REPORT

City of Nelson

Water Master Plan 2006

0795.0077.01-R / March 23, 2007

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March 23, 2007 File: 0795.0077.01-R

City of Nelson Public Works Office
Suite 101, 310 Ward Street
Nelson, BC V1L 5S4

Attention: Peter Hartridge

RE: WATER MASTER PLAN

Enclosed is the final draft of the Water Master Plan, incorporating the review comments received by you and your staff.

We trust the document meets with your approval and will be happy to assist in any presentations to Council or the public at your request.

Sincerely,

URBAN SYSTEMS LTD.

Peter Gigliotti, P.Eng.
/lp

Enclosure

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LIST OF UNITS, ABBREVIATIONS, AND ACRONYMS

µg	Microgram
µg/L	Microgram per liter
°C	Degree Centigrade
cm	Centimetre
DOC	Dissolved organic carbon
°F	Degree Fahrenheit
gpm	Gallon per minute
gpm/sf	Gallon per minute per square foot
GWUDI	Ground water under the direct influence of surface water
HAA	Haloacetic acid
kW	Kilowatt
L	Litre
L/s	Litres per second
L/min	Litres per minute
Log I	Log inactivation
mg	Milligram
mg/L	Milligram per litre
mgd	Million gallon per day
min	Minute
mJ	Millijoule
mJ/cm^2	Millijoule per centimetre squared
mL	Millilitre
ML/d	Megalitres per day
mm	Millimetre
mWs/cm^2	Milliwatt second per square centimetre
O&M	Operation and maintenance
PLC	Programmable logic controller
psi	Pounds per square inch
s	Second
TCU	Total colour unit
TOC	Total organic carbon
UV	Ultraviolet
UVT	Ultraviolet transmittance

EXECUTIVE SUMMARY

The report was commissioned by the City of Nelson to provide a comprehensive overview of the status of their water utility. The focus of the work is on the age of the infrastructure, the risks to the consumer, and development of a long-term strategy to provide reliable service to Nelson residents.

Many of the system weaknesses relate to the age of the infrastructure as it was initially built at the turn of the previous century. Source supply (Five Mile Creek) is at risk of falling short due to:

- More pronounced drought conditions brought on by climate change.
- Mountain Pine Beetle and forest fire damage in the watershed.

Source water quality does not meet current Interior Health targets and disinfection with chlorine is insufficient for micro-biological protection. Chlorine by-products also present a long-term health risk. Filtration of this source water is inevitable under current standards.

The study also shows that it is prudent to invest in a supplementary source to deal with supply shortfall events and with potential total loss of the primary source (forest fires, slides, spills). The two supplementary sources that demonstrate the most promise are Kootenay Lake and Clearwater Creek.

The recommended strategy is as follows:

- Develop a program for annual replacement of old water pipes in conjunction with sewer, storm drain and road surface upgrades.
- Investigate filtration technologies and costs and budget for a filtration plant located at the Mountain Station site by 2010.
- Undertake further assessment of a secondary source by additional sampling and testing over the next several years.

In the shorter term, a recommended list of actions is as follows:

a) Discuss the WMP with IHA and obtain their input.

b) Present and get Council ratification of the WMP.

c) Prepare a financial plan to address funding of the required upgrades, and access to senior government assistance programs.

d) Prepare and facilitate a public information "open house" to obtain public input.

e) Undertake repair and upgrade of the Five Mile Creek intake structure.

f) Undertake design and construction of the Fort Sheppard supplementary storage.

g) Embark on a leak detection program.

h) Develop and refine a public education and conservation awareness program.

i) Prepare a cross-connection control by-law.

j) Update the Emergency Response Plan.

k) Prepare a "needs and objectives" for a City-wide SCADA system to monitor and record water usage, chlorine residuals, and other parameters.

l) Undertake yearly Pressure Reducing Station upgrades.

m) Solicit for filtration pilot plants and undertake pilot filtration work.

1.0 INTRODUCTION

1.1 Preamble

The City of Nelson commissioned Urban Systems Ltd. to undertake a comprehensive review of their water system in September 2005. While previous reviews and studies had periodically been undertaken to address specific issues in parts of the system, an overall integrated review of all components of the water system had never been undertaken.

Through further discussions with City staff, it was decided that this document should be a long-range planning document for the City's water system and it would be appropriate to characterize it as a Water Master Plan (WMP).

1.2 Need for a Water Master Plan

The need for a long-term comprehensive plan arises out of a number of issues that City operations staff must deal with on a daily basis. These issues include:

1. **The age of the infrastructure**. Many components of Nelson's water system were built at the turn of the century and are approaching the end of their useful life.

2. **The adequacy of supply**. With a single main source of water supply, drought and forest fires have put the supply at serious risk of total loss.

3. **City growth**. While the City's growth pattern has been sporadic, the overall population increase from when the water system was originally built (1916) to 2006 is roughly double (5,000 people in 90 years). The same basic infrastructure is still being utilized.

4. **Legislation and Public Health**. New legislation and public health protection protocols in the Province of British Columbia mandate the City to review its water quality requirements.

5. **Level of Service**. Modern fire protection regulations, water conservation and demand management techniques require the City to meet new standards of performance.

6. **Risk Management**. The City must contend with, and therefore plan for, a number of service loss scenarios, including loss of supply, rupture of transmission mains, low creek flows due to climate change, contamination in the watershed and low fire protection flows.

1.3 Scope

The scope of the review is limited to the foregoing key issues. It is not intended to examine operations and day-to-day repair and maintenance activities. It is recognized that City staff must cope with very old infrastructure and they currently do their best to keep the system running as efficiently as possible.

The intent of the Plan is to identify those key elements which require updating and improvement in order to provide the required level of service.

1.4 Guiding Principles for the Water Master Plan

1. Comply with the Drinking Water Protection Act and Regulations to ensure a supply of water that is safe to drink consistently.

2. Take a long-term, big picture approach to planning:

   - Ultimate service area – City in a regional context.
   - Ultimate service, population

3. Strive to meet target fireflows throughout the service area.

4. Ensure sufficient capacity of supply and system components to accommodate growth and economic development. The service area will be confined to the existing City boundaries.

5. Ensure immediate and short-term improvements support the long-term plan.

6. Promote water conservation, encouraging the wise use of this valuable resource.

7. Maximize the potential for phasing of improvements on a priority basis.

8. Be strategic in financing water system improvements over time with the multiple objectives of:

   - Generating sufficient revenue to carry out improvements in a timely manner.
   - Achieving reasonable, affordability targets.
   - Allocating costs based in the principle of benefits received.
   - Maximizing grants from BC and Canada.

9. Follow best practices and principles for managing the water system infrastructure as an asset; and maximize the use and lifetime expectancy of existing system components.

1.5 Approach and Methodology

The study work program begins with a review of the City's main water system components. The review is based on a combination of information sources, including:

- Field observation and interview.
- Hydraulic modelling and analysis.
- Review of previous reports.
- Water sampling and testing.
- Available Provincial government data on creek flows and groundwater.

The exercise examines the City's historical water consumption patterns and develops projections for future demands. A comparison is made of per capita demand with other municipal water systems in the region. It then compares and assesses the available sources of water and their ability to meet those demands.

Water quality and public health protection, with the available options and costs of treatment are assessed and presented.

The distribution network and storage components are also examined in the context of maintaining the required level of service.

The last chapters deal with risk management, demand management and discussion of phasing improvements in a fiscally responsible manner.

