund Water Improvement District (LWID). The water poses a potential health risk to consumers and the Vancouver Coastal Health Authority has issued a directive to the LWID to improve water quality and make upgrades to the distribution system. This directive, the high cost of the necessary improvements and the liability associated with providing poor quality water prompted the LWID to ask the Powell River Regional District (PRRD) to assume ownership of the system. The PRRD has agreed to take over the system provided it is upgraded to meet current regulations and standards in order to minimize the district's liability. A conversion plan is underway, but the transfer is dependent on upgrading to address water system deficiencies.

As the prospective owner of the system, the PRRD retained Kerr Wood Leidal Associates Ltd. (KWL) to complete a feasibility study to:

- Assess the Lund Water System;
- Determine existing and future water demands;
- Evaluate three water treatment options to improve water quality;
- Propose water quality and distribution system upgrades;
- Prepare capital, operation and maintenance, and life-cycle cost estimates for proposed water treatment and distribution system upgrades.

ASSESSMENT OF EXISTING WATER SYSTEM

Most of the residents of Lund, B.C. are supplied with water from the LWS. The system has 87 residential customers (households) and 18 non-residential customers primarily commercial. The LWS receives water from Thulin Lake, which is then gravity fed to the Main pump station and chlorination building. The water is disinfected with calcium hypochlorite and then pumped into the distribution system. The distribution system has three reservoirs and one booster station.

Water from Thulin Lake does not meet Guidelines for Canadian Drinking Water Quality (GCDWQ) for the following health-based parameters:

- *Giardia;*
- *Cryptosporidium;* and
- Trihalomethanes (THMs).

The existing level of treatment of only chlorine disinfection on a surface water source is not adequate to treat for these contaminants. Additionally, the water is high is turbidity, colour, iron and manganese. There is indication of the presence of a high level of natural organic matter which is responsible for the consequent formation of THMs, a potentially carcinogenic disinfection by-product. THMs are produced due to the reaction of chlorine-based disinfectants with the organic matter. The THMs for 23 samples collected since 2004 are all significantly above the health based limit. The average of these samples is nearly double the specified limit.

In addition to the water quality issues, other deficiencies have been identified in the LWS: Areas of the system have undersized watermains. In some cases these result in inadequate pressure and/or flows for fire fighting. Also, Reservoir No. 2 (old wood-stave tank) has significant leaks and loses approximately 45 m^3 per day, while Reservoirs No. 1 and No. 3 have openings in the roof which pose a contamination risk from avian wildlife. Additionally, some of the watermains are located along private property and not along easements of rights of way.

WATER DEMAND

The average day demand (ADD) for the LWS is 287 m^3/d, of which 45 m^3/d is lost through leaks in Reservoir No.2 and 70 m^3/d is unaccounted-for water (UFW). Water demand from residential and non-residential customer is 172 m^3/d or approximately 60% the total ADD. With water conservation implementation including universal metering and a leak detection program, the ADD will be significantly reduced by approximately 35%. This is considered in the determination of future water demand estimates for 10-year and 20-year forecasts.

The 20-year ADD with the implementation of water conservation practices is 236 m^3/d and the maximum day demand (MDD) is 707 m^3/d. These values consider a population growth rate of 2%, a water conservation reduction of 20% in customer use, a reduction in UFW to 15% customer use, and the elimination of lost water from Reservoir No.2, since this reservoir will be decommissioned. The 20-Year MDD is used as the design flow for the proposed water treatment plant and system upgrades.

ALTERNATIVE WATER SOURCE

Alternative water sources for Thulin Lake were investigated. One study examined possible locations to drill a well to replace the Thulin Lake water source, but the only suitable sites found to date have required drilling more than 500 feet through rock. The projected well yields were insufficient to meet the required demand, which means multiple wells would have been needed. Four test wells have been drilled over the last several years and in addition to low yields, the water has been of poor quality and requiring substantial treatment. The cost of developing a groundwater source for Lund was considered prohibitive, which is why the idea was ultimately rejected. Supplying the Lund Water System with water from the City of Powell River was also considered. However, this idea was also rejected since it would require the construction of a water main over 20 km in length. The cost of this transmission main itself would be in the range of $8.0 million and would still require the proposed distribution system improvements. It was thus determined that despite its water quality issues, Thulin Lake remains the best source of drinking water for Lund.

PROPOSED WATER TREATMENT

Since no alternative water sources are viable, the only option remaining is to provide treatment for the existing water source. Three water treatment filtration options are considered:

- Option 1 – Enhanced slow sand filtration;
- Option 2 – DAF and rapid sand filtration;
- Option 3 – Membrane filtration.

Each filtration technology is evaluated for quality of finished water, ease of plant operation, wastes generated, capital cost, and 20-year life cycle cost. The recommended option is Option 1, enhanced slow sand filtration. The filtration will be followed by primary disinfection with UV and secondary disinfection with calcium hypochlorite to provide a distribution system residual. The proposed level of treatment will meet the requirements of the Drinking Water Protection Act, GCDWQ and Vancouver Coastal Health Authority by providing a multi-barrier treatment process.

DISTRIBUTION SYSTEM UPGRADES

The distribution system upgrades include construction of a new 392 m^3 (86,000 Igal) reservoir to provide water system balancing, emergency storage, and fire protection. The Main pump station requires new pumps that are appropriately selected and able to supply for the future MDD. New pump stations are required at Larson Road and Grouse Ridge to serve the customers in the higher pressure zone.

A new water main from Finn Bay Road to service Sevilla Island by land was considered but ruled out due to high cost. Fire protection on this island will be improved by the use of portable fire pumps suitable for pumping salt water. Water main along Larson Road and Murray Road will be upgraded to provide improved water pressure and fire protection.

IMPLEMENTATION PLAN

The proposed water treatment and water system upgrades for the LWS should be implemented in a logical sequence of construction. A preliminary schedule for this project is attached to this Executive Summary and is based upon the assumption that approval of the infrastructure funding can be obtained by September 2009. If this milestone can be met, all of the proposed works can be completed before March 31, 2011.

The project will be managed as two separate contracts: one for the distribution system upgrades and one for the new treatment plant. To expedite project completion, detailed design of some distribution system upgrades will begin before the preliminary design report is completed. The upgrades selected for expedited detailed design are the ones viewed to be necessary regardless of preliminary design conclusions. For example, the configurations of new watermains along Finn Bay Road, Alannah Road, Highway 101 and Quarry Place are already known and can therefore be designed before preliminary design is complete. Other watermains, such as the one from the intake pump station to Finn Bay Road will be designed after preliminary design is complete, since conclusions from preliminary design may affect design of this watermain.

The detailed design for the distribution system upgrades will be completed in the first quarter of 2010 to allow construction to begin in the second quarter of 2010. Construction of all distribution system upgrades is projected to be complete in the third quarter of 2010. Weekly distribution system upgrades is projected to be complete in the third quarter of 2010. Weekly water quality monitoring of Thulin Lake will begin in May 2009 to ensure a full year of data is available before construction of the water treatment plant begins. Water treatment plant design will begin in conjunction with the distribution system design but will be completed slightly later, in the second quarter of 2010. This will allow outdoor construction to take place in the third quarter of 2010 with the installation of equipment and commissioning to take place over the winter of 2010-2011. A summary of major activities by quarter follows:

Q2 2009
- Project initiation
- Begin water quality monitoring of Thulin Lake
- Confirmation of infrastructure grant approval

Q3 2009
- Continue water quality monitoring
- Preliminary design of water system upgrades

Q4 2009
- Continue water quality monitoring
- Preliminary design of water system upgrades
- Detailed design of watermains along Finn Bay Road, Alannah Road, Highway 101 and Quarry Place

Q1 2010
- Continue water quality monitoring
- Complete design of all distribution system upgrades
- Tender and award contract for distribution system upgrades
- Detailed design of WTP

Q2 2010
- Complete water quality monitoring of Thulin Lake
- Complete design of WTP
- Tender and award contract for WTP
- Begin construction of distribution system upgrades

Q3 2010
- Begin construction of WTP
- Substantial completion of distribution system upgrades
- Complete construction of distribution system upgrades

Q4 2010
- Continue construction of WTP

Q1 2011
- Substantial completion of distribution system upgrades
- Complete construction of WTP
- Project completion

COST ESTIMATES

The capital cost of the proposed water treatment with enhanced slow sand filtration and distribution system upgrades is a total of approximately $6,000,000 including a contingency of 30 percent.

The estimated annual operation and maintenance (O&M) costs is a total of approximately $89,000.

CONCLUSIONS

Based on the scope and findings of this report, the following conclusions are presented:

- The water currently supplied does not meet existing health-based limits of *Guidelines for Canadian Drinking Water Quality*.
- Water quality reports and inspection reports from the Vancouver Coastal Health Authority support that a new water treatment plant providing multiple barriers of treatment is needed for the LWS.
- An enhanced slow sand filtration system will provide good drinking water quality with a lower life cycle cost and most simple operation in comparison with other water treatment technologies such as dissolved air flotation with rapid sand filtration or membrane ultrafiltration.
- Reservoir No.2 should be removed from service as soon as a new reservoir is commissioned.
- A new reservoir is needed to provide adequate storage for balancing, emergency use, and fire protection for the community.
- Reservoirs No.1 and No.3 are in need of roof repairs to prevent potential contamination from avian wildlife.
- The Larson Road Pump Station requires replacement.
- The Main Pump Station requires new pumps to supply the design flow to the proposed water treatment plant.
- The Grouse Ridge area should be served by one central booster pump station instead of the current configuration of multiple individual household booster pumps.
- Sections of 100 mm (4-inch) water main should be upgraded to 150 mm (6-inch) to provide adequate water pressure and fire protection abilities to all customers.
- Watermains running through private property that require upgrading should be decommissioned and replaced with new watermains located in a legal right-of-way or easements.
- Water meters should be installed at all water service connections to promote water conservation.

- A Water Conservation Plan for the LWS is required to reduced per capita water use and should be implemented as soon as possible (Note: This plan has been prepared by KWL for the LWS as a separate document).

RECOMMENDATIONS

Based on the conclusions presented above, KWL recommends the following:

- Implementation of all LWS water treatment and distribution system upgrades as described in Section 5 of this report and in accordance with the Implementation Plan, in Section 6.

- Implementation of recommendations of the final Water Conservation Plan (submitted under separate cover).

Section 1

Introduction

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1. INTRODUCTION

1.1 BACKGROUND

This *Lund Water System Feasibility Study* is part of the conversion plan for the transfer of the Lund Water System (LWS) from the Lund Water Improvement District (LWID) to the Powell River Regional District (PRRD). Under the terms of the conversion plan, the PRRD is willing to accept the assets of the LWS and operate the system to current standards on behalf of the property owners and residents within the LWS boundaries.

The conversion of the LWS to the PRRD was prompted by a direction from the Vancouver Coastal Health Authority to improve the water quality and by upgrading the water system. The LWID trustees recognized that the required work will involve high capital costs and increasing technical complexity that the LWID could not undertake on their own. The LWID does not have the financial or technical resources to upgrade the water system to current standards.

There is a risk that if the water system is not upgraded at this time, the current water quality status and public health risk will eventually be deemed unacceptable by Vancouver Coastal Health. At that point, they may issue an order for the upgrade of the LWS. Since the LWID is not equipped to fund the necessary upgrades themselves, there is a risk the current volunteer operators may walk away from the system, leaving the Province as the system purveyor. This situation can be mitigated by securing municipal, provincial and federal support now to implement water system upgrades.

In order for the PRRD to take ownership of the water system assets of the LWID, the water supply and distribution system must be brought up to current standards for domestic water supply. The PRRD retained Kerr Wood Leidal Associates Ltd. (KWL) to prepare this study to provide a feasibility study to outline the necessary improvements to the LWS, including the implementation of water treatment.

1.2 SCOPE

The scope of this feasibility study is to:

- describe and assess the existing water system;
- estimate existing and future water demands;
- recommend distribution system upgrades;
- recommend a water treatment solution to improve water quality;
- provide capital and operation cost estimates; and
- provide a water conservation plan (under separate cover).

1.3 PROJECT TEAM

The KWL project team includes:

- Irfan Gehlen, P.Eng., Project Manager; and
- Laura Weston, M.Eng., EIT, Project Engineer.

