Pender Harbour Water Treatment Feasibility Study

September 2008
Final Report

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

Pender Harbour Water Treatment Feasibility Study

September 2008
Final Report

KWL File No. 724.012

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

STATEMENT OF LIMITATIONS

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of the Sunshine Coast Regional District for the Pender Harbour Water Treatment Study. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

COPYRIGHT NOTICE

These materials (text, tables, figures and drawings included herein) are copyright of Kerr Wood Leidal Associates Ltd. (KWL). The Sunshine Coast Regional District is permitted to reproduce the materials for archiving and for distribution to third parties only as required to conduct business specifically relating to the Pender Harbour Water Treatment Study. Any other use of these materials without the written permission of KWL is prohibited.

CONTENTS

EXECUTIVE SUMMARY I

1. INTRODUCTION 1-1
1.1 BACKGROUND 1-1
1.2 SCOPE OF WORK 1-2
ASSESSMENT OF EXISTING WATER SYSTEMS 1-2
EVALUATION OF WATER SUPPLY OPTIONS 1-2
1.3 REFERENCE DOCUMENTS 1-2

2. ASSESSMENT OF EXISTING WATER SYSTEMS 2-1
2.1 DESCRIPTION OF WATER SYSTEM 2-1
NPHWSA 2-1
SPHWSA 2-1
2.2 WATER QUALITY 2-1
2.3 WATER LICENSES 2-3
2.4 FUTURE WATER DEMANDS 2-4

3. EVALUATION OF WATER SUPPLY OPTIONS 3-1
3.1 TREATMENT PROCESS ALTERNATIVES 3-1
3.2 OPTION A: TWO TREATMENT FACILITIES 3-3
NPHWSA 3-3
SPHWSA 3-3
WATER LICENSES 3-4
COST ESTIMATE 3-4
3.3 OPTION B: ONE TREATMENT FACILITY AND A SINGLE WATER SOURCE 3-5
WATER SOURCE 3-5
WATER TREATMENT 3-7
COST ESTIMATE 3-7
3.4 OPTION C: ONE TREATMENT FACILITY AND MULTIPLE WATER SOURCES 3-8
WATER LICENSES 3-8
COST ESTIMATE 3-9
3.5 FEASIBILITY ANALYSIS 3-9
3.6 IMPLEMENTATION 3-11
SOURCE WATER CHARACTERIZATION 3-11
PILOT TESTING 3-12
WATER LICENSING APPROVAL 3-12

4. CONCLUSIONS AND RECOMMENDATIONS 4-1
4.1 CONCLUSIONS 4-1
4.2 RECOMMENDATIONS 4-2
4.3 REPORT SUBMISSION 4-3

TABLES

Table 2-1: Existing Water Licenses and Current Utilization 2-3
Table 2-2: Existing Water Licenses and Future Water Demands 2-3
Table 2-3: Current and Future Water Demands 2-4
Table 3-1: Design Flowrates for each Option 3-1
Table 3-2: Water License Capacity for Short Term ADD - Option A. 3-4

Table 3-3: Water License Capacity for Long-Term ADD - Option A. 3-4
Table 3-4: Water License Capacity for Long-Term ADD - Option B. 3-5
Table 3-5: Water Quality of Blended Source Water for Option C. 3-8
Table 3-6: Summary of Capital and O&M Cost Estimates. 3-10
Table 3-7: Estimated Present Value and Production Costs 3-10

FIGURES

Figure 2-1: Overview Map of Sunshine Coast Regional District Electoral District 'A' 2-5

APPENDICES

Appendix A: Photos from Site Visit
Appendix B: List of Reference Documents
Appendix C: Water Quality Data
Appendix D: Household water demands from the SCRD
Appendix E: Detailed Feasibility Cost Estimates
Appendix F: Sample Calculations
Appendix G: DAF Process Flow Diagram and References

Executive Summary

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

EXECUTIVE SUMMARY

INTRODUCTION

Pender Harbour is a region comprised of the small communities of Madeira Park, Francis Peninsula, Garden Bay and Irving's Landing located on the Sunshine Coast of British Columbia. Currently, the residents of this area are served by two water treatment systems. The communities of Madeira Park and Francis Peninsula are served by the South Pender Harbour Water Service Area (SPHWSA) system; and the communities of Garden Bay and Irvines Landing are served by the North Pender Harbour Water Service Area (NPHWSA) system. Both systems were recently converted from water improvement districts to regional government services.

The SCRD retained Kerr Wood Leidal Associates Ltd. (KWL) to complete a report to:

- Evaluate the Pender Harbour water systems;
- Consider three water supply options for the Pender Harbour water systems; and
- Provide capital and operation and maintenance cost estimates for each option.

EVALUATION OF EXISTING SYSTEM

The NPHWSA consists of two small water systems known as the Hotel Lake Water System and Garden Bay Lake System. The Hotel Lake Water System is supplied by Hotel Lake and the Garden Bay Lake System is supplied by Garden Bay Lake. Garden Bay Lake supplies the majority of the water for the NPHWSA, approximately 81 percent, according to water licences. The two systems meet current, short-term and long-term water quantity demands and each system has a chlorination building where the water is disinfected with sodium hypochlorite. The Hotel Lake System and Garden Bay Lake System have been connected since April 2008.

The existing SPHWSA system is supplied by McNeill Lake and Haslam Creek. The system meets current and short-term water quantity demands. Source water quality issues include consistently high organic matter and turbidity levels above 1 NTU. Chlorine disinfection by gas chlorination is currently the only treatment performed on this water.

Both water systems do not meet the current expectations for the level of water treatment required for a surface water source. The SCRD's *Area 'A' Water Master Plan* addresses potable water concerns by stating that their primary objective is to provide its residents with high quality drinking water with multi-barrier protection. Achievement of this objective would require upgrades to the NPHSWA and SPHWSA systems. Some immediate improvements suggested include the following:

- Installation of on-line turbidity meters at the point of disinfection;

- Installation of on-line chlorine residual monitoring at the point of disinfection; and
- Configuration of alarm set points and transmission of alarms for the above instruments.

The above should be completed as soon as possible while preliminary design of the future facilities is being completed.

EVALUATION OF WATER SUPPLY OPTIONS

Short-term and long-term water demands have been defined by the SCRD to consider 25 percent and 100 percent projected increases, respectively, above the current household populations. Three water supply options were presented by the SCRD and considered by KWL in this study. The options are as follows:

- **Option A:** Two separate treatment facilities, one servicing NPHWSA and one servicing SPHWSA, each supplied by their own water source(s).