1.6 Acknowledgements

City staff were active participants in the process and we wish to thank the following for their timely assistance and advice:

Peter Hartridge
Gil Bogaard
Allen Fillion
Ed Cook

1.7 Bibliography

1968 November: "Kootenay Lake Water Supply"
Dayton and Knight Ltd.

1982 October: "Selous Creek Dirt Removal Feasibility Study"
EPEC Consulting Western Ltd.

1987 March: "Water System Study"
Urban Systems Ltd.

1989 April: "Selous Creek Supply System Improvement Study"
Urban Systems Ltd.

1996 March: "Water Supply Review"
Urban Systems Ltd.

2005 February: "Water Conservation and Drought Management Study"
Urban Systems Ltd.

2006 January: "Five Mile Intake Pipeline Corrosion Evaluation"
Levelton Consultants Ltd.

2006 February: "Water Main Failure Evaluation 500 Front Street"
Levelton Consultants Ltd.

2006 April: "Cast Iron Water Main Evaluation Baker Street"
Levelton Consultants Ltd.

2006 July: "Fairview Reservoir and Watermain Design and Operational Brief"
Urban Systems Ltd.

2007 January: "Watershed Hydrologic Assessment, Five Mile Creek"
Deverney Engineering Services Ltd.

2.0 NELSON'S WATER SYSTEM

2.1 Primary Water Source

Nelson's primary water source is Five Mile Creek. The original intake and supply pipeline were constructed in 1925. The log-crib dam was upgraded in 1958 with a concrete dam.

The intake utilizes a coarse screen to retain larger rocks, followed by a separate fine screen chamber approximately 200m downstream. The supply pipeline is cast iron pipe constructed overland on rugged terrain. The pipe joints are not rated for high pressure and "pressure break" tanks are located strategically along its route. Many parts of the pipeline on steep embankments are not buried. The Deverney watershed report identifies a relatively high risk of landslides on the pipeline route.

The pipeline terminates at a storage/sedimentation pond located at Mountain Station. The overall length of the supply pipeline is approximately 6,700m. The elevation at the intake is 1,112.5m A.S.L. and the discharge elevation at the Mountain Station pond is 802m A.S.L.

A profile of the pipeline is provided on Figure 2.1.

2.2 Supplementary Sources

Recent years have seen the addition of supplementary creeks to the water supply to cover low flow periods in Five Mile Creek.

2.2.1 Anderson Creek

An intake on Anderson Creek was constructed at elevation 710m A.S.L. This intake is supplied with a chlorination facility and can supply supplementary water to the north-east part of the distribution network.

The City also has a license on Fell Creek, and a small intake routes water to the Anderson Creek intake.

2.2.2 Selous Creek

Selous Creek was developed in the early 1970's to further supplement water supply during drought conditions. The intake supplies water to the south-west part of the distribution network.

Both of the above supplementary sources play a minor role in the overall supply as the watersheds are relatively small. Water quality is good, but deteriorates in spring freshet.

Figure 2.2 presents the relative locations of Five Mile, Anderson and Selous Creek intakes, as well as the Mountain Station Reservoir.

2.3 Treatment

The method of treatment for the Five Mile Creek water is **sedimentation** (at the Mountain Station Reservoir) and **disinfection** by chlorination. Chlorination takes place in a baffled chlorine contact tank designed for 3-log (99.9%) Giardia Lamblia inactivation. The contact tank was constructed in 2001.

Anderson Creek and Selous Creek do not provide any sedimentation and chlorine contact is limited to residence time in the supply line. In all cases, chlorination is carried out with chlorine gas.

2.4 System Storage

The historical finished water storage in Nelson was provided by the Park Street Reservoir. This was a lined earth reservoir located on Park Street at elevation 701.0m A.S.L. The volume of this reservoir was 3,600m^3 (3.6 ML).

The reservoir collapsed in 2003 due to an embankment failure and it has not been replaced.

A second reservoir exists in the Rosemont area off Choquette Avenue. This is a concrete tank of 1.36 ML capacity at elevation 736.0m A.S.L. The purpose of this reservoir is to provide fire flow to the Rosemont area.

Another reservoir is currently under construction in the Fairview area of 1.9 ML capacity. Its purpose is to provide fire flow to the Fairview area. The operating water level of the Fairview reservoir is to be 710m A.S.L.

2.5 The Distribution Network

The City's distribution network is spread on relatively steep terrain on the hillside above Kootenay Lake. Accordingly, it is divided into several pressure zones. These pressure zones are achieved with the use of PRV (pressure reducing valve) stations, located throughout the network.

The currently operating pressure zones are as follows:

Zone 1: Immediately below Mountain Station
El. 769 to El. 748
A relatively narrow band at the upper levels of the City boundary
Percentage of overall demand: 2 – 3%

Zone 2: Largely residential land on the hillsides
El. 748 to El. 728m
Percentage of overall demand: 25 – 30%

Zone 3: Residential and Institutional above the downtown
El. 728 to El. 709m
Percentage of overall demand: 25 – 30%

Zone 4: The downtown and lakefront
El. 708 to El. 640m
Percentage of overall demand: 45 – 50%

The zones are spread out along the hillside and a total of 8 PRV stations regulate pressures in these zones.

There are numerous bottlenecks in the network and water does not easily move through the network in an east-west or west-east direction. The system was developed to supply water from the south and move in a northerly direction down the hillside.

The network contains a hierarchy of pipe sizes which generally provide sufficient flows to most areas, but fall short on fire flows in some areas.

The age of the pipework varies from 20 to 90 years, and this will play a significant role in the development of a pipe replacement program.

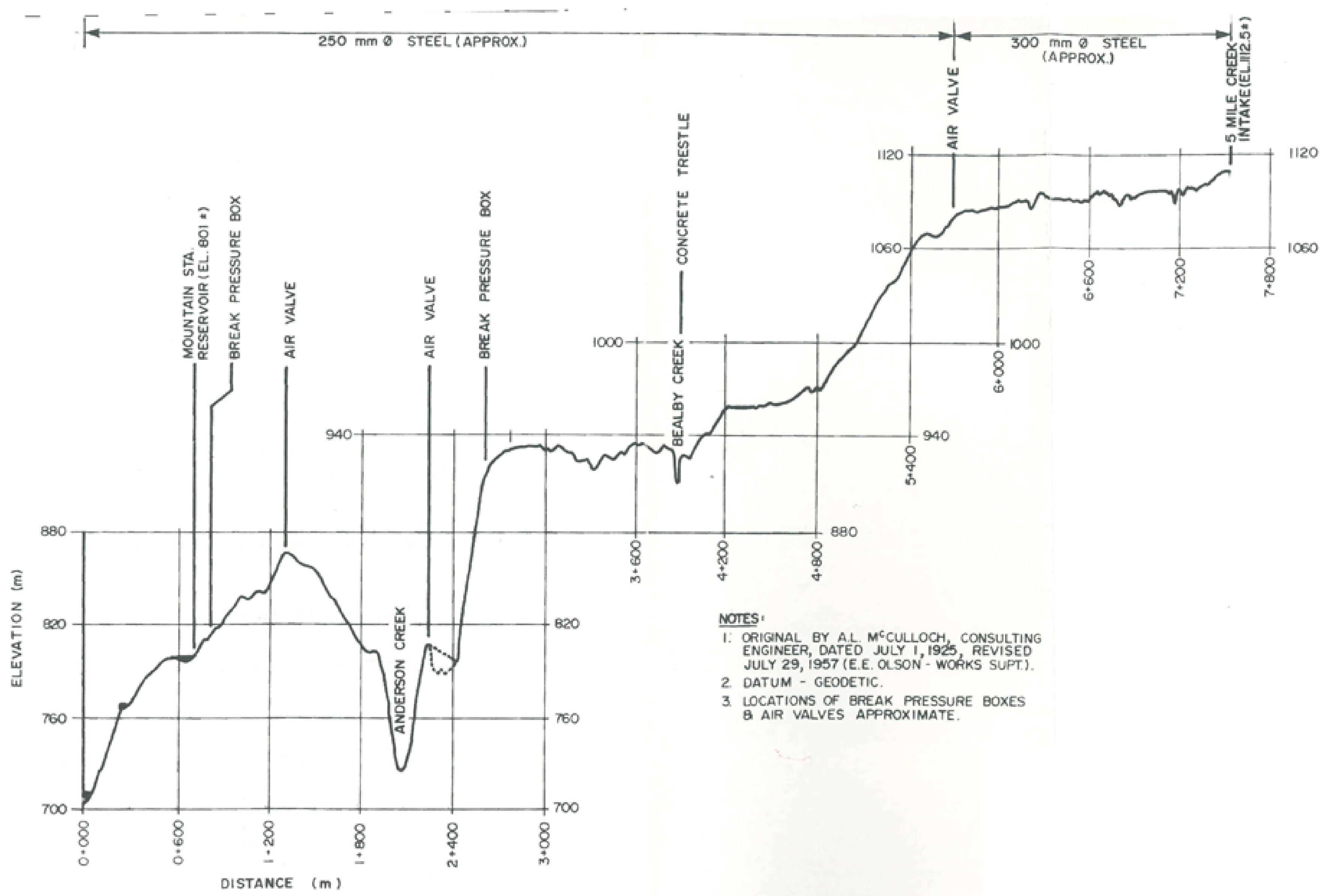
Figure 2.3 depicts the overall network, storage and pressure zones.