Input was provided by a number of external sources, including the following:

- Lloyd Ryan, Chair, LWID;
- Neil Gustafson, Trustee, LWID;
- Wayne Watson, Trustee, LWID;
- Frances Ladret, Administrator, PRRD;
- Patrick Brabazon, Director, PRRD; and
- Dan Glover, PHI., Vancouver Coastal Health.

Section 2

Assessment of Existing Water System

2. ASSESSMENT OF EXISTING WATER SYSTEM

2.1 DESCRIPTION

Lund is a small community of approximately 350 residents located approximately 27 kilometres north of the City of Powell River and within the jurisdiction of the Powell River Regional District. Most of the residents of Lund are supplied with water from the Lund Water System (LWS), while others rely on individual wells for their domestic water supply.

The Lund Water Improvement District (LWID) was inaugurated in 1972 to operate the LWS, which currently has 87 residential customers/households and 18 commercial customers. Most residential and commercial customers have one water service connection however there are a few customers that require additional flow capacity and have two or more connections.

The LWS has a main pump station and chlorination building to where raw water from Thulin Lake is gravity supplied, disinfected with calcium chlorite, and then pumped into the distribution system. The distribution system has three reservoirs, one booster station, and over 5 km of various size water main.

The existing water treatment is considered to inadequately protect public health for the following reasons:

- The surface water source only goes through one treatment barrier before being distributed to the public. Best practices call for surface water to go through multiple barriers of treatment.
- Chlorine disinfection alone does not adequately treat water for *Giardia* cysts and *Cryptosporidium* oocysts.
- The water is chlorinated without pre-removal of organic matter. This leads to disinfection by-product (DBP) formation above GCDWQ levels (as has been evidenced in the LWS).

Figure 2-1 is a schematic drawing of the existing layout of the LWS.

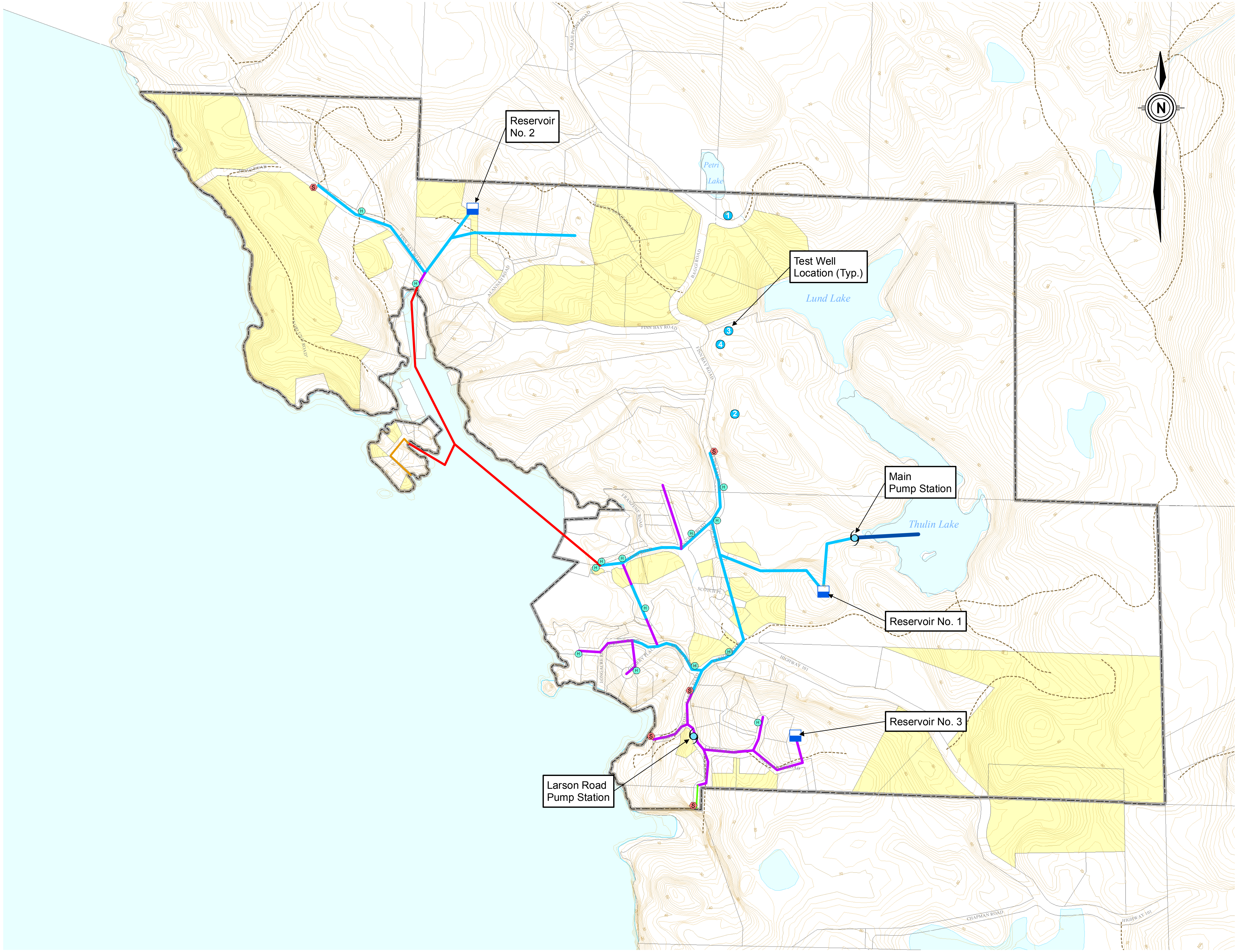
2.2 WATER SOURCE

The source of water for the LWS is from Thulin Lake and Lund Lake. The lakes are interconnected and dammed with water running from Lund Lake into Thulin Lake. The LWS intake is from a 250 mm diameter intake pipe, submerged by a float, in the middle of Thulin Lake. The LWID has a water licence of 36.5 million imperial gallons per year (166,000 m^3/year), which is sufficient to meet the current and future (20 year) water demands for the LWS.

The water volumes stored in the lakes are regulated by the dams and spillways at each lake. Water is retained within the lakes during periods of heavy precipitation for use during periods of high demand and low precipitation. The Thulin Lake dam has been previously raised to the maximum allowed by the water license.

The watershed is largely protected from development by a community watershed designation for Crown land and by the PRRD Watershed Protection Bylaw No. 172. Most of the watershed including Lund Lake and the north half of Thulin Lake are within District Lot 1613, which is undeveloped and owned by the Crown. Private property is regulated under Bylaw No. 172 which restricts land use and density on private lands within geographic watershed boundaries. There is no development of the land which drains directly into Thulin Lake, and there is development of only one property on the north side of Lund Lake in Plan 16312.

The LWID protects the watershed by posting signage in the area, installing and locking access gates, and walking the area regularly. Regular watershed inspections include cleaning up dumped refuse, instituting rodent control, and monitoring other forms of potential contamination.



Powell River Regional District
Lund Water System
Feasibility Study

Legend

- Lund Waterworks District Boundary
- Existing Watercourse
- Existing Gravel Road

Property Service Status

- Serviced
- Unserviced
- Existing Hydrant
- Existing Stand Pipe

Existing Watermain (Size Inches)

- 2" Existing Main
- 3.5" Existing Main
- 3.5" Existing Underwater Main
- 4" Existing Main
- 6" Existing Main
- 10" Existing Main

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250 0 250
Scale in Metres 1:10,000

Project No.	Date
355-008	April 2009

Existing Water System

Figure 2-1

Map Document: (O:\0300-0399\355-008\430-Gis\MXD-Rp\355008Fig2-1.mxd)
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2.3 WATER QUALITY

The primary health concern with the water quality is the lack of treatment for microbiological parameters such as *Giardia* and *Cryptosporidium*. In addition, the high level of natural organic matter causes excessive formation of disinfection by-products DBPs such as trihalomethanes (THMs). The organic matter and current chlorine disinfection system result in reactions that produce THMs, which are potentially carcinogenic and have a GCDWQ maximum acceptable concentration of 100 ug/L (0.1 mg/L). The concentration of THMs in the LWS distribution system have been tested by the local Health Authority and are consistently above the maximum limit. The average of 23 samples since 2004 is nearly double the health based limit. Copies of the THMs test results are provided in Appendix A.

Water quality results collected by the Vancouver Coastal Health Authority (VCHA) show that raw water from Thulin Lake is high in turbidity, colour, iron and manganese. A summary of the key water quality results is given in Table 2-1 and full water quality reports are provided in Appendix A.

Table 2-1: Summary of Key Water Quality Parameters

	Units	Date				CGDWQ[1]
		August 2004	September 2005	March 2006	July 2008	
Colour (apparent)	CU	25	80	52	40	See note 2
Turbidity	NTU	1.78	3.65	0.76	0.77	1.0 NTU
Iron	mg/L	0.342	0.451	0.219	0.372	AO < 0.3
Manganese	mg/L	0.0718	0.000697	0.00452	0.0227	AO < 0.05

Notes:

1. GCDWQ are Guidelines for Canadian Drinking Water Quality (Health Canada, 2008) where AO is aesthetic objective.
2. Apparent colour measures water with suspended particles and it does not have a GCDWQ limit. GCDWQ only has a limit for true colour (AO < 15). True colour measures water that has had particulate matter removed by filtration.

The water quality has levels of iron and manganese above the aesthetic limits. At these elevated concentrations, the iron and manganese can stain laundry and plumbing fixtures and can have undesirable taste. The precipitation of iron imparts a reddish-orange colour that can build-up in pipes and promote the growth of slimy, iron bacteria. Manganese can also form a coating on pipes that is typically black in colour.

The LWS has been subject to boil water advisories in the past and according to the Health Authority, the LWS is in need of water system improvements including water treatment to address microbiological parameters and disinfection by-products. The domestic water supplied to the existing customers does not meet Health Canada's Guidelines for Canadian Drinking Water Quality.

2.4 WATER TREATMENT

The existing LWS water treatment consists of disinfection by calcium hypochlorite ($Ca(ClO)_2$) located in the Main pump station. Calcium hypochlorite ‘tablets’ are dissolved in water to form a chlorine solution; the solution is injected into the water stream with a diaphram pump. The chlorine is intended to provide primary disinfection and maintain a free-chlorine residual within the distribution system to minimize bacterial regrowth. The concentration of chlorine solution injected has to be monitored to ensure primary disinfection requirements are met.

The LWS is equipped with an on-line chlorine analyzer at the Main Pump Station that monitors and records the chlorine concentration entering the distribution system. The chlorine solution dosing pumps are controlled by the chlorine analyzer and adjusted to ensure the water entering the distribution system has adequate chlorine residual. There are no other chlorine analyzers installed in the distribution system.

Due to the presence of elevated natural organic matter, the chlorine demand and subsequent dose required to meet primary disinfection requirements is excessive and results in high disinfection byproducts (THMs).

2.5 PUMP STATIONS

The LWS has two pump stations to maintain storage tank levels and pressure in the distribution system. The Main pump station has three pumps, two in operation and one standby, which supply water to the entire distribution system. The three 10 HP pumps can pump 30 Igpm (2.3 L/s) which can sustain continuous pumping during peak demand periods in the summer months. These pumps provide adequate pump capacity and back-up for the existing LWS water demands. A manually controlled standby generator provides back-up power to one pump and the chlorine dosing pump in the event of a power failure.

The Larson Road pump station has a single pump that supplies water to Reservoir No.3, and water is gravity fed from the reservoir to the properties in the area. The pump does not provide adequate pressures to all homes in the Larson Road area and some residences at higher elevations require household booster pumps to raise service water pressure.

Some individual residences in the Grouse Ridge area (near Reservoir No. 2) also require household booster pumps to raise water pressure to receive adequate flow.

2.6 STORAGE

The LWS has three existing reservoirs with a total storage volume of 47,000 Igal (214 m^3). The volumes of each reservoir are as follows:

- Reservoir No.1 18,000 Igal (82 m^3);
- Reservoir No.2 20,000 Igal (91 m^3); and
- Reservoir No.3 9,000 Igal (41 m^3).