- **Option B:** One treatment facility, servicing both NPHWSA and SPHWSA, supplied by a single water source.

- **Option C:** One treatment facility, servicing both NPHWSA and SPHWSA, supplied by multiple water sources.

Option B requires the construction of new infrastructure to connect NPHWSA and SPHWSA. Option C requires the construction of new infrastructure to deliver raw water from all sources to the sole treatment plant and infrastructure to connect the NPHWSA and SPHWSA. Both Option B and C require significant water license increases on McNeill Lake, of 142 and 93 percent respectively, in order to meet long-term demands. It is beyond the scope of this report to determine if the increase in water license capacity is feasible.

Option A continues to maintain the separation of NPHWSA and SPHWSA and requires the construction of two separate treatment facilities. The SPHWSA system requires a 22 percent water license increase on McNeill Lake in order to meet long-term demands.

CONCLUSIONS

Based on the findings of this study, it is concluded that:

- Water license increases are not required to meet short-term demands.

- A water license increase is required to meet long-term demands for McNeill Lake.

- Additional source water quality testing should be collected for up to a one-year period to determine the seasonal variation of the water sources.

- The cost of connecting the NPHWSA and SPHWSA are greater than the cost of keeping the systems separate and building two treatment facilities. Thus, Option A has the lowest capital cost.

- Annual operation and maintenance (O&M) costs are lowest for Option B and C since the construction of one larger treatment facility provides some economies of scale over the construction of two smaller treatment facilities.

- Present value costs and production costs over a 50-year period are lowest for Option A.

RECOMMENDATIONS

Of the three options evaluated, it is recommended that Option A be implemented. The implementation of Option A will require:

- Additional source water quality data for both the NPHWSA and the SPHWSA.

- Pilot testing for both NPHWSA and SPHWSA to confirm optimum design criteria.

- Application for a Waterworks Permit on crown land adjacent to the existing facility for locating the facility proposed for the NPHWSA.

- Completion of preliminary design for each proposed facility.

- An application for an additional water license of 774 m3/d (282,351 m3/y) on McNeill Lake to meet long-term demands.

- Design and construction of a new treatment plant for the NPHWSA consisting of flocculation, DAF, rapid gravity filtration, UV and chlorine disinfection.

- Design and construction of a new treatment plant for the SPHWSA consisting of flocculation, DAF, rapid gravity filtration, UV and chlorine disinfection.

Section 1

Introduction

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

1. INTRODUCTION

1.1 BACKGROUND

Pender Harbour is a region comprised of the small communities of Madeira Park, Francis Peninsula, Garden Bay and Irvines Landing located on the Sunshine Coast of British Columbia. Currently, the residents of this area are served by two water treatment systems: the North Pender Harbour Water Service Area (NPHWSA) and the South Pender Harbour Waterworks District (SPHWSA).

The NPHWSA consists of two small water systems known as the Hotel Lake Water System and Garden Bay Waterworks District. The two systems are connected by a watermain and have been operated as one system since April 2008. The NPHWSA provides water from Hotel Lake and Garden Bay Lake to over 400 properties in the Irvine's Landing and Garden Bay area. The water is disinfected by sodium hypochlorite at one of the two chlorination buildings in the NPHWSA.

The SPHWSA was an independent water improvement district run by a board of trustees, but has now been taken over by the Sunshine Coast Regional District (SCRD). The water for the SPHWSA is supplied by McNeill Lake and Haslam Creek, which serve approximately 986 residences in Francis Peninsula and Madeira Park areas. As with NPHWSA, chlorine disinfection is the sole treatment process for this water.

According to the Vancouver Coastal Health Authority, the SPHWSA and NPHWSA are in need of water treatment improvements. The SPHWSA has been subject to multiple boil water advisories in the past. The SCRD's *Area 'A' Water Master Plan* addresses potable water concerns by stating that their primary objective is to provide its residents with high quality drinking water with multi-barrier protection. Achievement of this objective would require upgrades to the NPHSWA and SPHWSA systems.

The SCRD retained Kerr Wood Leidal Associates Ltd. (KWL), primarily, to:

1. Provide the SCRD with a feasibility assessment of water supply options for the NPHWSA and SPHWSA.

KWL was also asked to:

2. Provide capital and operation and maintenance cost estimates for the water supply options.
3. Recommend a preferred option for development of a water treatment facility or facilities to service NPHWSA and SPHWSA.

A site visit was undertaken on May 20, 2008 by the KWL project team. Photos from the site visit are given in Appendix A.

1.2 SCOPE OF WORK

The following is a summary of the scope of work for this study:

ASSESSMENT OF EXISTING WATER SYSTEMS

- Evaluate the merits and limitations of each water source based on water quality, water availability and location.
- Correspond with the health authority concerning water system permits and water quality issues.

EVALUATION OF WATER SUPPLY OPTIONS

- Consider the following options for providing potable water to the Pender Harbour area:
  - **Option A:** Two separate treatment facilities, one servicing NPHWSA and one servicing SPHWSA, each supplied by their own water source(s).
  - **Option B:** One treatment facility, servicing both NPHWSA and SPHWSA, supplied by a single water source.
  - **Option C:** One treatment facility, servicing both NPHWSA and SPHWSA, supplied by multiple water sources.
- Determine the level of water treatment required for each of the water supply options.
- Develop a capital cost estimate for each water supply option (Class D).
- Develop an operation and maintenance cost estimate for each water supply option (Class D).
- Evaluate the merits and limitation of each water supply option.

1.3 REFERENCE DOCUMENTS

A list of reference documents, that were made available by the SCRD, is given in Appendix B.

Section 2

Assessment of Existing Water Systems

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

2. ASSESSMENT OF EXISTING WATER SYSTEMS

2.1 DESCRIPTION OF WATER SYSTEM

Figure 2-1 at the end of this section provides a map showing the approximate location of existing facilities.

NPHWSA

The NPHWSA serves 435 households with two distinct water systems, Hotel Lake water system and Garden Bay Lake water system. The Hotel Lake system serves approximately 135 homes and the Garden Bay Lake system serves approximately 300 homes. The SCRD has joined the two water systems by watermain, and the connection has been activated since April 2008. There are separate treatment facilities for the water systems, which include disinfection by sodium hypochlorite.