Table 2.1 summarizes the range of pipe ages within the network.

Table 2.1
Watermain Age Summary

Total Length of Watermain = 73,982m

Year of Installation	Watermain Age (years)	Length of Pipe Installed (m)	Percentage of Total
1917	90 or greater	919	1.24%
1918-1937	70 to 89	7,789	10.53%
1938-1957	50 to 69	15,857	21.43%
1958-1977	30 to 49	23,376	31.60%
1978-1997	10 to 29	19,677	26.60%
1998-2007	9 or less	6,365	8.60%
	Total	73,983	100%



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City of Nelson
Water Master Plan

Five Mile Creek Pipeline Profile

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Figure 2.1

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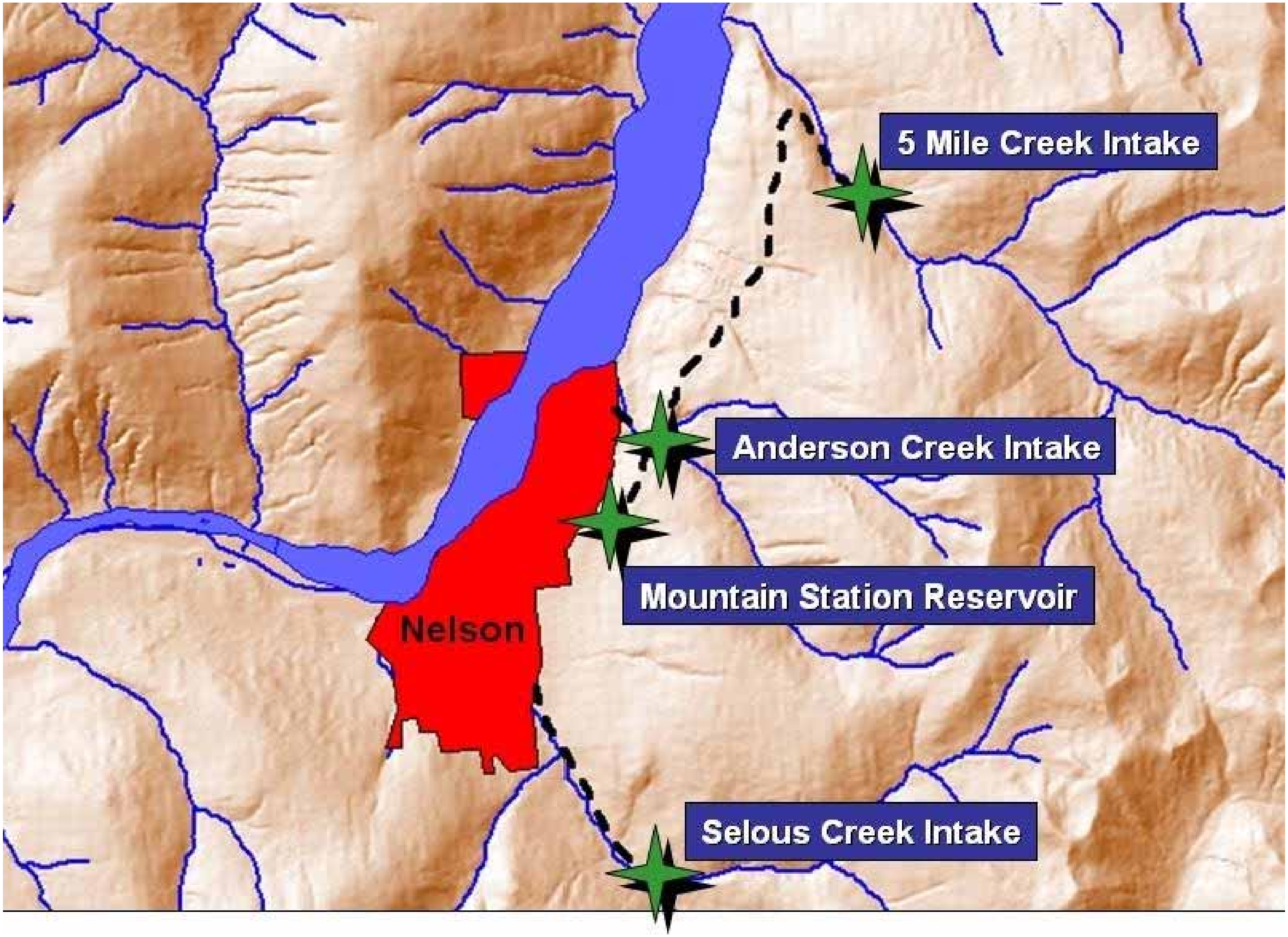