Reservoir No.1 and No.2 are reported to be at the same elevation providing water storage for the entire distribution system. Reservoir No.3 is reported to be higher than the others and only supplies water to those in the Larson Road area. Water is pumped from Larson Road pump station to Reservoir No.3. Since the storage from Reservoir No.3 is only available to residents in the Larson Road area and not to the rest of the water system, the net storage for the entire system is 38,000 Igal (173 m^3).

Reservoir No.2 is a single wood-stave storage tank located east of Finn Bay. According to the LWID, the tank loses approximately 10,000 Igal (45 m^3) of treated water per day as leakage from the tank structure. There are also structural integrity concerns expressed by LWID. During periods of high demand periods, there are conditions where this tank can not be completely filled due to the hydraulic restriction of the existing submarine watermain from the Finn Bay. This reservoir has been flagged by LWID as a high priority for replacement due to concerns with the age and structural condition of the tank.

Reservoir No.1 consists of two steel tanks located on a hill 120 m south of the Main pump station. Reservoir No.1 and No.3 require some roof repairs to prevent potential contamination from birds, etc. Reservoir No.3 should have an access hatch installed for entry and occupational safety requirements during cleaning of the tank.

2.7 DISTRIBUTION SYSTEM

The distribution system is made up of approximately 5 km of water main. Most water mains are 150 mm (6-inch) diameter polyvinyl chloride (PVC) series 160. A few sections of water main are 100 mm (4-inch) diameter on Sorenson Road, Larson Road and Finn Bay Road, and the underwater main from Lund Road to Finn Bay is 88 mm (3.5-inches) in diameter. Not all water mains are located on road allowances and right-of-ways (ROWs).

Figure 2-1 shows the layout of the piping of the existing distribution system.

2.8 RECORDS

The LWID keeps records of the operation of all components of the system at the following frequencies:

- lake levels – weekly;
- power consumption – monthly;
- chemical consumption – daily;

- residual chlorine – continuously;
- dam inspection – annually; and
- flow rate at main pump station – monthly.

There are very few reliable record drawings for most components of the water distribution system.

2.9 WATER METERING

The LWS has water metering in place for all commercial customers and for 15 residential customers/households. Table 2-2 shows a breakdown of the number of metered and unmetered customers in the LWS.

Table 2-2: Number of Metered and Unmetered Customers

Type of Customer	Number of Customers		
	Metered	Unmetered	Total
Residential Single-family Households	15	72	87
Non-residential	18	0	18
Total	**33**	**72**	**105**

All metered and unmetered customers are charged a fixed fee of $500 per connection, which includes the service charge and an allotment of 25,000 Igal (114 m^3) of water per month. This rate structure is called a minimum charge fixed rate. All commercial customers are billed for additional water use above 25,000 Igal (114 m^3) per month at a uniform rate of $5 dollars for every 1,000 Igal (4.5 m^3) of water consumed. The "non-residential customers include some mixed use properties that have both commercial and multiple residential users. Residential customers are not charged for water based on their consumption since not all residential customers are metered and costs could not be fairly allocated.

Section 3

Water Demands

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3. WATER DEMANDS

3.1 EXISTING DEMAND

The LWS has a water meter at the Main pump station that measures the volume of water supplied to the system; this is the water demand. Based on 2008 data, the current annual water demand is 104,755 m^3/year. This corresponds to an average day demand (ADD) of 287 m^3/d. A summary of the current water demands is given in Table 3-1.

Table 3-1: Summary of Current Water Demands

Water Demands	Volume (m^3/year)	ADD (m^3/day)[5]
Residential		
Residential, metered[1]	5,692	16
Residential, unmetered[2]	27,322	75
Total residential	33,014	90
Non-residential		
Non-residential, metered[1]	29,646	81
Non-residential, unmetered	0	0
Total non-residential	29,646	81
Unaccounted-for water[3]	25,502	70
Lost water from Reservoir No.2[4]	16,593	45
Total	**104,755**	**287**

Notes:
1. Current water demands are based on 2008 water meter data from the LWID.
2. Unmetered water is calculated by multiplying the number of unmetered customers by the respective ADD per customer.
3. Unaccounted-for water is unmeasured water and water lost to leakage (not including water lost from Reservoir No.2)
4. Water lost from reservoir No.2 is 10,000 Igal/day - from LWID.
5. ADD is calculated by dividing the annual volume by the number of days per year.

The ADD per customer is different for residential and non-residential users and is calculated based on the water demand of metered customers. The ADD per customer is given in Table 3-2.

Table 3-2: Average Day Demand per Customer

Type of Customer	ADD per customer (m^3/day)[1]
Residential	1.0
Non-residential	4.5

Notes:
1. Divide the ADD (m^3/day) by number of metered residential or non-residential customers.

UNACCOUNTED-FOR WATER

Unaccounted-for water (UFW) consists of two components: (1) leakage; and (2) unmeasured water use. The portion of UFW that is lost to recoverable leakage represents water that could otherwise be sold or put to some useful purpose. Unmeasured water use is that taken by hydrant-flushing, fire-fighting, inaccurate meters, unauthorized usage, and other related uses. While unmeasured uses for fire control and system maintenance (e.g., main and hydrant flushing) are essential, non-recorded or under-recorded usage represents water that was used but not paid for, resulting in revenue-losses that are passed on to customers. Experience indicates that most water systems can assume a 70:30 split between leaks (water losses) and unmeasured use (lost revenues).

UFW in the LWS is 25,502 m^3/year or approximately 40% of the total customer water use, as given in Table 3-1. This is well above the “normal” UFW of 15% for small water systems.

3.2 FUTURE DEMAND

The number of future customers is based on a projected growth of 2% for both residential and non-residential customers. Table 3-3 gives the current and forecasted number of customers.

Table 3-3: Current and Forecasted Number of Customers

	Current	10-Year Forecast[1]	20-Year Forecast[1]
Number of Customers[1]			
Residential	87	106	130
Non-residential	18	22	27
Total	105	128	157

Notes:

1. The forecasted number of customers if based on a population growth of 2% for residential and non-residential customers.

The future water demands are estimated for 10-year and 20-year forecasts. The ADD considers customer demands and unaccounted-for water. Customer demands (residential and non-residential) are calculated by multiplying the number of projected customers by the ADD per-customer. The ADD per-customer is 1.0 m^3/d for residential customers/households and 4.5 m^3/d for commercial customers, as given in Table 3-2. These ADD per-customer values assume the customers demands remains constant overtime and water conservation measures are not implemented. The future water demands are given in Table 3-4.

Table 3-4: Forecast Water Demands without Water Conservation

	10-Year Forecast	20-Year Forecast
Average Day Demand (m3/day)		
Residential[1]	110	135
Non-residential[1]	99	121
Unaccounted-for Water[2]	70	70
Lost water from Reservoir No.2[3]	45	45
Total	325	371
Maximum Day Demand (m3/day)[4]	0	0
Total	975	1114

Notes:
1. ADD is calculated by multiplying the forecasted number of customers by the respective ADD per customer.
2. Unaccounted-for water is unmeasured water and water lost to leakage (not including water lost from Reservoir No.2).
3. Leakage from Reservoir No.2 is 10,000 Igal/day - from LWID.
4. The MDD is assumed 3 times the ADD.
5. Water conservation is based on a 20% reduction in the ADD per customer (residential and non-residential), and the unaccounted-for water is reduced to 15% the total customer water use.
6. Water savings is the difference between the water demand without water conservation and with water conservation.

The LWS does not record maximum day water use. As a result the MDD is assumed to be 3 times the ADD, since most MDD values are between 2 and 3 times that of the ADD for small water systems in B.C.

3.3 FUTURE DEMAND WITH WATER CONSERVATION

The water system can reduce water demand by setting a water reduction target. This target is reached over a set time frame by implementing water conservation measures and incentives.

The PRRD has set a water reduction targets for customers in the LWS of 20% in the next 10-years. The reduction of 20% in customer water use will be achieved by implementing universal metering, volume-based rate billing, sprinkler restrictions during high demand months, and public education. These water conservation measures and incentives are described in the PRRD's *Water Conservation Plan* (2009).

The PRRD has also set a target to reduce the unaccounted-for water (UFW) in the LWS from 40% to 15% of the total customer use. The reduction in UFW will be achieved by implementing a leak detection program, performing water system upgrades, and detecting unauthorized water use in the system with the installing a universal metering.

Although not a direct water conservation initiative, the replacement for Reservoir No.2 will eliminate a significant loss of water. Water lost from Reservoir No.2 is estimated to be approximately 45 m^3/d. The replacement of this reservoir is an item of high priority.

The water reduction targets are considered in the adjusted future water demands for 10-Years and 20-Years in Table 3-5 and Table 3-6, respectively.

Table 3-5: 10-Year Forecasted Water Demands with Water Conservation

	10-Year without Water Conservation	10-Year with Water Conservation[5]	Water Savings[6]
Average Day Demand (m3/day)			
Residential[1]	110	88	22
Non-residential[1]	99	79	20
Unaccounted-for Water[2]	70	25	45
Lost water from Reservoir No.2[3]	45	0	45
Total	325	193	132
Maximum Day Demand (m^3/day)[4]			
Total	975	579	396

Notes:

1. ADD is calculated by multiplying the forecasted number of customers by the respective ADD per customer.
2. Unaccounted-for water is unmeasured water and water lost to leakage (not including water lost from Reservoir No.2).
3. Leakage from Reservoir No.2 is 10,000 Igal/day - from LWID.
4. The MDD is assumed 3 times the ADD.
5. Water conservation is based on a 20% reduction in the ADD per customer (residential and non-residential), and the unaccounted-for water is reduced to 15% the total customer water use.
6. Water savings is the difference between the water demand without water conservation and with water conservation.

As shown in Table 3-5, water conservation practices reduce the 10-Year MDD by 396 m^3/d or approximately 41%. The 10-Year forecasted MDD with water conservation is 579 m^3/d. The customer water demands are reduced by 20% such that the ADD per-customer is 0.83 m3/d for residential customers and 3.61 m3/d for non-residential customers. The UFW is reduced to 15% the total customer water demand, which is considered acceptable for a small water system. The lost water from Reservoir No.2 is eliminated with the decommissioning of the reservoir and replacement with a new one.

Table 3-6: 20-Year Forecasted Water Demands with Water Conservation

	20-Year without Water Conservation	20-Year with Water Conservation[5]	Water Savings[6]
Average Day Demand (m3/day)			
Residential[1]	135	108	27
Non-residential[1]	121	97	24
Unaccounted-for Water[2]	70	31	39
Lost water from Reservoir No.2[3]	45	0	45
Total	371	236	136
Maximum Day Demand (m3/day)[4]			
Total	1114	707	407

Notes:

1. ADD is calculated by multiplying the forecasted number of customers by the respective ADD per customer.
2. Unaccounted-for water is unmeasured water and water lost to leakage (not including water lost from Reservoir No.2).
3. Leakage from Reservoir No.2 is 10,000 Igal/day - from LWID.
4. The MDD is assumed 3 times the ADD.
5. Water conservation is based on a 20% reduction in the ADD per customer (residential and non-residential), and the unaccounted-for water is reduced to 15% the total customer water use.
6. Water savings is the difference between the water demand without water conservation and with water conservation.

Similar to the 10-Year forecast with water conservation practices, the 20-Year forecast has a reduction in customer water demands, UFW and Reservoir No.2. As shown in Table 3-6, the 20-Year MDD is reduced by 407 m^3/d or approximately 37% when water conservation is implemented. The 20-Year forecasted MDD with water conservation is 707 m^3/d.

Section 4

Proposed Water Treatment

4. PROPOSED WATER TREATMENT

4.1 GENERAL

Three treatment options were considered for the LWS. Each treatment technology offers its own distinct advantages. This section presents each technology investigated and discusses its applicability for the LWS.