Water demands for NPHWSA are expected to increase with the construction of new sub-division developments and consequent population growth. Two storage tanks provide the NPHWSA with water storage.

SPHWSA

SPHWSA serves 986 households and is supplied by McNeill Lake or Haslam Creek. McNeill Lake is a reservoir which feeds into Haslam Creek. The intake is primarily from McNeill Lake, and the operator manually switches between the McNeill Lake intake and the Haslam Creek intake on a seasonal basis or as required for water quality considerations.

The water is treated through primary disinfection by chlorine gas at the chlorination building. The chlorination building has a propane powered generator on-site for back-up power. Three storage tanks in the distribution system provide a storage capacity of 1,464 cubic meters.

2.2 WATER QUALITY

Water quality data for the existing NPHWSA and SPHWSA water sources are summarized in this section. Detailed water quality results are provided in Appendix C.

GARDEN BAY LAKE

Raw water samples from Garden Bay Lake were taken twice in 2007 and they met the Guidelines for Canadian Drinking Water Quality (GCDWQ) for all parameters.

In July 2007, total organic carbon (TOC) and UV transmittance were analyzed. The TOC level was 3.0 mg/L and the UV transmittance was 40 percent. A TOC level above 2.5 mg/L is considered high due to the consequent formation of disinfection by-products such as trihalomethanes (THMs) when water is chlorinated. THMs can have adverse health affects and are considered carcinogenic. A UV transmittance level below 70 percent is considered low, because UV reactors are typically rated to treat water with a UV transmittance above 70 percent. Since there is only one set of water quality results available, it is difficult to know how the parameters vary throughout the year. Seasonal variation may occur as more organic matter is expected in lakes during the summer and fall. Given that the turbidity is generally low, the low UV transmittance can be attributed to the TOC.

In the distribution system supplied by Garden Bay Lake, a copper level of 0.129 mg/L was recorded in May 2007, slightly above the GCDWQ maximum of 0.1 mg/L and a high manganese level of 0.089 mg/L was recorded in July 2007, above the GCDWQ maximum of 0.050 mg/L. Other samples from the distribution system taken from the same site recorded much lower and acceptable levels of copper and manganese. The high copper and manganese readings could be a result of distribution system characteristics such as copper plumbing or build-up of manganese oxidizing bacteria and are not interpreted as an inorganics problem in the raw water source.

HOTEL LAKE

Raw water samples from Hotel Lake were taken twice in 2007 and they met the Guidelines for Canadian Drinking Water Quality (GCDWQ) for all parameters.

In July 2007, total organic carbon (TOC) and UV transmittance were analyzed. The TOC level was 4.0 mg/L and the UV transmittance was 35 percent. A TOC level above 2.5 mg/L is considered high due to the consequent formation of disinfection by-products such as trihalomethanes (THMs) when water is chlorinated. THMs can have adverse health affects and are considered carcinogenic. A UV transmittance level below 70 percent is considered low, because UV reactors are typically rated to treat water with a UV transmittance above 70 percent. Since there is only one sample it is difficult to know how the levels vary. Seasonal variation may occur as more organic matter is expected in lakes during the summer and fall. Given that the turbidity is generally low, the low UV transmittance can be attributed to the TOC.

In the distribution system supplied by Hotel Lake, trihalomethane (THM) levels were above the guidelines in two samples. Specifically, chloroform was detected at levels of 0.1 and 0.14 mg/L, which is just above the CGDWQ maximum of 0.1 mg/L. Chlorine by-products such as THMs are products of the reaction between organic matter and chlorine, therefore high levels of TOC contribute to THM production when chlorination is applied.

MCNEILL LAKE / HASLAM CREEK

McNeill Lake and Haslam Creek have water quality that is high in organic matter and colour. Since Haslam Creek is fed by McNeill Lake, it is expected that both water sources have similar water quality. A raw water sample from Haslam Creek reported a true colour of 30 TCU in a sample taken in October 2007, which is twice the GCDWQ maximum of 15 TCU. High colour levels suggest that Haslam Creek may also have high levels of natural organic matter (NOM). Raw water samples from McNeill Lake, taken between 1996 and 2005, all reported TOC concentrations above 3.6 mg/L. High organic matter levels can lead to the formation of disinfection by-products, increased chlorine demand and aesthetic issues.

2.3 WATER LICENSES

Existing water licenses for SPHWSA and NPHWSA are given in Table 2-1.

Table 2-1: Existing Water Licenses and Current Utilization

Water System	Water Source	Water Licenses (m3/y)	Current Water Demand (m3/y)	Water License Utilization (%)
NPHWSA	Hotel Lake	101,219	238,856	45%
	Garden Bay Lake	433,072		
SPHWSA	McNeill Lake [3]	663,729	473,040	71%

Notes:
1. Water licenses provided by the BC Ministry of Environment, Water Stewardship Division, 2008.
2. Current water demand is average day demand (ADD) as given by the SCRD.
3. Hotel Lake water licenses may be adjusted as a condition of the new license recently issued on Garden Bay Lake.

SPHWSA has an average day demand (ADD) of 1,296 m^3/d equivalent to 71 percent of its water license. The ADD for the NPHWSA is currently 658 m^3/d equivalent to 45 percent of its water license. NPHWSA has water licenses from Hotel Lake and Garden Bay Lake totalling 534,291 m^3/year. The ability of the water systems to meet future water demands is shown in Table 2-2.

Table 2-2: Existing Water Licenses and Future Water Demands.

Water System	Water Source	Current Water Demand (m3/d)	Short-term Water Demand (m3/d)	Long-term Water Demand (m3/d)	Water Licenses-Daily Equivalent (m3/d)
NPHWSA	Hotel Lake	654	690	1,104	277
	Garden Bay Lake				1,186
SPHWSA	McNeill Lake	1,296	1,620	2,592	1,818
Combined	Hotel Lake	1,950	2,310	3,696	3,282
	Garden Bay Lake				
	McNeill Lake				

Notes:
1. Water demands are Average Day Demands (ADD) as given by the SCRD.
2. Water licenses provided by B.C. Ministry of Environment, Water Stewardship Division, 2008.

Water licenses on Garden Bay Lake are capable of meeting long-term demands for the NPHWSA therefore supplementation by Hotel Lake water licenses is not required to meet long-term NPHWSA demands. SPHWSA will require an additional water license from its water source, McNeill Lake, to meet long-term demands. The existing SPHWSA water licenses are sufficient for the short term demand.