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Existing Water Sources

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Figure 2.2

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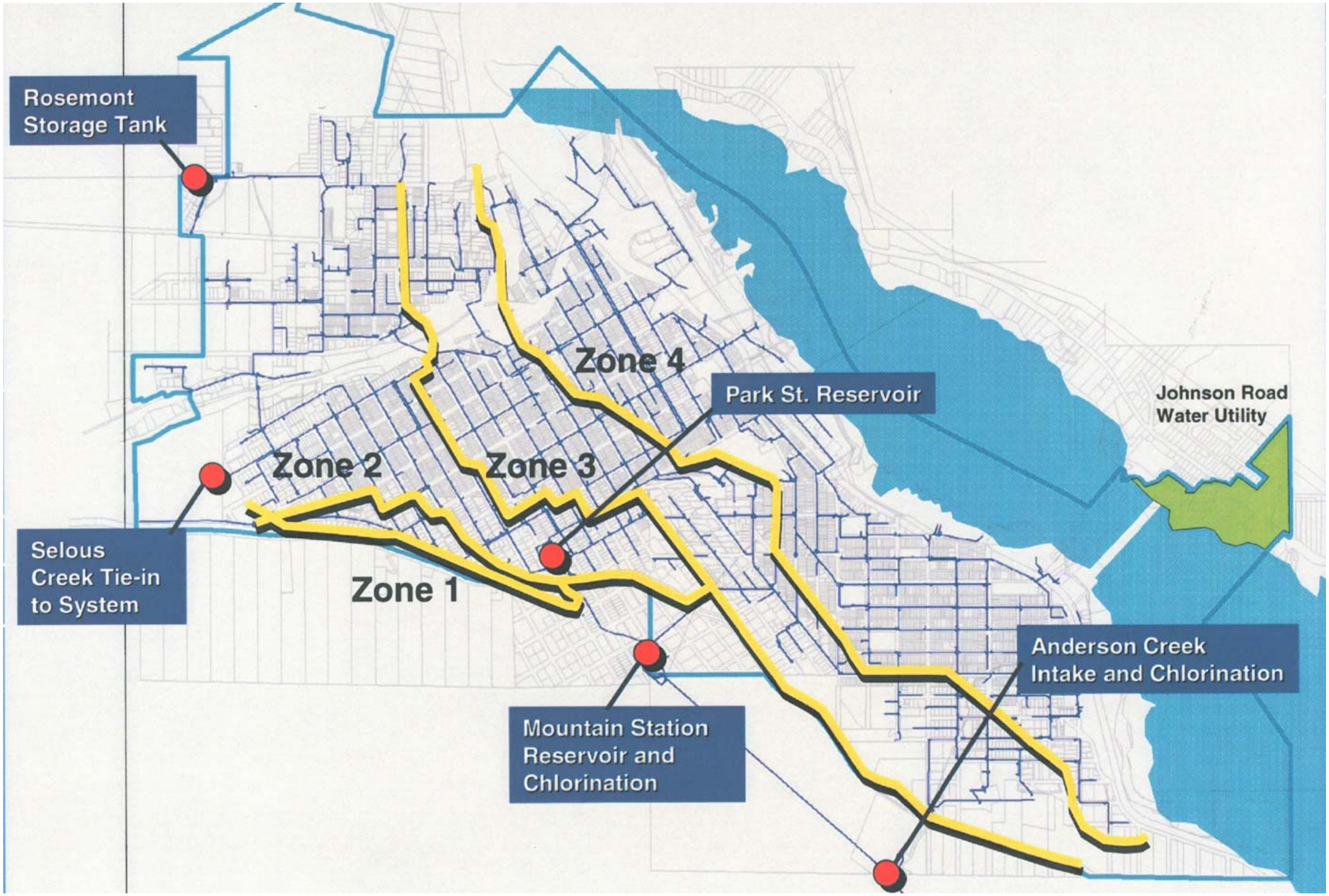

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City of Nelson Water Master Plan

Existing Distribution System

NTS

Figure 2.3

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3.0 WATER CONSUMPTION

3.1 Nelson's Population: An Overview

It is not the intent of this study to undertake a rigorous analysis of Nelson's population and growth patterns. Nevertheless, it will be useful to provide as background an overview of historical populations in the City.

The Canada Census figures date back to 1921 and a plot of the Census populations is provided on Figure 3.1 (from 1921 to 2001). It is evident that while there have been some growth "spurts", notably in the 1960's, other periods have seen population decline (mid 1980's).

The long-term pattern shows an approximately doubling of population over a period of 80 years. Forecasting population over the period of a Water Master Plan presents a number of difficulties as global economic situations, conflicts, the affect of "baby boomer" retirement, tourist development and a number of other factors come into play.

Discussions with City staff concluded that a reasonable projection for thirty or forty years could see an increase of 40 to 50%, if the past 80 years has shown roughly 100%.

There is also the factor of the physical capacity of the area to accommodate a larger population. Given the constraints of topography and Kootenay Lake, the City can accommodate limited numbers of people within the current boundaries. While boundaries could be extended on the "North Shore", it was decided that this should be the subject of a separate exercise, perhaps carried out in conjunction with the Regional District of Central Kootenay.

There are some opportunities for densification within the City's current boundaries, and the provision of housing for some 4,000 to 5,000 people over the next 30 – 40 years is not unreasonable.

For the purpose of water system planning, the "resident" populations which appear in the Census are not the only consumers of water. Visitors that occupy hotels/motels, students that are accommodated on a term basis, and water consuming industries must be considered, even if these do not appear in the resident census.

The concept of an "equivalent" population can be adopted, and the per capita water consumption can be related to this "equivalent" population.

3.2 Water Consumption Patterns

The City's water usage records from 1996 to 2005 were examined with the objective of establishing a valid per capita daily consumption rate.

Table 3.1 presents a summary of the recorded data in Mega Litres per day (ML/d) from 1996 through 2005.

The important parameters for planning and design are:

- Summer Maximum Day (SMD). This is the average of the five highest days of consumption during the summer months. It includes "outside uses" such as lawn sprinkling, car washing, etc. The water system must have the ability to supply the SMD rate.
- Winter Maximum Day (WMD). This rate represents the highest rate of consumption for "inside use" only. It is typically lower than the SMD so the network would have no difficulty providing the rate, but sources such as upland creeks often have lower productivity in winter, so it is also an important parameter.
- Annual Average Demand (ADD). This figure is the total annual consumption divided by 365 days. It is not a relevant design parameter for the system's hydraulic components, but is useful in the preparation of annual cost estimates for processing water. For example, total chlorine consumption is based on dosage rate applied to ADD.

Table 3.1 also provides the "equivalent serviced population" for each of the years recorded. This is the census population less the population in the North Shore (which is not serviced by Nelson's water system).

The "per capita" consumption (in Litres per capita per day) is then calculated for each of the three demand scenarios.

Table 3.1
Water Master Plan
Water Demand Derivation

Recorded Consumption	**1996**	**2001**	**2003**	**2005**	**2006**
Consumption from Records (ML/d)					
a) Annual Average (ADD)	9.3	9.5	7.7	6.4	6.9
b) Winter Maximum (WMD)	8.7	8.4	7.1	5.9	7.6
c) Summer Maximum (SMD)	18.6	13.9	13.0	10.8	11.5
Serviced Equivalent Population	9,400	9,100	9,200	9,200	9,260
Per Capita Consumption (Lcd) Litres/capita/day					
a) Annual Average (ADD)	989	1,044	837	696	745
b) Winter Maximum (WMD)	926	923	772	641	820
c) Summer Maximum (SMD)	1,980	1,527	1,413	1,174	1,242

3.2.1 Observations on Historical Patterns

- The per capita consumption figures for Summer Maximum Day (SMD) are lower than other communities in southern British Columbia. Records in other cities range from 2,000 Lcd to 4,500 Lcd. The Okanagan region records some of the highest summer figures because of hot dry summers.
- The Winter Maximum Demand (WMD) is somewhat higher than other communities, which range from 400 to 900 Lcd.
- The annual average figure (ADD) is comparable to other southern BC communities.

Discussions with staff indicate the following probable causes for high winter per capita consumption:

- Winter visitation in Nelson is relatively high compared to other communities because of available winter activities such as skiing and snow-mobiling.
- Older parts of the pipe network may have leaks which go unnoticed due to granular soils.

- Older homes have shallow uninsulated service lines and practice "bleeding" to prevent freezing.

- Some commercial refrigeration facilities use "drain-to-waste" cooling systems.

Notwithstanding the foregoing issues, the City has experienced an almost 20% decrease in consumption over the past ten years. This is largely due to staff efforts concentrating on:

- Regular leak repair programs.
- Water conservation and awareness programs.
- Summer sprinkling restrictions.
- Improved recording techniques.
- Development of separate sources for park irrigation.

3.3 Water Demand Derivation

The City's efforts over the past ten years have been successful in reducing demand rates, and it is not unreasonable to forecast that further reductions are achievable. Metering and more aggressive demand management programs can result in a further 20% reduction in per capita consumption. Techniques and opportunities for those reductions are discussed in a separate section of this document.

Figure 3.3 presents the derivation of per capita demand which will be used in planning and design for the remainder of this document.