Alternative water sources for Thulin Lake were investigated. One study examined possible locations to drill a well to replace the Thulin Lake water source, but the only suitable sites found to date have required drilling more than 500 feet through rock. The projected well yields were insufficient to meet the required demand, which means multiple wells would have been needed. Four test wells have been drilled over the last several years and in addition to low yields, the water has been of poor quality and requiring substantial treatment. The cost of developing a groundwater source for Lund was considered prohibitive, which is why the idea was ultimately rejected. Supplying the Lund Water System with water from the City of Powell River was also considered. However, this idea was also rejected since it would require the construction of a water main over 20 km in length. The cost of this transmission main itself would be in the range of $8.0 million and would still require the proposed distribution system improvements. It was thus determined that despite its water quality issues, Thulin Lake remains the best source of drinking water for Lund.

4.2 FILTRATION OPTIONS

OPTION 1 – ENHANCED SLOW SAND FILTRATION

Enhanced slow sand filtration, also known as multistage filtration, is based on the principles of conventional slow sand filtration with enhancements including re-ozonation, roughing filtration, and granular activated carbon (GAC) filtration. The treatment steps are as follows:

1. Raw water is supplied to the top of a splitter box that equally splits the flow between two filter tanks. The splitter box is elevated and also acts as a constant head tank to provide the driving head for flow through the rest of the filter.

2. Water flows by gravity from the splitter box to the base of the roughing filter and flows up through layers of media that decrease in size upwards. The roughing filter captures a high percentage of suspended solids.

3. Effluent from the roughing filter flows over a weir, which is submerged in normal filtration mode, and then to the top of the slow sand filter. The slow sand filter

consists of a bed of fine-grained sand. Due to the slow filtration rates and the lack of predisinfection, a biological layer (called a *schmutzdecke*) forms at the surface of the slow sand filter. The biological layer effectively traps and digests microbes and organic chemicals from the raw water and also acts as an effective solids strainer.

4. Effluent from the slow sand filter is collected in an underdrain and disinfected.

As the slow sand filter plugs up with solids, water will rise in the tank over the sand until it is close to the overflow pipe; filtered water quality does not deteriorate as the tank level increases. The pre-filtered water over these two compartments is used to backflush the roughing filter. The slow sand filter is cleaned by flushing the surface.

Advantages of enhanced slow sand filtration compared to the other treatment processes examined here include low operation and maintenance costs and ease of operation due to the passivity of the treatment process. Since no coagulants are added to the water, the rate at which the filter must be cleaned is much lower than chemically assisted filters; normally every 2 to 6 months. The major disadvantage is the large footprint required for the slow sand filter (about 120 m^2). The capital cost of this option is estimated at $1,780,000, which makes this the second most expensive option to implement. However, low annual operation and maintenance costs estimated at $22,100 result in a 20-year life cycle cost of $2,110,000, which is the lowest of the three options discussed.

OPTION 2 – DAF AND RAPID SAND FILTRATION

Dissolved air flotation (DAF) is based on the conventional coagulation/flocculation and particle settling treatment train. Instead of aiming to create large flocs that will easily settle to the bottom of a clarifier, the goal of DAF is to create small flocs that will easily rise to the top of the clarifier with the help of compressed air. The treatment steps are as follows:

1. Raw water is dosed with coagulant in a rapid mixer and then flows to a multi-stage mechanical flocculator. Each stage is equipped with a variable speed paddle. Flocculator paddle speeds are manually set from the plant control panel.

2. The flocculated water then enters the inlet contact zone of the DAF cell at a low level. Here, microscopic air bubbles of approximately 50 microns in diameter are introduced which attach to the floc particles rendering them buoyant. The contact zone is bounded by an inclined baffle which ensures good contact and eliminates the potential for denser layers of unaerated water to pass back to the air inlet zone. As the flow passes over the top of the inlet baffle the buoyant floc particles rise to the surface and form a floating sludge layer.

3. Clarified water is collected from the floor of the DAF cell through a submerged perforated pipe and through a rapid sand filter. The floating sludge layer is

periodically removed by a mechanical surface skimmer. The skimmer is controlled automatically with adjustable speed, duration and interval timers.

4. Effluent from the rapid sand filter is collected in an underdrain and disinfected.

To generate the microscopic air bubbles approximately 6-10% of the clarified water is pumped through a packed tower saturator. One saturator is provided for each DAF train. The water is sprayed into the top of the saturator and flows downwards over exposed ring packing. Compressed air is also introduced into the top of the saturator and the air space pressure maintained at between 40 and 60 psi. As the water passes downwards it becomes fully saturated with air and then collects in a pool at the foot of the saturator. The level of this pool is sensed and controlled by modulating the flow from the recycle pumps.

The proposed DAF plant for LWS would contain two parallel treatment trains. The clarification and filtration units would have a footprint of approximately 20 m^2. The capital cost of this option is estimated at $1,600,000, the lowest capital cost of the three options. The annual operation and maintenance cost is estimated at $44,100, which results in a 20-year life cycle cost is estimated at $2,260,000, slightly higher than the 20 year life-cycle cost for Option 1.

OPTION 3 - ULTRAFILTRATION MEMBRANES

Ultrafiltration membrane systems are typically found in two configurations. The first common configuration is “pressurized”, where water is pumped through membranes by creating a positive pressure for the water before going through the membranes while leaving the water that has already gone through the membranes (permeate) near atmospheric pressure. To ensure the water is pressurized before passing through the membranes, the membranes are located in closed modules. The second common membrane configuration is “submerged”, where a negative pressure is created on the permeate side to draw the water through the membrane. These membranes are immersed in tanks of water. A brief description of the treatment process (for both types of membrane systems) is as follows:

1. Raw water is dosed with coagulant in a rapid mixer and then flows to a multi-stage mechanical flocculator. Each stage is equipped with a variable speed paddle. Flocculator paddle speeds are manually set from the plant control panel. The floc needed for membrane filtration is even smaller than a DAF floc so les flocculation time is required.

2. The flocculated water then enters the membrane filter without clarification. A pressure gradient is created across the membrane to force water across the membrane barrier. Due to the small pore size of the membranes (~ 0.1 micron), most particles cannot cross the barrier.

3. Effluent that goes through the membrane (permeate) is collected and disinfected. The water and particles rejected by the membrane (concentrate) are either wasted or recycled through the treatment process again for increased efficiency.

The principal advantage of membrane filtration is the small pore size that prevents larger particles and pathogens from reaching the treated water. *Giardia* and *Cryptosporidium* log removal rates are very impressive compared with sand filters. The principal disadvantage of this technology is the energy required to maintain the pressure gradient and to keep the membranes clean. Backwashing of membranes typically occurs on an hourly basis while maintenance cleans (with a strong chlorine or citric acid solution) and recovery cleans (with a very strong chlorine solution) occur on a daily and monthly basis, respectively. This creates a wastewater stream which sometimes has to be dechlorinated or neutralized before being discharged to the wastewater treatment system.

The capital cost of this option is estimated at $1,920,000, approximately the same as Option 1. The annual operation and maintenance cost is estimated at $54,300 which results in a 20-year life cycle cost of $2,730,000, the highest of the three options.

4.3 RECOMMENDED WATER TREATMENT OPTION

The three treatment options were compared based on quality of finished water, ease of operation, wastes generated, capital cost and 20-year life cycle cost. A brief evaluation of the options according to each criterion follows:

QUALITY OF FINISHED WATER

Option 3 (membranes) would likely provide the highest quality finished water due to the small pore size of the membranes. However, enhanced slow sand filtration and DAF and rapid sand filtration would also provide high quality filtered water. Given the quality of the raw water, all three options would produce finished water of excellent quality.

EASE OF OPERATION

Option 1 would be the easiest to operate, since no coagulation chemicals would be required. Replacement of the GAC filter media would be required after several years but otherwise, operation and maintenance needs would be much less than the other two options. Backwashing would only have to take place a few times per year with Option 1 vs. daily with Option 2 and hourly with Option 3. Additionally, since Option 1 would be the easiest plant to operate, it would require lower operator certification than the plants proposed in Options 2 and 3.

WASTES GENERATED

Option 1 would generate minimal waste. The biological waste generated from cleaning of the filters could easily be disposed. The only other waste product is the spent GAC, which would have to be replaced relatively infrequently. In comparison, Option 2 would generate a sludge layer high in coagulant (likely alum) which may be difficult to dispose in a landfill. Option 3 would create a similar stream of concentrate high in coagulant that would likely have to be dewatered and disposed and face similar restrictions to the DAF sludge. Additionally, the cleaning water, high in chlorine or citric acid, would require dechlorination or neutralization before being discharged from the plant. Thus, due to the low generation of wastes, Option 1 minimizes the amount of generated wastes.

CAPITAL COST

Option 2 would carry the lowest capital cost at $1.6 million. The estimated cost of Options 1 and 3 are $1.8 and $1.9 million, respectively.

20-YEAR LIFE CYCLE COST

Due to the low chemical demands and passivity of treatment, Option 1 carries the lowest operation and maintenance cost. As such, Option 1 has the lowest 20-year life cycle cost. Option 2's life cycle cost is approximately $150,000 higher, while Option 3's life cycle cost is an additional $500,000. A graphical representation of the life cycle cost of each option is shown in Figure 4-1.

RECOMMENDED OPTION

Due to the ease of operation, low quantity of wastes generated, operator certification level required, good projected finished water quality and lowest 20-year life cycle cost, the recommended water treatment option for the LWS is Option 1: enhanced slow sand filtration. Although this option requires a larger initial investment, the low operation and maintenance costs give this option the lowest 20 year life cycle cost of the options investigated.

4.4 DISINFECTION

The disinfection proposed for LWS is the same for all options. UV disinfection followed by calcium hypochlorite chlorination is recommended. The existing calcium hypochlorite system currently in place at Lund would be used in the new treatment plant. The capital and O&M costs discuss above make provision for primary and secondary disinfection.

4.5 IMPLEMENTATION

The implementation of Option 1 will require additional source water characterization and consideration could be given to pilot testing.

SOURCE WATER CHARACTERIZATION

Source water characterization should be conducted on Thulin Lake through a one-year water sampling program. The water sampling program requires the testing of the following parameters at an accredited laboratory at the frequency noted below:

Every week
- Alkalinity;
- Colour;
- *E. coli* and Total Coliforms;
- pH (field-measured);
- Total Organic Carbon; and
- UV Transmittance (unfiltered).

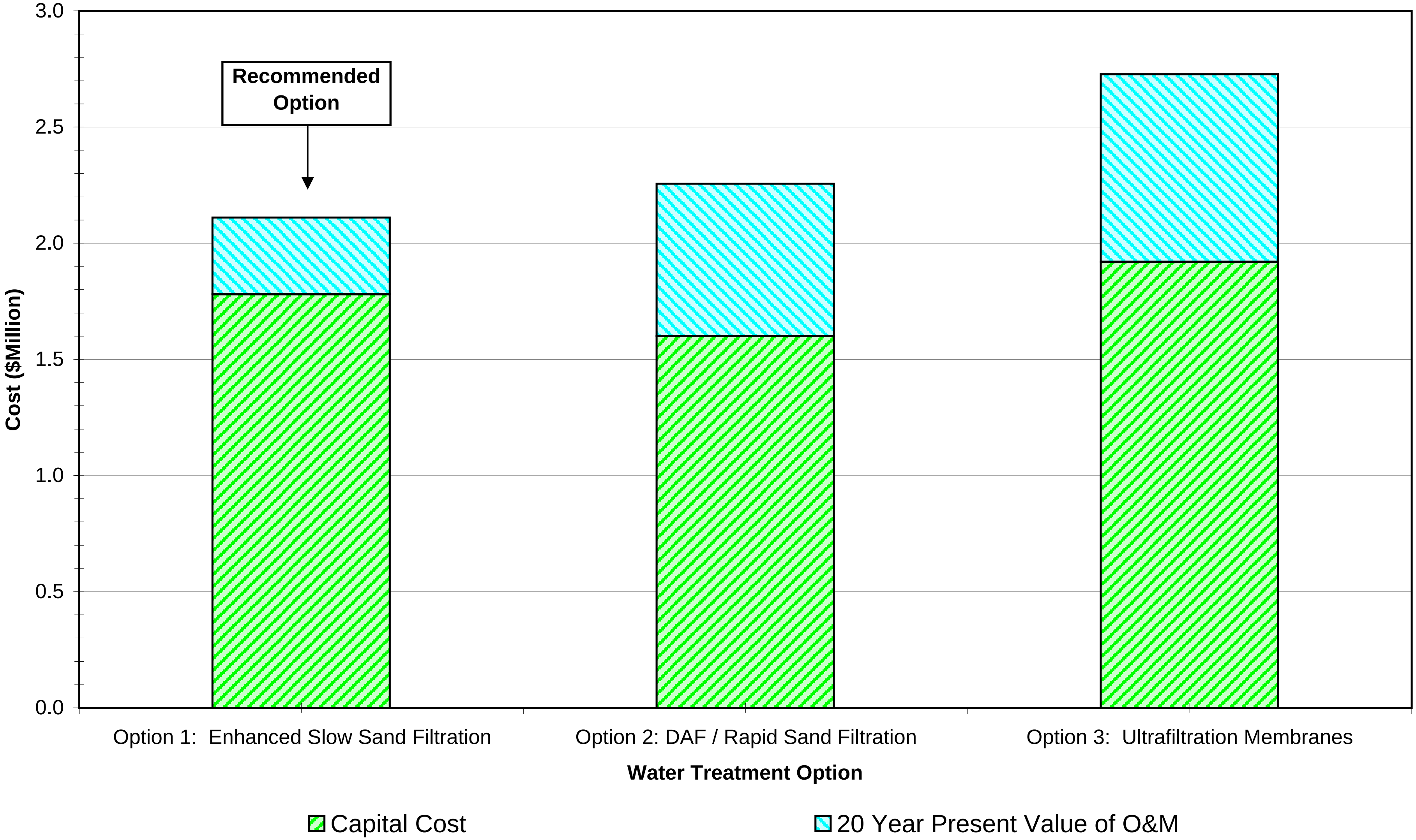
Every two weeks
- iron; and
- manganese.