A combined NPHWSA and SPHWSA system will also require an increase in water license capacity to meet long-term demands. The sum of the water licenses for Hotel Lake, Garden Bay Lake and McNeill Lake is 3,282 m3/d. The combined system is applicable to water supply Options B and C.

2.4 FUTURE WATER DEMANDS

The SCRD anticipates population growth in the Pender Harbour area over the coming years. Future water demands have been projected for a population growth of 25 percent in the short-term and a 100 percent in the long-term, above the current recorded population. The current and future population (as number of households) and the household water demands, as given by the SCRD, are provided in a table in Appendix D. The current and future water demands for NPHWSA, SPHWSA and a combined NPHWSA/SPHWSA system are given in Table 2-3.

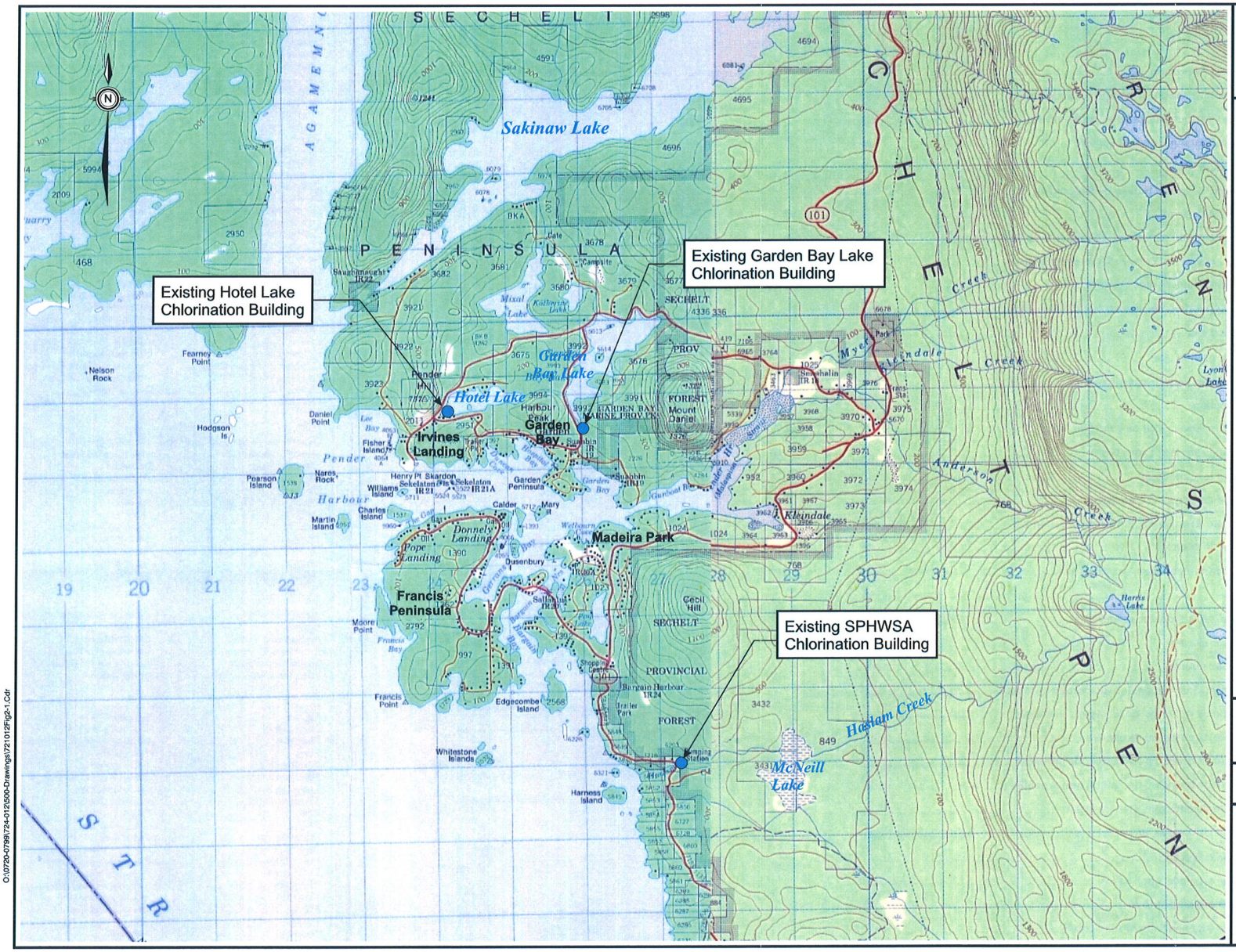
Table 2-3: Current and Future Water Demands

	Current Demands		Short-term Demands [3]		Long-term Demands [4]	
	ADD [1] (m3/day)	MDD [2] (m3/day)	ADD [1] (m3/day)	MDD [2] (m3/day)	ADD [1] (m3/day)	MDD [2] (m3/day)
NPHWSA	654	1309	690	1380	1104	2209
SPHWSA	1296	2592	1620	3240	2592	5184
Combined	1950	3901	2310	4620	3696	7393

Notes:

1. ADD is average day demand.
2. MDD is maximum day demand.
3. Short Term demands are 25% increase above current demands as given by the SCRD.
4. Long term demands are 100% increase above current demands as given by the SCRD.

The short-term and long-term ADDs and MDDs are based on household water consumption unit rates provided by the SCRD. These rates take into consideration economic and population growth, water quality improvement and progress in demand management programs. The future household water demands are the same for both the NPHWSA and SPHWSA and are 2.7 m^3/day per household.



Sunshine Coast Regional District
Pender Harbour Water Treatment
Feasibility Study

Legend

KERR WOOD LEIDAL associates limited
CONSULTING ENGINEERS

1000 0 1000
Scale in Metres

Project No.	Date
724-012	August 2008

Overview Map of Sunshine Coast Regional District Electoral Area "A"

Figure 2-1

O:\0720-0799\724-012\500-Drawings\721012Fig2-1.Cdr

Section 3

Evaluation of Water Supply Options

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

3. EVALUATION OF WATER SUPPLY OPTIONS

The proposed water supply options will supply water directly from source to treatment facility. Existing water tanks will remain in the distribution system for treated water storage. The design flowrates for the treatment facilities are long-term maximum day demands (MDD) as projected by the SCRD. For each option the design flowrate is as follows:

Table 3-1: Design Flowrates for each Option

	Water System	Design Flowrate (m3/d)	Design Flowrate (L/s)	Design Flowrate (USgpm)
Option A	NPHWSA	2,209	26	405
	SPHWSA	5,184	60	951
Option B	Combined	7,393	86	1356
Option C	Combined	7,393	86	1356

Notes:
1. Water treatment Design Flowrates are Maximum Daily Demands (MDD) as given by the SCRD.