Table 3.2
Per Capita Demand Derivation

	Winter Usage (Inside Only) Lcd	Summer Usage (Inside & Outside) Lcd
1996	926	1,980
2005	641	1,174
Average	784	1,577
Future (with further 20% Reduction)	660	1,300

3.4 Forecast Demands

Three horizons are chosen at 10-year intervals for a 30-year planning period. In order to assess the sensitivity of the water demand parameters, two hypothetical growth rates are chosen to reflect “low growth” and “high growth” (0.5% per year and 1.0% per year respectively). Table 3.3 presents these projections.

Table 3.3
Water Demand Forecasts

	Growth @ 1.0%/year			Growth @ 0.5%/year		
Future Water Demands – Year	**2016**	**2026**	**2036**	**2016**	**2026**	**2036**
Projected Population	10,700	12,000	13,200	10,200	10,800	11,300
Projected Demands (ML/d)						
a) ADD @ 760 Lcd	8.1	9.1	10.0	7.8	8.2	8.6
b) WMD @ 660 Lcd	7.1	7.9	8.7	6.7	7.1	7.5
c) SMD @ 1,300 Lcd	13.9	15.6	17.2	13.3	14.0	14.7

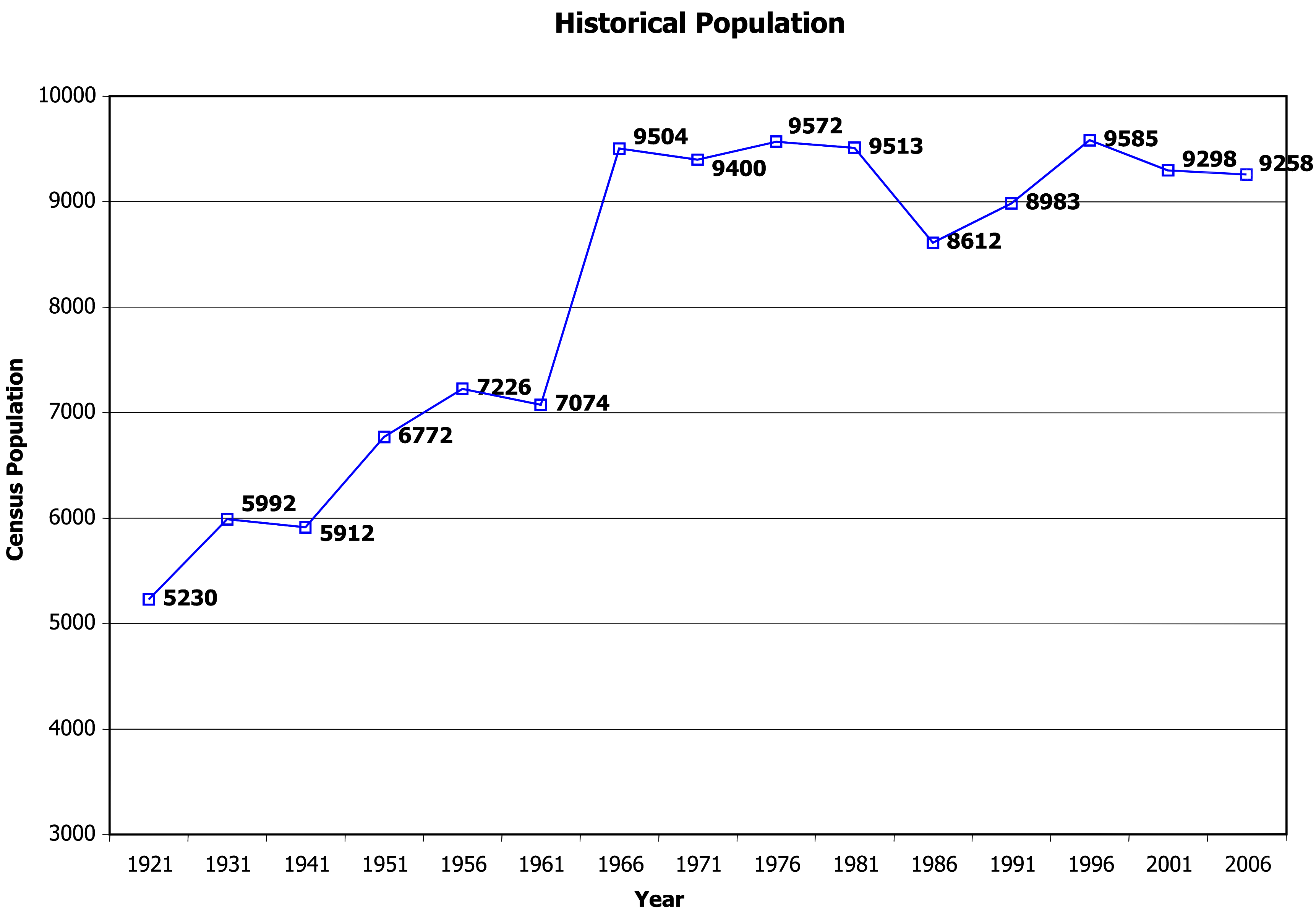
Table 3.3 presents the forecast water demands at each 10-year horizon and under each of the two growth scenarios. When the reliability of source is being considered, the long-term requirement is the prudent choice. The relevant winter and summer demands are:

Winter:	30-year @ 11,300 population (0.5%/year growth):	7.5 ML/d
	30-year @ 13,200 population (1.0%/year growth):	8.7 ML/d
Summer:	30-year @ 11,300 population (0.5%/year growth):	14.7 ML/d
	30-year @ 13,200 population (1.0%/year growth):	17.2 ML/d

The “build-out” horizon within the existing City boundaries is approximately 15,000 people. This would provide a population density in line with the City’s Official Community Plan. Growth rate at 1% per year would hit the 15,000 population in 2050. Growth rate at 0.5% per year would hit a 15,000 population at the end of the century.

The forecast demands show that in selecting one or more sources of water, the sources should be able to deliver the “build-out” requirement. Rounding off the projected demands, the long-term requirements for Maximum Day Demand are:

Winter:	**10 ML/d**
Summer:	**20 ML/d**



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City of Nelson
Water Master Plan

Historical Population

NTS

Figure 3.1

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4.0 AVAILABLE WATER SOURCES

4.1 Developed and Undeveloped Sources

The City of Nelson currently has Water Licenses in four creeks in the region. It has constructed intakes and supply mains on three of these creeks. Table 4.1 presents a summary of the Licensed creeks, the licensed amount, the watershed drainage area and the recorded winter and summer low flows (obtained from the Water Survey of Canada, Water Resources Branch).

Five Mile Creek has been the historical primary source of water for the City. The drainage basin is relatively large (over 47 km^2) and well protected as a Provincial Park. Water quality is good and the yield has been consistent.

The other two creeks (Anderson and Selous) are used as supplementary sources only when required. Both creeks have smaller watersheds and are reported to have prolonged periods of higher turbidity than Five Mile Creek. Neither of these supplementary creeks have any sedimentation facility.

Fell Creek is licensed but not developed. Its watershed, at 4.4 km^2, is not significant.

A search of potential additional sources in the region reveals the following:

a) Clearwater Creek
b) Apex Creek
c) Grohman Creek
d) Kootenay Lake
e) Groundwater

Table 4.1 presents a summary of the historical data on the potential additional creeks. Kootenay Lake is not included since its yield is substantially larger than any source. Groundwater potential is discussed in a later section.

Table 4.1 Water Master Plan Summary of Creek Sources – Recorded Yields							
Source	**Drainage Area (km^2)**	**Licensed to City (ML/d)**	**Winter Low Flows (ML/d)**		**Summer Low Flows (ML/d)**		**Years of Record**
			Mean	**Extreme**	**Mean**	**Extreme**	
Licensed							
Anderson	9.1	6.8	2.16	0.69	3.20	1.47	31
Fell	4.4	6.8	1.21	0.26	2.16	0.69	31
Five Mile	47.5	16.8	13.13	6.22	37.50	19.70	8
Selous	14.5	4.5	4.92	1.12	7.43	2.51	12
Not Licensed							
Clearwater	49.7	---	25.90	14.17	60.83	58.49	3
Grohman	80.8	---	39.83	19.61	50.28	34.21	4
Apex	21.8	---	19.00	12.1	34.8	26.9	3

4.2 Regional Analysis of Low Flow Projections

Creek flows vary from year to year and long-term planning must take into account drought years and their return frequency.