PILOT TESTING

Pilot testing should be considered for LWS for a three to six week period. The pilot testing can provide operational design information for refinements to the treatment process.

LUND WATER SYSTEM

20-Year Life Cycle Cost Comparison for Water Treatment Options



Kerr Wood Leidal Associates Ltd.
Consulting Engineers
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FIGURE 4-1

Section 5

Distribution System Upgrades

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5. DISTRIBUTION SYSTEM UPGRADES

5.1 GENERAL

Distribution system upgrades include the installation of a new reservoir, pump station, water mains and water meters as well as improvements to some of the existing infrastructure. The distribution system upgrades are described in this section and shown in Figure 5-1.

5.2 STORAGE

Water storage should be provided for water system balancing, emergency use, and fire protections. The *Design Guidelines for Rural Residential Community Water Systems* states that storage should have the capacity to supply all of the following:

- 25 percent of maximum day demand (MDD) for balancing;
- 25 percent of MDD for emergency use; and
- Fire flow for one hour.

Fire flow is calculated in accordance with the Fire Underwriters Survey, *Water Supply for Public Fire Protection – A Guide to Recommended Practice*. For the LWS that serves primarily residential detached homes of wood construction with greater than 30 m separation, the minimum fire flow is 2,000 L/min (120 m^3/h).

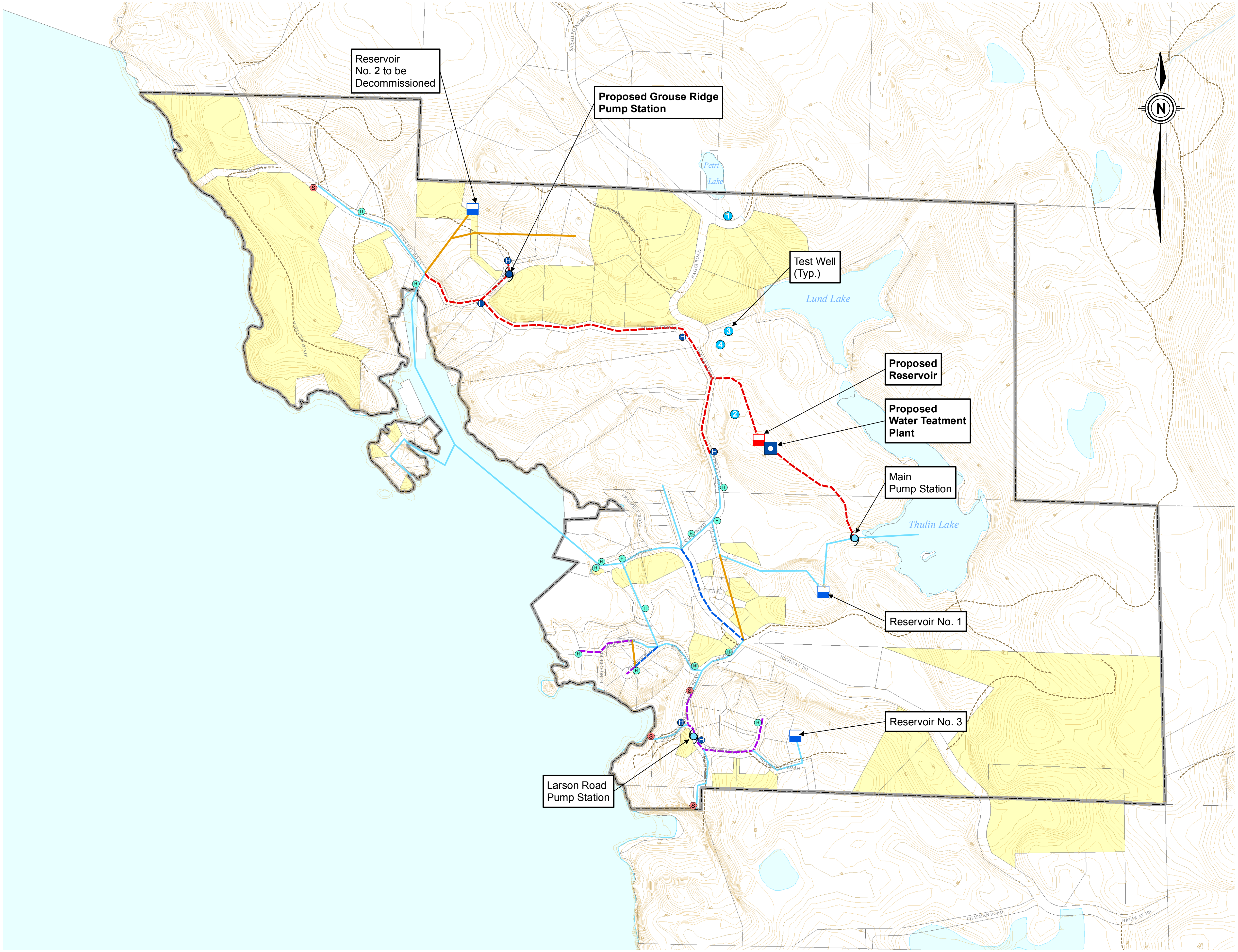
The minimum storage capacity for the LWS based on the 20-year forecast MDD of 707 m^3/d is 474 m^3 and is calculated as follows:

$$\begin{aligned} Storage &= 0.25(707\,m^3/d) + 0.25(707\,m^3/d) + 1h(120m^3/h) \\ &= 474\,m^3 \end{aligned}$$

With the decommissioning of Reservoir No.2 and the isolation of Reservoir No.3 from the entire system, the LWS will require additional storage of approximately 392 m^3 (86,000 Igal) to supplement Reservoir No.1 (82 m^3). A new reservoir will need to be installed to provide adequate water storage for the LWS.

The proposed new 392 m^3 (86,000 Igal) reservoir will be located adjacent to the proposed water treatment plant, as shown in Figure 5-1.

Powell River Regional District
Lund Water System
Feasibility Study



Legend

- Lund Waterworks District Boundary
- Existing Watercourse
- Existing Gravel Road

Property Service Status

- Serviced
- Unserviced
- Existing Hydrant
- Existing Stand Pipe
- Exsiting Watermain
- Existing Main to be Decommissioned
- Existing Main to be Upgraded to 6"
- Proposed Hydrant

Proposed Watermain (Size Inches)

- 6" Proposed main
- 8" Proposed Main

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250 0 250
Scale in Metres 1:10,000

Project No.	Date
355-008	April 2009

Proposed Water System

Figure 5-1

Map Document: (O:\0300-0399\355-008\430-Gis\MXD-Rp\355008Fig5-1.mxd)
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MAIN PUMP STATION

The pumps in the Main pump station need to be replaced with new pumps that are appropriately selected and able to supply for the future MDD of 720 m^3/d. The new pumps will supply water to the distribution system via the proposed water treatment plant and new reservoir. The new pumps will be retrofitted inside the existing building.

LARSON ROAD PUMP STATION

The Larson Road pump station needs to be replaced. The existing booster pump does not supply adequate water pressures to all residences in the Larson Road area. Consequently, the residences at higher elevations are supplied with water at low pressure and require individual booster pumps to receive water from the system.

The proposed new Larson Road pump station will have pumps that are appropriately selected and able to supply all customers in the Larson Road area with adequate water pressure. The new pump station will be constructed at the existing Larson Road pump station location.

GROUSE RIDGE PUMP STATION

The Grouse Ridge area has residences at higher elevations that require individual booster pumps to receive water at adequate pressure from the system. A new, central pump station for the area would eliminate the need for individual booster pumps.

The proposed Grouse Ridge pump station will have pumps that are appropriately selected and able to supply all customers in the Grouse Ridge area with adequate water pressure. The proposed pump station will be constructed near Alannah Road, as shown in Figure 5-1.

5.3 WATER MAINS

The proposed water treatment plant and new 392 m^3 (86,000 Igal) reservoir will be connected to the system via a 200 mm (8-inch) water main from the Main pump station, and to the distribution system via a 200 mm (8-inch) water main at Finn Bay Road.

A 200 mm (8-inch) water main will be installed along Finn Bay Road to the existing 150 mm (6-inch) water main on Finn Bay Road serving the Finn Bay area. This new main will improved the supply of water by gravity from the new reservoir and will provide supply redundancy to the existing underwater main that connects the two ends of the system via Sevilla Island.

Upgrading the main to Sevilla Island was considered since the existing 100 mm water main does not provide adequate fire flow to the island. The cost of upgrading part of the underwater main to 150 mm was investigated, but the cost was determined to be prohibitive. As an alternative and more cost effective option, the PRRD is considering providing mobile salt water fire pumps to the Lund Volunteer Fire Department which can be transported by boat to fight fires on Sevilla Island. This is considered a better option than keeping a salt water pump stored on the island since portable pumps with the fire department are more likely to be maintained and operable. The easiest way to move a pump to where it may be needed on Sevilla Island is by boat.

Sections of the 100 mm (4-inch) diameter water mains on Murray Road and Larson Road will be upgraded to 150 mm (6-inch) diameter water mains to provide adequate water pressure and fire protection to residences in the area.

The 100 mm (4-inch) diameter sections of water main that extend through private property near Emil Road and Quarry Place will need to be decommissioned. They will be replaced and upgraded to 150 mm (6-inch) diameter water mains that will be installed along Hwy 101 and Murray Road/Quarry Place, respectively.

All proposed water mains are shown in Figure 5-1.

5.4 WATER METERS

Water meters will be installed at all water service connections in the LWS. Universal water metering will enable the LWS to administer fair water rate billing procedures for all residential and non-residential customers. It also encourages customers to monitor water use and implement water conservation practices.

Water metering is supported by the PRRD and is a planned initiative in their Water Conservation Plan.

Section 6

Implementation Plan

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6. IMPLEMENTATION PLAN

The proposed water treatment and water system upgrades for the LWS should be implemented in a logical sequence of construction. A preliminary schedule for this project is provided in Appendix B and is based upon the assumption that approval of the infrastructure funding can be obtained by September 2009. If this milestone can be met, all of the proposed works can be completed before March 31, 2011.

The project will be managed as two separate contracts: one for the distribution system upgrades and one for the new treatment plant. To expedite project completion, detailed design of some distribution system upgrades will begin before the preliminary design report is completed. The upgrades selected for expedited detailed design are the ones viewed to be necessary regardless of preliminary design conclusions. For example, the configurations of new watermains along Finn Bay Road, Alannah Road, Highway 101 and Quarry Place are already known and can therefore be designed before preliminary design is complete. Other watermains, such as the one from the intake pump station to Finn Bay Road will be designed after preliminary design is complete, however, since conclusions from preliminary design may affect design of this watermain.