3.1 TREATMENT PROCESS ALTERNATIVES

All of the existing water sources require the use of flocculation prior to filtration primarily due to the presence of elevated organic content shown in the few water samples summarized in this report. The only exception is the Haslam Creek intake for the SPHWSA, (the seasonal alternative for drawing water directly from McNeill Lake), which is subject to elevated organic content and turbidity. The available treatment process options include:

- Flocculation;
- Clarification (Dissolved air floatation);
- Conventional filtration; and
- Membrane Filtration

Following pre-treatment and filtration selected from the above, UV light disinfection and then chlorine disinfection are intended to be provided as part of each proposed facility. UV disinfection technology is an inexpensive additional barrier and chemical-free way of inactivating Giardia and Cryptosporidium and complements a multi-barrier treatment process. The final chlorine disinfection step provides a second barrier to inactivate bacteria and viruses as well as provides a residual through the distribution system to prevent re-growth.

Flocculation is the process of creating "flocs" of suspended solids and organics by adding a coagulant to the raw water and providing gentle agitation. These larger suspended solids are then typically removed in some type of clarifier or directly by a filtration process (conventional or membrane).

The clarification process best suited to remove organic content typical of many BC coastal water sources is Dissolved Air Floatation (DAF). The DAF process is based upon gentle agitation of the water in the flocculator section which uses a coagulant to create and allow flocs to grow before they pass into the flotation zone. The process then removes the flocs by bubbling saturated air through the water to create microscopic air bubbles. The flocs adhere to the bubbles and float to the water surface where they are then removed from the water surface with a skimmer. The accumulated float is skimmed off and the clarified water passes to the filtration process for final polishing.

The filtration processes suggested are either conventional rapid gravity filtration or membrane filtration. The conventional filtration process is typically composed of a sand/anthracite media filter which is simple to operate and maintain. This conventional filtration process requires the use of coagulation/flocculation process in order to provide effective filtration. The ultrafiltration membrane option provides a physical barrier to particulates and waterborne pathogens. These membrane filters provide greater than 4 log removal of Giardia and Cryptosporidium and some of the manufacturers have independent testing showing greater than 4 log removal of viruses. Ultrafiltration can be used to remove organic content when preceded by a flocculation step. An alternative is the addition of DAF prior to Ultrafiltration which offers several potential advantages such as:

- Removal of organic based flocs prior to filtration, thereby reducing potential for fouling.
- Less frequent backwashing and chemical cleaning and less waste.
- Potential for increasing filtration flux, thereby reducing numbers of filters.
- Longer membrane life (Option 1 and 3)

The SCRD operators are already familiar with the process technology of DAF and rapid gravity filtration as these are already installed and in use at the Chapman Creek Water Treatment Plant. There are many other locations where DAF is used successfully as the primary treatment for organics removal and turbidity below 100 NTU. An example of a DAF based treatment process schematic and a reference list for operational DAF based water treatment plants are provided in Appendix G.

The three treatment process trains considered appropriate for the water sources evaluated are as follows:

- **Option 1**: Flocculation + Ultrafiltration,
- **Option 2**: Flocculation + Dissolved air floatation + Rapid gravity filtration, and
- **Option 3**: Flocculation + Dissolved air floatation + Ultrafiltration.

As noted previously, each of the above options will be followed by UV disinfection and chlorine disinfection.

Although each of the above options is technically feasible, Option 2 provides the lowest capital and operational cost as outlined in subsequent sections of this report. A conventional DAF water treatment facility is relatively simple to operate and maintain and the SCRD has significant operational experience with the existing Chapman Creek facility. Based upon these considerations, the development of the water treatment options are all based upon the implementation of Option 2.

3.2 OPTION A: TWO TREATMENT FACILITIES

Option A continues to maintain the separation of NPHWSA and SPHWSA and consists of two separate treatment facilities, one servicing NPHWSA and one servicing SPHWSA.

NPHWSA

The NPHWSA system will be supplied by Garden Bay Lake and can have a treatment facility located adjacent to the existing Garden Bay chlorination building. The crown land has sufficient area and can potentially be used as the site for a new water treatment facility under a permit of occupation. Hotel Lake will no longer be required to regularly supply water to the NPHWSA system to alleviate some of the water license load on Hotel Lake and eliminate the cost of transporting water from a second water source to the treatment facility. The Hotel Lake intake and chlorination building can remain intact and be kept as an emergency use back-up for the Garden Bay supply and treatment system.

There is little water quality data available for Garden Bay Lake, so it is uncertain if the data is representative of the water source for all seasonal variations. Comprehensive water quality tests should be conducted for a one-year period in order to accurately characterize the water quality of Garden Bay Lake. The available water quality results show high concentrations of organic matter and a low UV transmittance. Based on these results, the water supply will require a multi-barrier treatment process such as Option 2 as outlined in the previous section above. The need and suggestions for additional water quality monitoring are outlined in subsequent sections of this report.

SPHWSA

The SPHWSA system will be supplied by McNeill Lake via the McNeill Lake intake. The water will be gravity fed from the lake to a new SPHWSA treatment facility located at the existing SPHWSA chlorination building site.

Over ten years of water quality results show that McNeill Lake has high organic content and elevated turbidity. The water supply will require a multiple barrier treatment process such as Option 2 as outlined in the previous section above. Therefore the treatment process train will be similar to that proposed for the NPHSWA treatment facility with

pre-treatment, by flocculation and DAF, followed by rapid gravity filtration and disinfection by UV and chlorination.

WATER LICENSES

In the short-term, the NPHWSA and SPHWSA do not require additional water license capacities to meet future demand. The ability of the existing water licenses to meet short-term water demands is shown in Table 3-2, below.

Table 3-2: Water License Capacity for Short Term ADD - Option A.

Water System	Water Source	Existing Water Licenses - Daily Equivalent (m3/d)	Short-term Demand (m3/d)	Additional Water License Capacity Required (m3/d)
NPHWSA	Garden Bay Lake	1,186	690	0
SPHWSA	McNeill Lake	1,818	1,620	0

Notes:
1. Short-term demands are based on average daily demand (ADD) as given by the SCRD.