Typical return frequencies used for water system planning use the probability of a drought event with the following frequencies:

1-year Low: Probable low flow on any given year; generally not used as criterion for a primary source.

5-year Low: Probable low flow once in 5 years; still too risky for a primary source.

25-year Low: A low flow occurrence once in 25 years. This is typically used as a relatively low risk criterion.

50-year Low: The probability of occurrence once in 50 years makes this a very low risk criterion.

Climate change has been impacting flows in upland creeks over the past 20 years. Steadily decreasing snowpacks and warmer, drier summers have been observed over this period.

In the case of creeks in the Nelson area, flows are typically lowest in late fall/winter. Hydrologists forecast that watersheds will continue producing lower creek flows and yields as much as 10% below current averages could be possible over the next 20 years.

Theoretical yield curves for the creeks being considered were developed on the basis of relative watershed drainage areas. The curves were derived from creeks which have extended periods of flow gauging (10 or more years). Figure 4.1 presents the regional analysis curves.

Using the curves developed for watershed yield based on size ($m^3/s/km^2$), Table 4.2 presents the projected yield of the various creeks under consideration on the basis of return frequency.

Table 4.2
Water Master Plan
Theoretical Predicted Yields of Creek Sources

	Drainage Area km^2	1-Year Low (ML/d)		5-Year Low (ML/d)		25-Year Low Estimated (ML/d)		50-Year Low (ML/d)	
		Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Anderson	9.1	11.8	5.2	0.8	1.9	0.7	1.8	0.6	1.6
Fell	4.4	---	---	---	---	---	---	---	---
Five Mile	47.5	13.8	51.8	6.9	22.5	6.0	16.5	4.1	10.4
Selous	14.5	3.5	16.4	1.0	3.1	0.8	2.0	0.5	1.6
Clearwater	49.7	16.8	55.8	7.7	23.6	6.5	17.6	4.3	11.6
Grohman	80.8	27.9	104.7	14.0	38.4	11.2	30.0	8.4	21.6
Apex	21.8	5.6	18.8	2.6	7.5	2.0	5.5	1.4	3.4

4.3 Primary Source

Nelson's primary water source has historically been Five Mile Creek, and there are good reasons to retain this as the primary source.

The condition of the supply pipeline is a major consideration, since it has been in service for almost 80 years. Accordingly, Levelton Consultants Ltd. was engaged to undertake an extensive analysis of corrosion in the pipeline and its expected remaining life. An Executive Summary of their report can be found in Appendix A.

Levelton's conclusions on the basis of pipe samples and soils analysis is that the pipe is in "good to very good condition" and "should continue to provide satisfactory service for the foreseeable future".

The competency of the supply pipeline, which consists of roughly 7,000 metres over rugged terrain, is a major factor in choosing to retain Five Mile Creek as the primary source of water for Nelson.

Other factors include:

- Consistently good quality water.
- Gravity supply incurs no pumping costs.
- The watershed is well protected as a Provincial Park.

4.4 Five Mile Creek Shortcomings

The main shortcomings of Five Mile Creek are:

- The diversion License is limited to 16.8 ML/d, which falls short of the projected long-term demand.
- The Creek's predicted yields in fall/winter seasons fall short of demand as follows:

Demand in 2016 ML/d - Winter	5-year Low ML/d	25-year Low ML/d	50-year Low ML/d
7.1	6.9	6.0	4.1

- The supply pipeline size limits the maximum flow to 11.4 ML/d, while the forecast summer demand reaches 13.9 ML/d as early as 2016. The joint style in the supply main precludes utilizing higher pressures for additional capacity.
- Climate change may further reduce the creek's yield.
- There is risk of landslides along the pipe route, damage of the pipe and consequent loss of service.
- There is risk of forest fires in the watershed and possible application of fire retardants which may contaminate the water.
- The Deverney report forecasts that it is probable that Lodgepole Pine trees in the watershed will be killed by Mountain Pine Beetle within the next five years.
- The loss of mature timber may not be a concern for low season runoff. However, the loss can result in increases in peak runoff flows and heavier sediment load in the creek.
- Pine Beetle kill may result in greater fire risk as recently killed trees remain standing and increase the abundance of fine dry fuels (branches and needles).

Therefore, while Five Mile Creek is an excellent primary source of supply, consideration must be given to developing an appropriate supplementary source.

4.5 The Requirements of a Supplementary Source

A secondary source of water must have the ability to fulfil a number of functions. Among those are:

a) Supply the primary source shortfall during drought years. In the case of Five Mile Creek, the calculated shortfall is shown on Table 4.3:

Table 4.3 Surplus/Shortfall Estimates Five Mile Creek			
	ML/d	Demand ML/d	Surplus (Shortfall) ML/d
5-Year Low			
Winter	6.9	10	(3.1)
Summer	22.5 (11.4)*	20	2.5 (8.6)
25-Year Low			
Winter	6.0	10	(4.0)
Summer	16.5 (11.4)*	20	(3.5) (8.6)
50-Year Low			
Winter	4.1	10	(5.9)
Summer	10.4 (11.4)*	20	(9.6) (8.6)

* 11.4 ML/d is the hydraulic capacity of the supply pipe.

The secondary source must supply roughly **4.0 ML/d** in winter and **9.0 ML/d** in summer to make up the shortfall during a 25-year drought event.

b) Supply the "total" demand in the case of catastrophic loss of the primary source. In the case of the Five Mile Creek supply, this could occur with a landslide, and source contamination from forest fire or vandalism.

Provision of Summer Day Demand during emergency conditions is a significant expectation for a secondary facility. The more common design for this event is to provide the "inside use" demand only, and issue a total sprinkling ban during the emergency event. In this case the supply capacity should be up to **10 ML/d** (winter demand).

c) The secondary source water should be available for all of Zones 1 through 4 in the system. In this case the water should be directed to Mountain Station as the City's main hydraulic start point for all four zones.

The distribution network is configured with the largest pipes at the top end of supply, so feeding secondary water in from the lower zones would not be effective.

d) The water quality must be capable of meeting the Provincial quality criteria.

4.6 Discussion of Secondary Source Options

4.6.1 Kootenay Lake

Kootenay Lake meets the criteria described in a) to c) above. In order to determine whether water quality is suitable, a one-year sampling program was developed. The results are presented in Appendix B and discussed in Chapter 5.

4.6.2 Anderson and Selous Creeks

These two creeks are already developed as secondary sources, although they feed in to the system at different locations. If they were to be used, they would need to be piped to the central location at Mountain Station for treatment.

Given that their contribution during drought conditions would be relatively small because of their small catchment areas (9.1 and 14.5 km^2), they cannot provide the required shortfall flow (4 ML/d winter and 9 ML/d summer). Neither can they satisfy criterion (b), 10 ML/d in case of total loss of Five Mile. Their water quality is reportedly poorer than Five Mile Creek, but capable of meeting targets with filtration. Therefore, these will only be considered as adjuncts to other secondary sources if they can be conveniently added.

4.6.3 Grohman Creek

Grohman Creek has a large watershed (almost twice the size of Five Mile Creek), and it can meet criteria a) through c). Little is known of Grohman Creek's water quality, but it can be anticipated that it would be capable of meeting IHA targets with filtration.