The detailed design for the distribution system upgrades will be completed in the first quarter of 2010 to allow construction to begin in the second quarter of 2010. Construction of all distribution system upgrades is projected to be complete in the third quarter of 2010. Weekly water quality monitoring of Thulin Lake will begin in May 2009 to ensure a full year of data is available before construction of the water treatment plant begins. Water treatment plant design will begin in conjunction with the distribution system design but will be completed slightly later, in the second quarter of 2010. This will allow outdoor construction to take place in the third quarter of 2010 with the installation of equipment and commissioning to take place over the winter of 2010-2011. A summary of major activities by quarter follows:

<u>Q2 2009</u>
- Project initiation
- Begin water quality monitoring of Thulin Lake
- Confirmation of infrastructure grant approval

<u>Q3 2009</u>
- Continue water quality monitoring
- Preliminary design of water system upgrades

<u>Q4 2009</u>
- Continue water quality monitoring
- Preliminary design of water system upgrades
- Detailed design of watermains along Finn Bay Road, Alannah Road, Highway 101 and Quarry Place

Q1 2010
- Continue water quality monitoring
- Complete design of all distribution system upgrades
- Tender and award contract for distribution system upgrades
- Detailed design of WTP

Q2 2010
- Complete water quality monitoring of Thulin Lake
- Complete design of WTP
- Tender and award contract for WTP
- Begin construction of distribution system upgrades

Q3 2010
- Begin construction of WTP
- Substantial completion of distribution system upgrades
- Complete construction of distribution system upgrades

Q4 2010
- Continue construction of WTP

Q1 2011
- Substantial completion of distribution system upgrades
- Complete construction of WTP
- Project completion

Section 7

Cost Estimates

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7. COST ESTIMATES

7.1 CAPITAL COSTS

The capital cost of the proposed LWS totals approximately $6,000,000 including contingencies. This capital cost assumes that water treatment Option 1 will be implemented. A breakdown of capital costs by category can be found in Table 7-1. A detailed cost estimate can be found in Appendix B.

Table 7-1: Capital Cost Summary

Category	Projected Cost
Mobilization/Demobilization, Insurance and Bonding	$335,250
Water Treatment Plant	$1,780,000
Storage	$455,000
Pump Stations	$155,000
Piping	$823,800
Valves	$5,700
Fire Hydrants	30,000
Other	$103,000
Engineering	$553,163
Project Management	$368,775
Contingency (30%)	$1,382,906
Total	**$5,992,594**

7.2 OPERATION AND MAINTENANCE COSTS

The estimated annual operation and maintenance (O&M) costs for the proposed LWS works totals approximately $89,000. This cost estimate assumes that water treatment Option 1 will be implemented. A breakdown of annual O&M costs by category can be found in Table 7-2. A detailed cost estimate can be found in Appendix C.

Table 7-2: O&M Cost Summary

Category	Projected Cost
Intake Cleaning	$1,000
Water Treatment Plant	$21,247
Pump Stations	$8,400
Distribution System	$15,100
Water Quality Monitoring	$13,445
Repairs	$7,260
Other	$22,227
Total	**$88,680**

7.3 CASH FLOW

The estimated cash flow is based on the capital cost estimates in conjunction with the project schedule discussed in section 6. Table 7-3 shows the anticipated quarterly cash flows for this project.

Table 7-3: Estimated Quarterly Cash Flows

Year	Quarter	Cash Flow
2009	Q2	$130,000
	Q3	$160,000
	Q4	$160,000
2010	Q1	$130,000
	Q2	$1,360,000
	Q3	$2,170,000
	Q4	$940,000
2011	Q1	$940,000
TOTAL (Rounded)		**$5,990,000**

Section 8

Conclusions

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8. CONCLUSIONS

Based on the scope and findings of this report, the following conclusions are presented:

- The water currently supplied does not meet existing health-based limits of *Guidelines for Canadian Drinking Water Quality*.
- Water quality reports and inspection reports from the Vancouver Coastal Health Authority support that a new water treatment plant providing multiple barriers of treatment is needed for the LWS.
- An enhanced slow sand filtration system will provide good drinking water quality with a lower life cycle cost and most simple operation in comparison with other water treatment technologies such as dissolved air flotation with rapid sand filtration or membrane ultrafiltration.
- Reservoir No.2 should be removed from service as soon as a new reservoir is commissioned.
- A new reservoir is needed to provide adequate storage for balancing, emergency use, and fire protection for the community.
- Reservoirs No.1 and No.3 are in need of roof repairs to prevent potential contamination from avian wildlife.
- The Larson Road Pump Station requires replacement.
- The Main Pump Station requires new pumps to supply the design flow to the proposed water treatment plant.
- The Grouse Ridge area should be served by one central booster pump station instead of the current configuration of multiple individual household booster pumps.
- Sections of 100 mm (4-inch) water main should be upgraded to 150 mm (6-inch) to provide adequate water pressure and fire protection abilities to all customers.
- Watermains running through private property that require upgrading should be decommissioned and replaced with new watermains located in a legal right-of-way or easements.
- Water meters should be installed at all water service connections to promote water conservation.

- A Water Conservation Plan for the LWS is required to reduced per capita water use and should be implemented as soon as possible (Note: This plan has been prepared by KWL for the LWS as a separate document).

Section 9

Recommendations

9. RECOMMENDATIONS

Based on the conclusions presented above, KWL recommends the following:

- Implementation of all LWS water treatment and distribution system upgrades as described in Section 5 and in accordance with the Implementation Plan, in Section 6.
- Implementation of recommendations of the Water Conservation Plan, submitted under separate cover to the PRRD.

Section 10

References

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Powell River Regional District, *Lund Water System Feasibility Report,* April 2008.

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Section 11

Report Submission

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

11. REPORT SUBMISSION

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

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Laura Weston, M.Eng., EIT
Project Engineer

Reviewed by:

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Irfan Gehlen, P.Eng.
Project Manager

Appendix A

Water Quality Results

KERR WOOD LEIDAL
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Table 1-1: Water Quality Results for Thulin Lake

	Units	Results				CGDWQ[1]
		Lund CWS Aug 18 2004	Thulin Lake Intake (DW4,TOC) Sept 30th 2005	Thulin Lake March 14th 2006	Lund Waterworks District - Thulin Lake July 3rd 2008	
General Parameters						
Alkalinity	mg CaCO3/L	23.7	22.9	13.9	21.1	
Bromide	mg/L	<0.05	<0.05	<0.05	<0.05	
Chloride	mg/L	7.4	2.4	2.2	2.5	AO < 250
Colour (Apparent - not filtered)	CU	25	80	52	40	AO < 15
Dissolved Sulfate	mg/L	1.7	0.9	1.6	1.2	AO < 500
Fluoride	mg/L	<0.01	0.03	0.03	0.05	MAC < 1.5
Hardness (CaCO3 equiv)	mg/L	20.3	22.9	16.9	18.6	see note 2
Nitrite	mg/L	<0.005	<0.005	<0.005	<0.005	MAC < 1
Nitrate	mg/L	0.031	<0.002	0.08	0.003	MAC < 10
Phosphorus	mg/L	0.39	<0.05	<0.05	<0.001	
Physical Properties						
Conductivitiy	uS/cm	69	56	42	48	see note 3
pH	mg/L	7.39	6.9	7.26	7.64	6.5 - 8.5
Total Dissolved Solids	mg/L	<10	47	50	51	AO < 500
Turbidity	NTU	1.78	3.65	0.76	0.77	see note 4
Microbiological Parameters						
Coliforms (Total)	MPN/100mL					MAC < 1
Fecal Coliforms (E.Coli)	MPN/100mL					MAC < 1
Special Analysis						
Total Organic Carbon	mg/L					
UV Transmittance	%					
Total Metals						*set in mg/L*
Aluminum	mg/L	0.0311	0.013	0.109	0.0237	see note 5
Antimony	mg/L	0.000017	0.000021	0.000015	0.000022	MAC < 0.006
Arsenic	mg/L	0.0041	<0.0001	<0.0001	0.0001	MAC < 0.01
Barium	mg/L	0.0028	0.00313	0.00207	0.00186	MAC < 1
Berylium	mg/L	<0.000002	0.000016	0.000024	0.000005	
Bismuth	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	
Boron	mg/L	0.006	0.0008	<0.002	0.02	MAC < 5
Cadmium	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	MAC < 0.005
Calcium	mg/L	5.6	6.4	4.5	5.1	see note 3
Chromium	mg/L	0.0026	<0.0002	0.0002	<0.0002	MAC < 0.05
Cobalt	mg/L	0.000083	0.000024	0.000044	0.000057	
Copper	mg/L	0.0186	0.00074	0.00058	0.00053	AO < 0.1
Iron	mg/L	0.342	0.451	0.219	0.372	AO < 0.3
Lead	mg/L	0.00012	0.00008	0.00012	0.00008	MAC < 0.01
Lithium	mg/L	0.00009	0.00007	0.00006	0.00016	
Magnesium	mg/L	1.17	1.42	1.06	0.021	see note 3
Manganese	mg/L	0.0718	0.000697	0.00452	0.0227	AO < 0.05
Mercury	mg/L					MAC < 0.001
Molybdenum	mg/L	0.00079	0.0003	0.00027	0.00029	
Nickel	mg/L	0.00043	0.00019	0.00021	0.00024	
Phosphorus	mg/L	<0.1	<0.1	<0.1	0.2	
Potassium	mg/L	0.4	0.3	0.3	0.1	see note 3
Selenium	mg/L	0.0036	<0.0002	0.0002	<0.0002	MAC < 0.01
Silicon	mg/L	2.1	1.43	4.86	0.54	
Siliver	mg/L	0.00009	<0.00002	<0.00002	<0.00002	
Sodium	mg/L	35.1	3.9	2.9	3.7	AO < 200
Strontium	mg/L	0.023	0.0285	0.0187	0.0241	
Sulfur	mg/L	0.74	0.47	0.63	0.46	
Thallium	mg/L	0.00001	0.000002	<0.000002	0.000058	
Tin	mg/L	0.00001	0.00002	0.00001	0.00002	
Titanium	mg/L	<0.002	<0.002	<0.002	<0.000002	
Uranium	mg/L	0.000021	0.000072	0.000044	0.000019	MAC < 0.02
Vamadium	mg/L	0.00067	0.00063	0.00068	0.00019	
Zinc	mg/L	0.0039	0.0021	0.0007	0.0013	AO < 5

Notes:
1. GCDWQ are Guidelines for Canadian Drinking Water Quality (Health Canada, 2007) where AO is aesthetic objective and MAC is maximum allowable concentration.
2. Levels above 500 mg/L are unacceptable for most domestic purposes.
3. A guideline has not been specified.
4. Turbidity limits are operational based on processes. See GCWDQ supporting documentation for turbidity.
5. Operational values, of 0.1 mg/L for conventional treatment and 0.2 mg/L for other treatment, are only applied when aluminum-based coagulants are used.