In the long-term, the NPHWSA will not require an additional water license to meet future demands. However the SPHWSA will require an additional water license of 774 m3/d (282,351 m3/year) from McNeill Lake; this is a 43 percent increase in water license capacity on McNeill Lake. Table 3-3 shows the additional water license capacity required for the water systems.

Table 3-3: Water License Capacity for Long-Term ADD - Option A.

Water System	Water Source	Existing Water Licenses - Daily Equivalent (m3/d)	Long-term Demand (m3/d)	Additional Water License Capacity Required (m3/d)
NPHWSA	Garden Bay Lake	1,186	1,104	0
SPHWSA	McNeill Lake	1,818	2,592	774

Notes:
1. Long-term demands are based on average daily demand (ADD) as given by the SCRD.

It is beyond the scope of this report to determine if an increase in water license capacity is feasible.

COST ESTIMATE

Option A will require the construction of two treatment facilities and will decommission the existing chlorination buildings located in the SPHWSA and NPHWSA. The SCRD has expressed interest in retaining the Hotel Lake chlorination facility as an emergency back-up water source for Garden Lake.

The cost estimates for the treatment facilities includes site work, building and concrete work and treatment equipment. Major equipment costs for the treatment process are

based upon budgetary quotes from the suppliers. The cost estimates do not include the cost for acquisition of any land.

Based upon discussions with suppliers and previous experience, the building foot print required for each new facility was determined. The NPHWSA treatment facility will have a footprint of approximately 240 sq. meters and the SPHWSA treatment facility will have a footprint of approximately 300 sq. meters. The footprints are estimated based on typical water treatment plant layouts.

The capital cost of the NPHWSA facility is estimated to be approximately $2.9 to $3.8 million dollars and the annual O&M costs are estimated to be in the range of $121,000. The total capital cost of the SPHWSA facility is estimated to be approximately $4.1 to $5.4 million dollars and the annual O&M costs are estimated to be approximately $155,000. In total, the Option A capital cost is estimated to be approximately $7.0 to $9.1 million dollars and the total annual O&M costs are estimated to be approximately $276,000. A detailed breakdown of these cost estimates are provided in Appendix E.

The cost estimates in this study are Class D and follow the classification of the Treasury Board of the Canadian federal government. As defined by the Treasury Board, the Class D estimate is "based upon a statement of requirements, and an outline of potential solutions, this estimate is strictly an indication (order of magnitude) of the final project cost, and should be sufficient to provide an indication of cost and allow for ranking options being considered."

3.3 OPTION B: ONE TREATMENT FACILITY AND A SINGLE WATER SOURCE

This option proposes one treatment facility, servicing both NPHWSA and SPHWSA, supplied by a single water source. The water source will need to meet the long-term ADD of 3,696 m3/day as given in Table 2-2.

WATER SOURCE

The additional water license capacity required for a single water source to meet the long-term demands for Option B is given in Table 3-4. The three existing NPHWSA and SPHWSA water sources are considered in the table.

Table 3-4: Water License Capacity for Long-Term ADD - Option B.

Water Source	Existing Water License - Daily Equivalent (m3/d)	Long-term Demand (m3/d)	Additional Water License Capacity Required (m3/d)	Percent Increase in Water License Capacity
Hotel Lake	277	3,696	3,419	1233%
Garden Bay Lake	1,186	3,696	2,510	212%
McNeill Lake	1,818	3,696	1,878	103%

Notes:
1. Long-term ADD is for a combined NPHWSA and SPHWSA system.

For McNeill Lake to take on the long-term demands for both NPHWSA and SPHWSA, it will require a water license increase of 103 percent or 1,878 m3/day (685,420 m3/year). A water balance on McNeill Lake will need to be calculated to determine if the lake is able to support an additional water license of this capacity. This can be done by updating the *Hydrologic analysis of the Haslam Creek watershed* report by Summit Environmental (2006). It is beyond the scope of this report to determine if an increase in water license capacity is feasible.

Garden Bay Lake and Hotel Lake are less feasible water source options. Garden Bay Lake will require a water license increase of 212 percent or 2,510 m^3/day (916,078 m^3/year) to meet long-term demands, which is not sustainable based on the lake's annual water balance created by KWL for the *Water Development Plan for Sakinaw Lake* study in 2006. Hotel Lake is in the process of having water licenses deferred to other water sources, because it is already heavily water licensed.

Sakinaw Lake is the largest lake on BC's Sunshine Coast making it an obvious consideration for a Pender Harbour water source. According to Westland Resource Group (1992), the lake has a volume of about 350 x 10^6 m^3, and a hydraulic retention time (the ratio of lake volume to total annual inflow) of approximately 9.3 years. The lake has the capacity to support the long-term demands of NPHWSA and SPHWSA based on the annual water balance created by KWL for the *Water Development Plan for Sakinaw Lake* study in 2006. With an additional water license of 3,696 m3/d (1,349,040 m3/year) on the lake, the maximum lake drawdown was shown to be approximately 10 centimetres.

Sakinaw Lake is meromictic, with salt water at its lower depths, causing the effective retention time of the freshwater storage to be reduced. Water licensing on Sakinaw Lake faces resistance from lake residents and the approval process may be lengthy. A water license application for Sakinaw Lake for 141 m3/d (51,439 m3/year) was submitted by the SCRD in December 2006 and is still pending. The Sakinaw Lake watershed includes numerous lakes including Garden Bay Lake and Hotel Lake. All the lakes in the Sakinaw Lake watershed feed into Sakinaw Lake itself, so water licenses should be transferable to Sakinaw Lake in the future, if desired.

At this time, McNeill Lake is the most feasible water source for Option B since it currently has the greatest water license capacity to serve both NPHWSA and SPHWSA. Long term planning (>50 yr horizon) should consider and include the potential use of Sakinaw Lake as a domestic water source for the local region as population and density increases in the area.

WATER TREATMENT

Assuming McNeill Lake is approved for an increase in water license capacity and meets the long-term demands for NPHWSA and SPHWSA, the treatment facility will require a multiple barrier treatment process including pre-treatment, filtration and disinfection to remove organics and turbidity and to inactivate Giardia, Cryptosporidium, bacteria and viruses. The water supply will require a multiple barrier treatment process such as Option 2 as outlined previously. Therefore the treatment process train will be similar to that proposed for the other locations and include pre-treatment, by flocculation and DAF, followed by rapid gravity filtration and disinfection by UV and chlorination.