The significant shortcoming of Grohman Creek is its location on the north side of Kootenay Lake. Integrating this source would involve a Lake crossing and transmission main through developed downstream streets in Nelson. Nevertheless, it is a gravity source within a large watershed and should be considered.

4.6.4 Clearwater Creek

Clearwater Creek is within a similarly sized watershed to Five Mile Creek. While its aspect is more westerly, it can be considered to have similar yield to Five Mile Creek. In the 25-year drought event, its winter production is estimated at 6.5 ML/d and summer production is 17.6 ML/d. In both cases, it can meet the estimated shortfall in Table 4.3. It cannot meet the winter demand on its own (10 ML/d) should there be a total loss of Five Mile Creek, criterion (b).

Clearwater Creek is a gravity source and its intake would be higher than Mountain Station, meeting criterion (c). Its water quality has not been monitored, but is anticipated to be similar to Five Mile Creek.

If Clearwater Creek is to be considered, it should be in the context of connecting both Selous Creek and Apex Creek to the supply main. In that instance, the 25-year drought flow could be increased to 9.3 ML/d in winter. The 25-year flow from the three sources could also meet criterion (b), i.e., replace total loss of Five Mile Creek.

The option of using Clearwater Creek would therefore be combined with the use of Apex and Selous Creeks.

4.6.5 Groundwater

Groundwater availability in the area has not been extensively investigated. BC Water Resources records a total of 26 mapped well locations ranging from test wells to irrigation wells. Only six of these have recorded well productivity, the highest being 30 US gmp (0.16 ML/d). Figure 4.2 shows the well locations and Figure 4.3 shows recorded yields in some wells.

A 1971 report by Pacific Hydrology Consultants Ltd. indicated potential for "moderate" yield aquifers in the Cottonwood Creek fan and the Anderson Creek fan near the Kootenay Lake shoreline. Both of these fans contain old industrial sites and groundwater quality would be suspect.

The report also indicates potential in the area of upper Cottonwood with a possible well yield of up to 1 ML/d.

The overall yield is not likely to provide the shortfall, criterion c), nor criterion b), unless a well-field were developed. Since groundwater quality is also unknown, this does not present a good option to pursue as a secondary source.

Testing, however, could be undertaken, and groundwater could be added as a adjunct to the Clearwater Creek option.

4.6.6 Summary of Potential Secondary Source Options

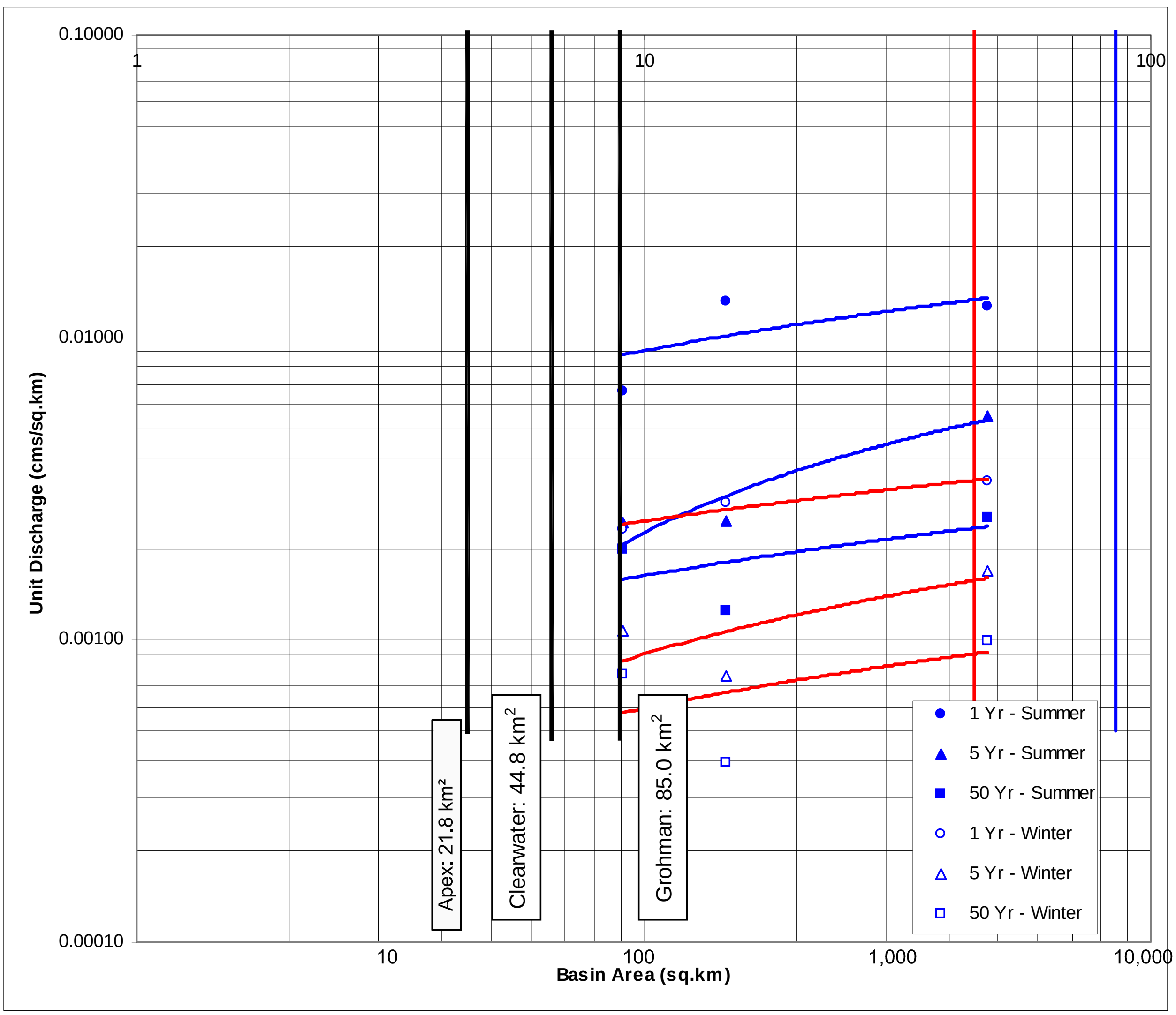
The following options are selected for further costing and analysis:

1. Kootenay Lake
2. Grohman Creek
3. Clearwater, Apex, Selous Creeks

Regional Analysis

08NJ Regime

Drainage Basin	Drainage Basin Area km²	Unit Discharge - m³/s/km² 1 Yr	Unit Discharge - m³/s/km² 5 Yr	Unit Discharge - m³/s/km² 50 Yr	Discharge - m³/s 1 Yr	Discharge - m³/s 5 Yr	Discharge - m³/s 50 Yr
		Monthly Mean For August					
Anderson Creek	9.1	0.00662	0.00243	0.00198	0.0600	0.0220	0.0180
Selous Creek	14.5	0.01310	0.00248	0.00124	0.1900	0.0360	0.0180
Five Mile Creek	47.5	0.01263	0.00547	0.00253	0.600	0.260	0.120
		Annual Low-Flow (Usually Winter)					
Anderson Creek	9.1	0.00232	0.00107	0.00077	0.0210	0.0097	0.0070
Selous Creek	14.5	0.00283	0.00076	0.00039	0.0410	0.0110	0.0057
Five Mile Creek	47.5	0.00337	0.00168	0.00099	0.160	0.080	0.047



Regional Analysis - Creek Flows

Figure 4.1

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5.0 WATER QUALITY AND TREATMENT

5.1 The Drinking Water Protection Act

The Drinking Water Protection Act (DWPA), assented to on April 11, 2001 is the legislation that governs drinking water supplies, both surface sources and groundwater.

The Water Act of 1996 governs the approval of Licenses for the diversion of surface water for utilities.