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Results Exceed Limit

Table 1-3: Trihalomethane Water Quality Results from Various Locations in the Distribution System

Sample location in distribution system	Date	Trihalomethanes (THMs)				
		Bromodichloromethane (ug/L)	Bromoform (ug/L)	Chloroform (ug/L)	Dibromochloromethane (ug/L)	Total THMs (ug/L)
Lund Waterworks District	March 10 2004	<10	<10	145	<10	145
9781 Edmondson Rd	May 26th 2004	<10	<10	134	<10	134
Lund Waterworks District #1	Dec 1st 2004	<10	<10	183	<10	183
Lund Waterworks District #2	Dec 1st 2004	<10	<10	176	<10	176
Lund ID CWS	Feb 8th 2005	<10	<10	217	<10	217
Lund ID CWS	June 14th 2005	<10	<10	185	<10	185
Lund ID CWS Edmonston Rd	Sept 13th 2005	<10	<10	100	<10	100
Thulin Lake Intake (DW4,TOC)	Sept 30th 2005	7	<2	312	<2	319
Lund ID CWS	Nov 15th 2005	3	<2	149	<2	152
9781 Edmondson Rd Gustofsons Yard	Feb 8th 2006	4	<2	278	<2	282
Lund ID CWS Quarry Place	May 30th 2006	10	7	270	8	295
Lund Water Works	Aug 30th 2006	3	<2	164	<2	167
Lund Water Works	Sept 1st 2006	3	<2	164	<2	167
Lund Waterworks	Oct 31 2006	9	<2	241	<2	250
Lund ID CWS	March 6th 2007	4	<2	246	<2	250
Lund ID CWS	June 27th 2007	4	<2	207	<2	211
Lund ID CWS	Oct 11 2007	6	<2	189	<2	195
Lund ID CWS	June 4th 2008	4	<2	163	<2	167
Lund ID- Blended 3:1	July 9th 2008	12	<2	172	7	191
Lund ID- Blended 1:1	July 9th 2008	17	4	119	14	154
Lund ID Treated Surface Water	July 9th 2008	4	<2	166	<2	170
Lund ID CWS	Sept 23rd 2008	7	<2	190	<2	197
Lund ID CWS	Dec 2nd 2008	5	<2	198	<2	203
CGDWQ[1]		**MAC<16**	**-**	**-**	**-**	**MAC<100**

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Results Exceed Limit

Average 196
Median 185

Appendix B

Project Schedule

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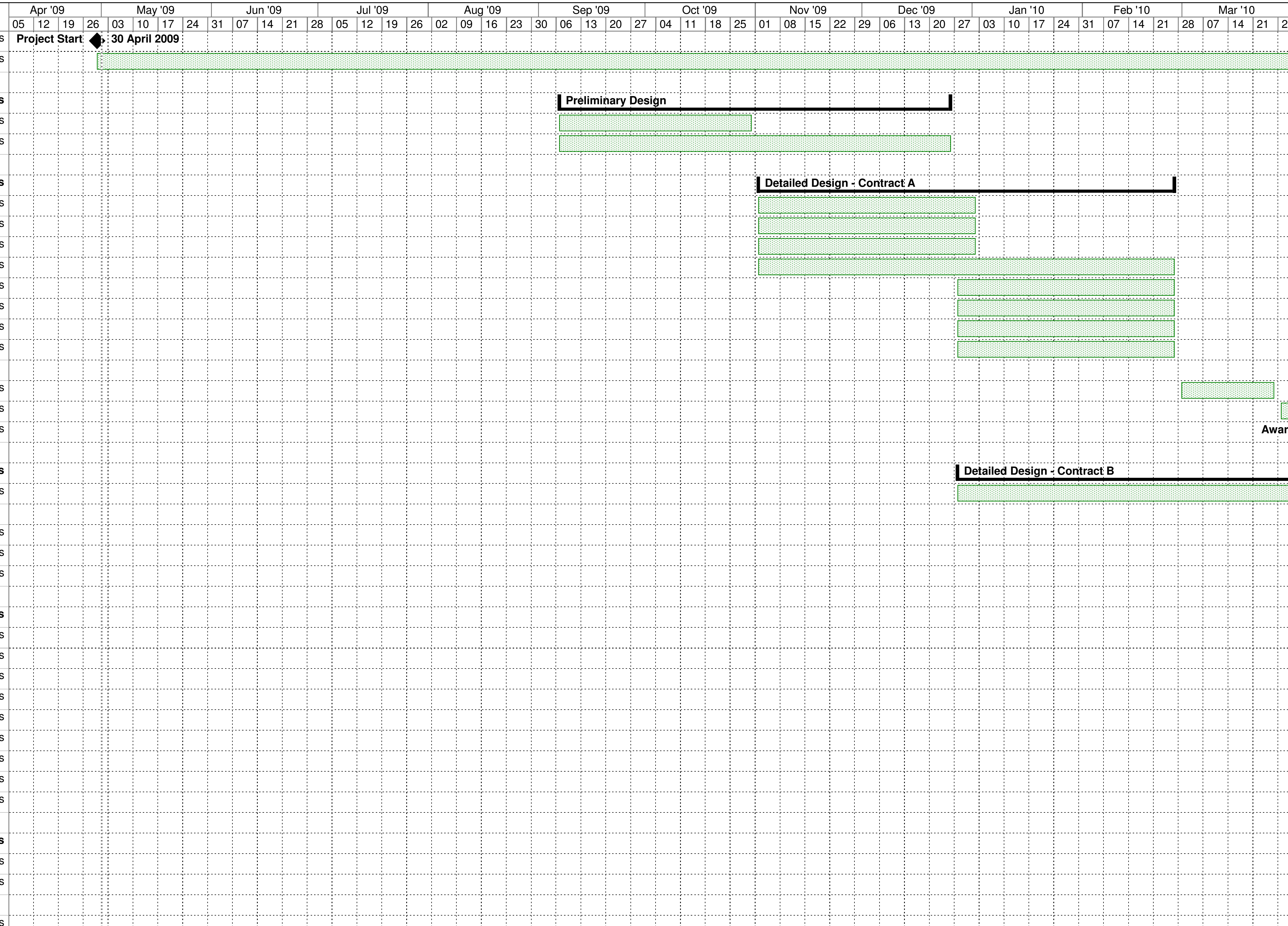
Powell River Regional District
Lund Water System Upgrades
Project No.: 355.008

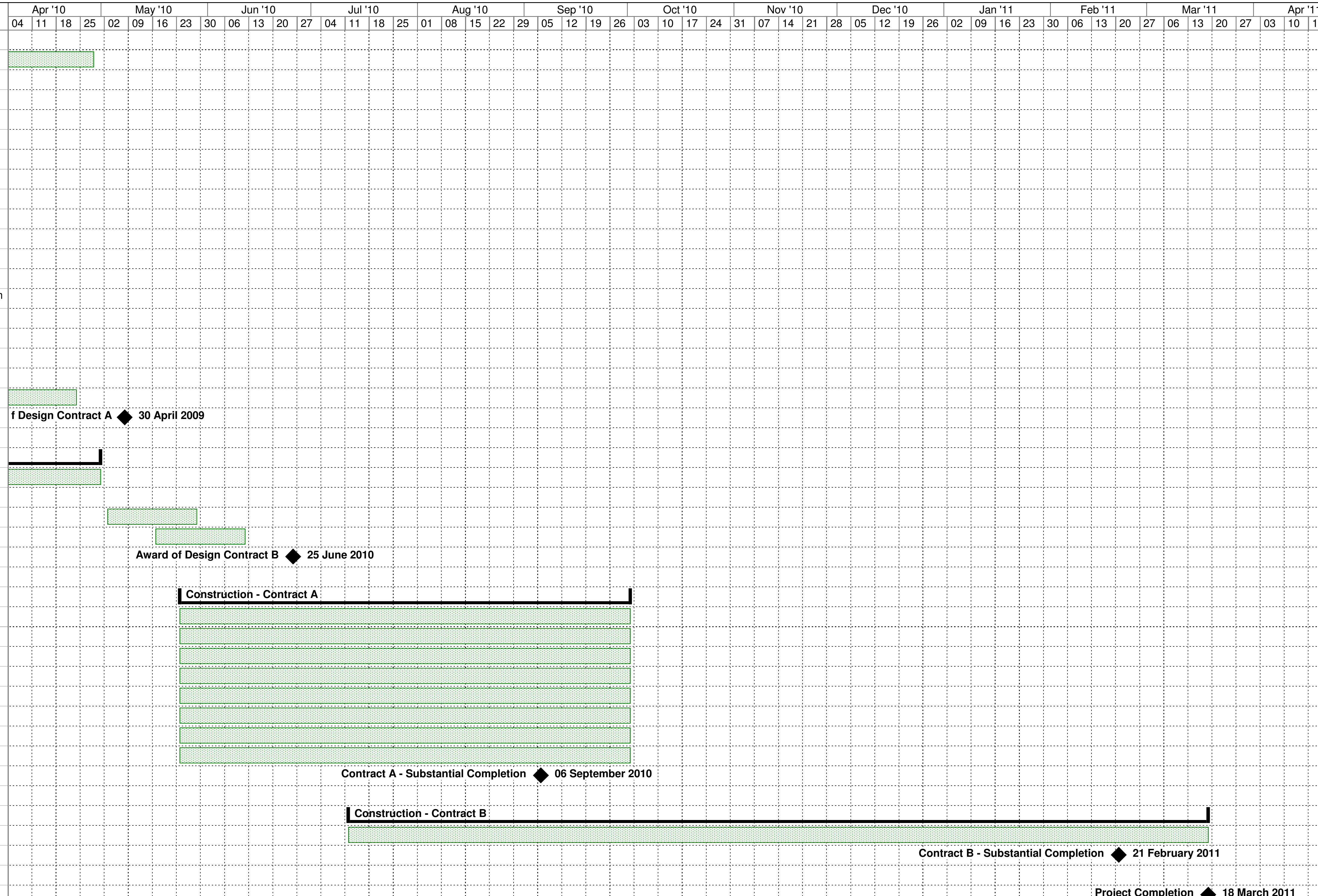
Preliminary Project Schedule
Water System Upgrades
May 1/2009

ID	Task Name	Duration
1	Project Start	0 wks
2	Water Quality monitoring of Thulin Lake	52 wks
3		
4	**Preliminary Design**	**16 wks**
5	Record Drawings (existing system survey)	8 wks
6	Preliminary Design Report	16 wks
7		
8	**Detailed Design - Contract A**	**17 wks**
9	8" main (1205 m) along Finn Bay Rd and Alannah Rd.	9 wks
10	6" main (310 m) on Hwy 101	9 wks
11	6" main (90 m) on Quarry Rd.	9 wks
12	Misc. Distribution Sys. Improvements	17 wks
13	8" Main (350 m) from Main Pump station to WTP site	9 wks
14	8" (225 m) connect new reservoir to distribution system (Finn	9 wks
15	Upgrade 4" to 6" (410 m) on Larson Rd.	9 wks
16	Storage	9 wks
17		
18	Construction Permit - Health Authority Review	4 wks
19	Tendering	4 wks
20	Award of Design Contract A	0 wks
21		
22	**Detailed Design - Contract B**	**18 wks**
23	Water Treatment Plant	18 wks
24		
25	Construction Permit - Health Authority Review	4 wks
26	Tendering	4 wks
27	Award of Design Contract B	0 wks
28		
29	**Construction - Contract A**	**19 wks**
30	8" Main (1205 m) from Main Pump station to WTP site	19 wks
31	8" (350 m) connect new reservoir to distribution system	19 wks
32	8" (225 m) main along Finn Bay Rd and Alannah Rd	19 wks
33	6" main (310 m) on Hwy 101	19 wks
34	Upgrade 4" to 6" (410 m) on Larson Rd	19 wks
35	6" main (90 m) on Quarry Rd.	19 wks
36	Misc. Distribution Sys. Improvements	19 wks
37	Storage	19 wks
38	Contract A - Substantial Completion	0 wks
39		
40	**Construction - Contract B**	**36 wks**
41	Water Treatment Plant	36 wks
42	Contract B - Substantial Completion	0 wks
43		
44	Project Completion	0 wks



Project: 355.008	Task		Milestone		Rolled Up Task		Rolled Up Progress		External Tasks		Group By Summary
Date: Fri 01/05/09	Progress		Summary		Rolled Up Milestone		Split		Project Summary		

ID	Task Name
1	Project Start
2	Water Quality monitoring of Thulin Lake
3	
4	**Preliminary Design**
5	Record Drawings (existing system survey)
6	Preliminary Design Report
7	
8	**Detailed Design - Contract A**
9	8" main (1205 m) along Finn Bay Rd and Alannah Rd.
10	6" main (310 m) on Hwy 101
11	6" main (90 m) on Quarry Rd.
12	Misc. Distribution Sys. Improvements
13	8" Main (350 m) from Main Pump station to WTP site
14	8" (225 m) connect new reservoir to distribution system (Finn
15	Upgrade 4" to 6" (410 m) on Larson Rd.
16	Storage
17	
18	Construction Permit - Health Authority Review
19	Tendering
20	Award of Design Contract A
21	
22	**Detailed Design - Contract B**
23	Water Treatment Plant
24	
25	Construction Permit - Health Authority Review
26	Tendering
27	Award of Design Contract B
28	
29	**Construction - Contract A**
30	8" Main (1205 m) from Main Pump station to WTP site
31	8" (350 m) connect new reservoir to distribution system
32	8" (225 m) main along Finn Bay Rd and Alannah Rd
33	6" main (310 m) on Hwy 101
34	Upgrade 4" to 6" (410 m) on Larson Rd
35	6" main (90 m) on Quarry Rd.
36	Misc. Distribution Sys. Improvements
37	Storage
38	Contract A - Substantial Completion
39	
40	**Construction - Contract B**
41	Water Treatment Plant
42	Contract B - Substantial Completion
43	
44	Project Completion