The treatment facility will be located at the existing SPHWSA chlorination building site near McNeill Lake. The treated water will be pumped to the NPHWSA via a watermain approximately 10 kilometres that follows the existing roadway alignment. A water distribution model would need to be developed to determine and verify the hydraulic conditions within the combined water system.

Currently the SCRD is planning extension of the NPHWSA water service to South Oyster Bay in 2009, which closely links the NPHWSA and SPHWSA. There is potential to connect the systems in the future by an underwater watermain. A water distribution model will need to be developed to determine and verify the hydraulic conditions and connection requirements to confirm feasibility of this alternative. In addition, various requirements, permits and approvals from the Department of Fisheries and Oceans, the Coast Guard and others will need to be confirmed prior to confirming feasibility of this potential connection.

COST ESTIMATE

Option B will require the construction of one treatment facility and the installation of over 10 kilometres of watermain. The cost estimate for this option assumes McNeill Lake is able to solely supply water to both NPHWSA and SPHWSA in the long-term.

The cost estimate for the Option B treatment facility includes site work, building and concrete work and treatment equipment. Major equipment costs for the treatment process are based upon budgetary quotes from the suppliers. The cost estimate does not include the cost for acquisition of any land. Based upon discussions with suppliers and previous experience, the building foot print required for this facility was determined. The treatment facility will have a footprint of approximately 600 sq. meters.

The total capital cost is estimated to be approximately $8.9 to $11.6 million dollars and the annual O&M costs are estimated to be in the range of $255,000. A detailed breakdown of the cost estimate is given in Appendix E. The cost estimates in this study are Class D and follow the classification of the Treasury Board of the Canadian federal government. As defined by the Treasury Board, the Class D estimate is "based upon a statement of requirements, and an outline of potential solutions, this estimate is strictly an

indication (order of magnitude) of the final project cost, and should be sufficient to provide an indication of cost and allow for ranking options being considered."

3.4 OPTION C: ONE TREATMENT FACILITY AND MULTIPLE WATER SOURCES

This option proposes one treatment facility, servicing both NPHWSA and SPHWSA, supplied by multiple water sources. Water from McNeill Lake, Hotel Lake and Garden Bay Lake will be blended to supply water for a combined system. Two watermains will need to be installed between NPHWSA and SPHWSA, one supply line and one distribution line. There is no existing watermain linking NPHWSA and SPHWSA.

WATER LICENSES

McNeill Lake, Hotel Lake and Garden Bay Lake have a combined water license capacity of 3,282 m3/day (1,198,020 m3/year). These water licenses meet the existing and short-term water demands for a combined system, but do not meet the long-term ADD, as shown in Table 2-2. An additional water license of 414 m^3/day (151,130 m^3/year) is required to meet long-term demands. Table 3-5 assumes that the additional water license is obtained by McNeill Lake. It is beyond the scope of this report to determine if an increase in water license capacity is feasible.

Table 3-5: Water Quality of Blended Source Water for Option C.

	McNeill Lake[1]	Hotel Lake[2]	Garden Bay Lake[2]	Blended Water
Water Supply (m3/d) [3]	2,232	277	1,186	3696
% of Total Volume	60%	8%	32%	100%
Colour (TCU)	30	10	10	22.1
TOC (mg/L)	9.5	4	3	7.0
Turbidity (NTU)	1	0.8	0.4	-

Notes:
1. Assumes McNeill Lake has an additional water license of 414 m3/d (151,130 m3/y).
2. Water supply values are based on existing water licenses for the water source.
3. Water supply is based on average daily demand (ADD).
4. Colour, TOC and turbidity values are the highest values for each water source from the available water quality data provided to KWL.
5. Turbidity of the blended water should be determined by pilot testing.

McNeill Lake makes up for 60 percent of the total water volume and contributes to the high organic matter in the blended water. The blending of water sources allows for the blending of the McNeill Lake water with the better quality water from Hotel Lake and Garden Bay Lake.

The blended water quality is likely to have high organic matter and a turbidity level above 1 NTU. Therefore the treatment facility will a treatment process to remove organics and turbidity and to inactivate Giardia, Cryptosporidium, bacteria and viruses. The water supply will require a multiple barrier treatment process such as Option 2 as

outlined previously. Therefore the treatment process train will be similar to that proposed for the other locations and include pre-treatment, by flocculation and DAF, followed by rapid gravity filtration and disinfection by UV and chlorination.

The treatment facility will be located at the existing SPHWSA chlorination building site near McNeill Lake since McNeill will be the primary water source for the combined system. Water from all water sources will be pumped to the common treatment facility through a new supply watermain. The treated water will be distributed to the NPHWSA via a watermain approximately 10 kilometres in length following the existing roadway alignment. The watermain connecting Hotel Lake Water System and Garden Bay Waterworks District will be opened. A water distribution model should be developed in the future to determine and verify the hydraulic conditions within the combined water system.

COST ESTIMATE

Option C will require the construction of one treatment facility and the installation of over 20 kilometres of watermain. The cost estimate for this option assumes that all of Hotel Lake, Garden Bay Lake and McNeill Lake contribute to the water supply and that McNeill is able to supply additional water to meet long-term demands.

The cost estimate for the Option C treatment facility includes site work, building and concrete work and treatment equipment. Major equipment costs for the treatment process are based upon budgetary quotes from the suppliers. The cost estimate does not include the cost for acquisition of any land. Based upon discussions with suppliers and previous experience, the building foot print required for this facility was determined. The treatment facility will have a footprint of approximately 600 sq. meters.

The total capital cost is estimated to be approximately $12.3 to $15.9 million dollars and the annual O&M costs are estimated to be in the range of $255,000. A detailed breakdown of the cost estimate is given in Appendix E.

The cost estimates in this study are Class D and follow the classification of the Treasury Board of the Canadian federal government. As defined by the Treasury Board, the Class D estimate is "based upon a statement of requirements, and an outline of potential solutions, this estimate is strictly an indication (order of magnitude) of the final project cost, and should be sufficient to provide an indication of cost and allow for ranking options being considered."

3.5 FEASIBILITY ANALYSIS

Table 3-6 presents a summary of the cost estimates for all options evaluated.

Table 3-6: Summary of Capital and O&M Cost Estimates.

	Capital Cost		Annual Operation & Maintenance Costs
	(Lower Range)	(Upper Range)	
Option A - North	$ 2,886,000	$ 3,752,000	$ 121,000
Option A - South	$ 4,142,000	$ 5,385,000	$ 155,000
Total Option A	$ 7,028,000	$ 9,137,000	$ 276,000
Total Option B	$ 8,890,000	$ 11,557,000	$ 255,000
Total Option C	$ 12,265,000	$ 15,945,000	$ 255,000

Note:
1. Cost estimates are Class 'D' and are subject to +/- 30 percent.

As shown, Option A has the lowest capital cost and Option C has the highest. Annual O&M costs are lowest for Option B and C because the construction of one larger treatment facility provides some economies of scale over the construction of two smaller treatment facilities.

Based on the cost estimates, the present value and production costs over a 50-year period are calculated and are shown in Table 3-7, below. Option A has the lowest estimated present value of approximately $16.3 million dollars. Option A also has the lowest estimated production cost of $0.30 per cubic meter of water.

Table 3-7: Estimated Present Value and Production Costs.

	Facility	Present Value O&M	Present Value Capital + O&M	Production Costs ($/m3)
Option A	NPHWSA	$3,113,301	$6,865,301	$0.42
	SPHWSA	$3,988,113	$9,373,113	$0.24
	Total	$7,101,415	$16,238,415	$0.30
Option B	Combined	$6,561,090	$18,118,090	$0.33
Option C	Combined	$6,561,090	$22,506,090	$0.41

Notes:
1. Present value is for a 50 year period at a 3 percent interest rate.
2. The production costs are based on ADD, 1-25 years is considered short-term and 26-50 years is considered long-term.

Option A is currently the most feasible water supply option for the Pender Harbour area. Option A has the lowest estimated capital costs as well as the lowest present value and production costs over a 50-year period. The option to continue to maintain separation of NPHSWA and SPHWSA eliminates the cost of watermain infrastructure required to combine the systems.

Present value and production rate sample calculations are given in Appendix F.

3.6 IMPLEMENTATION

The implementation of Option A will require source water characterization, pilot testing and water license approval.

SOURCE WATER CHARACTERIZATION

Source water characterization should be conducted on Garden Bay Lake for NPHWSA and on McNeill Lake for SPHWSA 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;
- Hardness;
- pH (field-measured);
- Total Organic Carbon; and
- UV Transmittance (unfiltered).

Every two weeks
- Iron;
- Manganese; and
- Total Dissolved Solids.

In addition, turbidity meters and chlorine analyzers with temperature monitoring should be installed at Garden Bay Lake and McNeill Lake, at the point of primary disinfection to continuously record the raw water turbidity, chlorine and temperature. There should be alarms for the turbidity meters and chlorine analyzers as well as data loggers to record the data.

A one-year water sampling program at Garden Bay Lake may determine if the NPHWSA is eligible for filtration exemption. This exemption of filtration may be considered if **all** of the following conditions are met:

1. Overall inactivation is met using a minimum of two disinfectants: i.e. UV and Chlorine disinfection

2. Prior to the point where the disinfectant is applied, the number of Escherichia coli bacteria in the source water does not exceed 20/100 mL (or, if E. coli data are not available, the number of total coliform bacteria does not exceed 100/100 mL) in at least 90% of the weekly samples from the previous 6 months.

3. Average daily source water turbidity levels measured at equal intervals (at least every 4 hours), immediately prior to where the disinfectant is applied, are around 1.0 NTU but do not exceed 5.0 NTU for more than 2 days in a 12-month period. Source water turbidity also does not show evidence of protecting microbiological contaminants.

4. A watershed control program (e.g., protected watershed, controlled discharges, etc.) is maintained that minimizes the potential for faecal contamination in the source water.

SPHWSA will not qualify for filtration exemption because the water quality of McNeill Lake has already shown to have a turbidity level greater than 1 NTU.

PILOT TESTING

Pilot testing should be conducted for both the NPHWSA and SPHWSA systems for a three to six week period. The pilot testing is required for confirming design parameters including optimal coagulant dose.

WATER LICENSING APPROVAL

Option A requires an additional water license on McNeill Lake of 774 m3/d (282,351 m3/y) to meet long-term ADD for SPHWSA. The NPHWSA does not require an additional water license on Garden Bay Lake to meet the long-term ADD.

Section 4

Conclusions and Recommendations

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Based on the findings of this study, it is concluded that:

- Water license increases are not required to meet short-term demands.
- A water license increase is required to meet long-term demands for McNeill Lake.
- Additional source water quality testing should be collected for up to a one-year period to determine the seasonal variation of the water sources.
- The cost of connecting the NPHWSA and SPHWSA are greater than the cost of keeping the systems separate and building two treatment facilities. Thus, Option A has the lowest capital cost.
- Annual operation and maintenance (O&M) costs are lowest for Option B and C since the construction of one larger treatment facility provides some economies of scale over the construction of two smaller treatment facilities.
- Present value costs and production costs over a 50-year period are lowest for Option A.

4.2 RECOMMENDATIONS

It is recommended to implement Option A because:

- Estimated capital costs are lowest at approximately $7.0 to $9.1 million dollars.
- Estimated present value costs are lowest at approximately $16.2 million dollars over 50-years.
- Estimated production costs are lowest at approximately $0.30 per cubic meter of water.
- NPHWSA does not require additional water license capacity to meet long-term demands.

The implementation of Option A will require:

- Additional source water quality data for both the NPHWSA and the SPHWSA.
- Pilot testing for both the NPHWSA and SPHWSA to confirm optimum design criteria.
- Application for a Waterworks Permit on crown land adjacent to the existing facility for locating the facility proposed for the NPHWSA.
- Completion of preliminary design for each proposed facility.
- An application for an additional water license of 774 m3/d (282,351 m3/y) on McNeill Lake to meet long-term demands.
- Design and construction of a new treatment plant for the NPHWSA consisting of flocculation, DAF, rapid gravity filtration, UV and chlorine disinfection.
- Design and construction of a new treatment plant for the SPHWSA consisting of flocculation, DAF, rapid gravity filtration, UV and chlorine disinfection.

4.3 REPORT SUBMISSION

Prepared by:

KERR WOOD LEIDAL ASSOCIATES LTD.

Laura Weston, E.I.T.
Project Engineer

Reviewed by:

Irfan Gehlen, P. Eng.
Project Manager