Project: 355.008 Date: Fri 01/05/09	Task	Milestone	Rolled Up Task	Rolled Up Progress	External Tasks	Group By Summary
	Progress	Summary	Rolled Up Milestone	Split	Project Summary	

Appendix C

Detailed Cost Estimates

KERR WOOD LEIDAL
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CONSULTING ENGINEERS

Table C-1: Capital Cost Estimate (Class "D")

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comments
1.0	**General**					
1.1	Mobilization and Demobilization			8%	$268,200	
1.2	Insurance & Bonding			2%	$67,050	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$335,250**	
2.0	**Water Treatment Plant**					
2.1	Site work	allow			$200,000	
2.2	Building and Furnishings	allow			$400,000	
2.3	Filtration equipment	allow			$550,000	MS Filter quote (Revised assumptions for DOC)
2.4	UV equipment	allow			$40,000	
2.5	Instrumentation	allow			$50,000	
2.6	Electrical	allow			$300,000	
2.7	Power connections	allow			$30,000	
2.8	Overhead Power Service from Finn Bay Road to WTP	allow			$40,000	
2.9	Mechanical	allow			$170,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$1,780,000**	
3.0	**Storage**					
3.1	Install 86,000 Igal reservoir tank	allow			$350,000	
3.2	Decommission reservoir No. 2	allow			$10,000	
3.3	Install control between reservoirs and main pump station (SCADA)	allow			$75,000	Assumes power and fibre optic run to WTP site and new reservoir. Assumes Reservoir No. 1 signal to new reservoir via radio link.
3.4	Repair roof on Reservoir No. 1	allow			$10,000	Assumes Reservoir No. 3 will not be required.
3.5	Install equipment or reconfiguring piping to improve water circulation in Reservoirs	allow			$10,000	Assumes work required at Reservoir No. 1
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$455,000**	
4.0	**Pump Stations**					
4.1	Upgrade pumps at Main PS	installed hp, no bldg	30	2500	$75,000	
4.2	Replace Larson Road PS	installed hp, bldg incl.	10	4000	$40,000	
4.3	Install new pump station on Grouse Ridge	installed hp, bldg incl.	10	4000	$40,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$155,000**	
5.0	**Piping**					
5.1	Install 8-inch from Main PS to new WTP	m	350	325	$113,750	WTP located adjacent to new reservoir
5.2	Install 8-inch from new WTP to new reservoir	m	20	325	$6,500	WTP located adjacent to new reservoir
5.3	Install 8-inch to connect new reservoir to distribution system (Finn Bay Road)	m	225	325	$73,125	Length revised to follow access route
5.4	Install 8-inch water main along Finn Bay Road and Alannah Road	m	1205	325	$391,625	Updated length
5.5	Install 6-inch water main on Hwy 101 and decommission water main along Emil Road and through private property.	m	310	240	$74,400	
5.6	Install 6-inch water main on Quarry Place and decommission water main through private property.	m	90	240	$21,600	
5.7	Upgrade 4-inch water main to 6-inch on Murray Road	m	160	240	$38,400	
5.8	Upgrade 4-inch water main to 6-inch on Larson Road	m	410	240	$98,400	
5.9	Install a section of 4-inch water main where gate valve was removed on Edmonson Road (at Node[1] 6) see Item 5.5	allow			$1,000	
5.10	Install 1 inch water line on Franzen Road to service lot 10681	allow			$5,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$823,800**	
6.0	**Valves**					
6.1	Install two 150 mm isolation valves on line between Lund Road and Murray Road	each	2	1000	$2,000	
6.2	Install 4-inch isolation valve at fire hydrant on Lund Road (Node 4)	each	1	1000	$1,000	
6.3	Install 6-inch isolation valve on Lund Road (after Node 3)	each	1	1000	$1,000	
6.4	Remove 2-inch saddle and 4-inch gate valve on Edmonson Road (Node 6) where standpipe was removed	each	2	350	$700	
6.5	Install 6-inch isolation valve to replace existing stainless steel head on Lund Road (at Node 9)	each	1	1000	$1,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$5,700**	
7.0	**Fire Hydrants[2]**					
7.1	Install fire hydrant on water main on Sorenson Road at Larson Road	each	1	5000	$5,000	
7.2	Install fire hydrant at Larson Road pump station	each	1	5000	$5,000	
7.3	Install four Hydrants on new 200 mm watermain along Finn Bay Road at Alannah Road	each	4	5000	$20,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$30,000**	
8.0	**Other**					
8.1	Install water meters and backflow prevention assemblies at all service connections	each	72	1000	$72,000	
8.2	Remove and seal stand pipe on Murray Road at Node 18	allow			$1,000	
8.3	Record Drawings	allow			$30,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$103,000**	
	SUBTOTAL FOR ALL TASKS				**$3,687,750**	
	Engineering			15%	$553,163	
	Project Management			10%	$368,775	
	TOTAL AMOUNT (excl. GST and Contingency)				**$4,609,688**	
	Range of Estimated Construction Costs Including Contingency					
		Lower Range		10%	**$5,070,656**	
		Upper Range		30%	**$5,992,594**	

This estimate is a reflection of the expected capital cost for budgeting purposes only. Estimates reflect KWL's recent experience with similar work, and therefore represent a reasonable forecast of 2009 capital costs. They were made with limited site information in order to indicate the approximate magnitude of cost of the proposed project, based on the Owner's broad requirements. They have been prepared primarily for planning purposes.

Notes:

1. Nodes refer to UMA Engineering Ltd. Watsys Model Schematic or Lund Water System, December 1998.
2. Allowance for fire hydrants includes isolation valves.

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Table C-2: Annual Operation & Maintenance Cost Estimate

Item	Description	Unit	Estimated Quantity	Unit Rate	TOTAL PRICE $	Comments
1.0	**General**					
1.1	Intake Cleaning	each	0.2	$5,000	$1,000	Allowance for diver inspection every 5 years, $1,000 per year.
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$1,000**	
2.0	**Water Treatment Plant**					
2.1	General maintenance	allow	1	$1,000	$1,000	
2.2	Calcium Hypochlorite	kg	292	$5.35	$1,562	Calcium hypochlorite disinfection
2.3	Certified operator - labour	hrs	416	$40	$16,640	Average of 1 day per week by certified operator.
2.4	Waste Disposal	tonnes	4.1	$200	$820	
2.5	Power	kWh	17500	$0.07	$1,225	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$21,247**	
3.0	**Pump Stations**					
3.1	Main PS maintenance	allow	1	$1,500	$1,500	
3.2	Larson Road PS maintenance	allow	1	$1,000	$1,000	
3.3	Grouse Ridge PS maintenance	allow	1	$1,000	$1,000	
3.4	Power	kWh	70000	$0.07	$4,900	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$8,400**	
4.0	**Distribution System**					
4.1	Cleaning of reservoirs	allow	1	$2,500	$2,500	Assume $5,000 per tank cleaning, clean 1 tank/ 2 years.
4.2	Fire hydrants	allow	12	$500	$6,000	Assume $500 per hydrant, every 2 years.
4.3	Distribution system flushing	allow	1	$2,000	$2,000	
4.4	Meter reading - labour	hrs	115	$40	$4,600	Assume 15 minutes per meter every 3 months.
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$15,100**	
5.0	**Water Quality Monitoring**					
5.1	Daily checks - labour	hrs	91.25	$40	$3,650	15 mins per day to check chlorine residual and monitoring equipment statuses.
5.2	Weekly sampling - labour	hrs	208	$40	$8,320	1 visit, 4 sites, 4 hours per week
5.3	Bi-weekly lab costs	allow	1	$5,902		Ecoli $48 x 4 Locations. Add $35 allowance for courier. From Cantest. Assume costs incurred by Vancouver Coastal Health Authority
5.4	Quarterly lab costs	allow	1	$1,040	$1,040	THM $75 x 3 locations. Plus $35 for courier. From Cantest.
5.5	Annual lab costs	allow	1	$435	$435	GCDWQ Package $200. 1 raw water, 1 distribution system. Plus $35 for courier. From Cantest.
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$13,445**	
6.0	**Repairs**					
6.1	Intake Repair Allowance	allow	1	$500	$500	
6.2	WTP Repair Allowance	allow	1	$1,000	$1,000	
6.3	Pumps at Main PS	allow	1	$500	$500	
6.4	Pumps at Larson Road PS	allow	1	$500	$500	
6.5	Pumps at Grouse Ridge PS	allow	1	$500	$500	
6.5	Watermain Repair Allowance	allow	1	$2,260	$2,260	Assume 1 major break/yr. Backhoe & crew for 2 days @ $110/hr + $500 for materials.
6.6	Service Connection/Flow Meter Repairs	allow	1	$2,000	$2,000	
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$7,260**	
7.0	**Other**					
7.1	Insurance	allow			$8,700	provided by PRRD
7.2	Administration	allow		8%	$6,012	provided by PRRD
7.3	Contribution to Replacement Reserves	allow		10%	$7,515	provided by PRRD
	SUBTOTAL AMOUNT FOR TASK (excl. GST)				**$22,227**	
	TOTAL FOR ALL TASKS (excl. GST)				**$88,680**	

This estimate is a reflection of the expected capital cost for budgeting purposes only. Estimates reflect KWL's recent experience with similar work, and therefore represent a reasonable forecast of 2009 capital costs. They were made with limited site information in order to indicate the approximate magnitude of cost of the proposed project, based on the Owner's broad requirements. They have been prepared primarily for planning purposes.

Table C-3: Water Treatment Life Cycle Cost Comparison

	OPTIONS			
	OPTION 1	OPTION 2	OPTION 3	Notes
	Multistage Fitration	Dissolved Air Flotation / Rapid Sand Filtration	Ultrafiltration Membranes	
Description	Slow sand filtration enhanced with ozonoation and roughing filter pretreatment, disinfection	Coagulation/flocculation, DAF, rapid sand filtration, disinfection	Coagulation/flocculation, direct membrane filtration, disinfection	
CAPITAL COSTS				
Treatment Equipment	$590,000	$430,000	$720,000	
Building	$400,000	$300,000	$300,000	
Other Construction Costs (e.g. electrical, excavation, etc.)	$790,000	$870,000	$895,000	
Subtotal, Capital Costs:	**$1,780,000**	**$1,600,000**	**$1,920,000**	
ANNUAL O&M COSTS				
Electrical Power	$1,200	$4,300	$8,000	
Maintenance/Repair	$1,000	$1,500	$2,000	
Consumables	$1,600	$7,500	$7,500	
Waste Disposal	$800	$3,800	$5,000	
Membrane Replacement Reserve	$0	$0	$10,000	
Misc. O&M	$1,000	$1,000	$1,000	
Labour	$16,600	$26,000	$20,800	
Subtotal, Annual O&M:	**$22,200**	**$44,100**	**$54,300**	
PV of O&M:	**$330,300**	**$656,100**	**$807,800**	Effective Rate: 3%, Period: 20 years
Total Investment:	**$2,110,000**	**$2,260,000**	**$2,730,000**	

This estimate is a reflection of the expected capital cost for budgeting purposes only. Estimates reflect KWL's recent experience with similar work, and therefore represent a reasonable forecast of 2009 capital costs. They were made with limited site information in order to indicate the approximate magnitude of cost of the proposed project, based on the Owner's broad requirements. They have been prepared primarily for planning purposes.

Notes:

1. Estimates prepared on basis of Class "D" capital cost estimate.
2. Assumed cost of labour: $40/hr
3. Estimate indicates the approximate magnitude of the cost of the capital tasks, for project planning purposes only. The estimate has been derived from unit costs for similar projects.