The DWPA is directed at safeguarding public health and concerns itself with source water quality, risk assessment, response planning and protection planning.

Water quality standards for "potable" water are given in the Drinking Water Protection Regulation deposited May 16, 2003.

The Regulation provides a standard for Fecal Coliform bacteria, Escherichia Coli, and Total Coliform bacteria.

Chemical constituents in source water are recommended in the Guidelines for Canadian Drinking Water Quality (GCDWQ) issued by Health Canada. These are not standards in British Columbia, but are often suggested as desirable guideline parameters.

Source waters for water utilities are assessed and approved on the basis of sufficient quantity and acceptable quality.

5.2 Surface Water Licensing

The procedure for obtaining a License to direct or store water is outlined in the Water Act (1996).

The procedure requires the applicant to research other existing licenses, conduct a hydrology study to confirm the availability of water, and submit yield scenarios under a variety of drought conditions. "Moderate" drought is considered to be a period of low stream flow with an average frequency of once in 25 years.

Activities in the watershed (logging, mining, etc.) must be documented and the Comptroller may request a Watershed Management Plan if the risks to water quality are felt to be unduly high.

The Interior of British Columbia is covered by Interior Health with respect to water quality. Interior Health bases its reviews and decisions on the Drinking Water Protection Act (DWPA) and the accompanying Regulations.

5.3 Interior Health Authority Directives

In addition to the Act's bacteriological provisions, Interior Health has set forth target levels for protozoan microbes and viruses, established as endemic in Interior surface waters and therefore a risk to consumers. Interior Health has issued a 4-3-2-1-0 directive, which requires the following approach to treating surface waters:

4-log Virus inactivation (99.99%)
3-log Giardia cyst and Cryptosporidium inactivation (99.9%)
2 – Double barriers for breakthrough of micro-organisms
1 – Turbidity to be no more than 1.0 NTU
0 – Coliform Bacteria to be zero

These targets require a minimum of disinfection of all surface waters, and will often require filtration to reduce turbidity to acceptable levels.

5.4 Groundwater

The use of groundwater as a source for a water utility is governed by the Ground Water Protection Regulation in effect November 1, 2005. The Regulation (BC Reg. 299/2004) falls under the umbrella of the Water Act.

The key provisions of the Regulation are that:

a) All groundwater wells must be drilled by registered qualified well drillers.
b) All well pump installations must be undertaken by registered qualified well pump installers.

The requirements for registration with the Comptroller's office are provided in the Regulation.

A groundwater protection protocol must be followed in every installation and that protocol includes:

- Surface sealing
- Well identification
- Well caps and well covers
- Floodproofing
- Protection of wellhead

The deactivation or closure of a well must also follow the requirements of the Regulation and a closure report submitted to the Comptroller's office. Appendix A of the Regulation provides the Code of Practice for Construction, Testing, Maintenance and Closure of Wells in British Columbia.

Groundwater quality must meet Interior Health targets. Wells are classified as GUDI, Groundwater Under the Direct Influence (of surface water), or confined aquifer wells. GUDI wells are treated as surface water since there is a risk of entry of contaminated surface water into the well. Wells in a confined aquifer may not require disinfection if the depth and extent of the confining layer is sufficient to prevent entry of surficial water and microbes. The classification must be performed by a BC Registered Hydrogeologist.

Wells developed at a capacity greater than 75 L/s are subject to an Environmental Impact Assessment procedure in accordance with federal government guidelines.

5.5 Source to Tap

The Ministry of Health has adopted a "source-to-tap" approach in the DWPA and has appointed Drinking Water Officers (DWO's) to cover all regions of the Province. The DWO's have broad discretionary powers and must review and approve all water utilities.

5.6 Disinfection and Filtration

The term "disinfection" refers to inactivation of micro-organisms by means of adding an oxidant such as chlorine or ozone. Disinfection can also be achieved by ultra-violet light which destroys the micro-organism's ability to reproduce. Disinfection does nothing for particle removal and is directed solely at inactivating micro-organisms.

Filtration achieves particle removal, and, since many micro-organisms are small particles, filtration plays a role in disinfection. The "effectiveness" of micro-organism reduction is expressed in terms of "log credits".

Log removals refer to percentages of removals of a variety of micro-organisms ranging from bacteria and viruses (the smallest) to Cryptosporidium and Giardia cysts (the largest). Log removals refer to the following percentages:

1-log:	90%
2-log:	99.0%
3-log:	99.9%
4-log:	99.99%

Table 5.1 provides a summary of the Log removal credits for a variety of filtration and disinfection processes (from US EPA).

Table 5.1
Log Removals of Filtration and Disinfection

	Bacteria	Viruses	Giardia	Cryptosporidium
Filtration				
• Conventional	2.0	2.0	2.5	1.5
• Direct	1.0	1.0	2.0	1.0
• Slow Sand	2.0	2.0	2.0	2.0
• Diatomaceous Earth	2.0	1.0	2.0	2.0
• Membrane	3.0	3.0	4.0	3.0
Disinfection				
• Chlorination	4.0	4.0	3.0	---
• Ultra-Violet	2.0	1.0	4.0	3.0
• Ozonation	4.0	4.0	4.0	3.0
• Chlorine Dioxide	3.0	2.0	2.0	---

5.7 Disinfection Techniques – Primary Disinfection

5.7.1 Chlorination or Chlorine Dioxide

Disinfection by Chlorine or Chlorine Dioxide does not inactive Cryptosporidium Parvum. While chlorination can be sufficient for 3-log Giardia inactivation, increases in consumption would reduce contact time values and very high chlorine dosages would be required to compensate. Therefore, for primary disinfection, chlorination is not a viable technique.

5.7.2 Ozonation

Ozone gas is a very powerful disinfectant and would provide sufficient protection for the required inactivation levels. Ozone gas is such an active oxidant that it cannot be stored and must be manufactured on-site by means of an ozone generator.

Required CT values for 3-log removal by Ozone contact are relatively small, ranging from 1 to 4 depending on temperature. That is, at a dosage of 1 mg/L, a nominal contact time of 1 to 4 minutes is required. This can easily be achieved by injection in the pipe at the treatment facility.

Ozonation can produce by-products such as Aldehydes and Ketones, depending on reactive constituents already in the water. The impact of these by-products on human health is not known; however Ozone is widely used throughout the world. The impact of chlorination by-products has been more extensively studied and guidelines are in place for maximum acceptable concentrations. No such guideline exists for Ozonation by-products.

5.7.3 Ultra-Violet Light

Irradiation with Ultra-Violet light has, in more recent years, been proven to inactivate both Giardia and Cryptosporidium, as well as Bacteria and Viruses. Provided the source water has a UV transmittance of 90% or higher, UV disinfection can achieve the required log removals.

Regulations governing UV radiation were finalized by US EPA in November 2006. The following is an excerpt from the Guidance Manual:

Unlike chemical disinfectants, UV leaves no residual that can be monitored to determine UV dose and inactivation credit. The UV dose depends on the UV intensity (measured by UV sensors), the flow rate, and the UV transmittance (UVT). A relationship between the required UV dose and these parameters must be established and then monitored at the water treatment plant to ensure sufficient disinfection of microbial pathogens.

Table 1.4. UV Dose Requirements - millijoules per centimeter squared (mJ/cm^2)

Target Pathogens	Log Inactivation							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	15	22
Giardia	1.5	2.1	3.0	5.2	7.7	11	15	22
Virus	39	58	79	100	121	143	163	186

The UV dose requirements in Table 1.4 account for uncertainty in the UV dose-response relationships of the target pathogens but do not address other significant sources of uncertainty in full-scale UV disinfection applications. These other sources of uncertainty are due to the hydraulic effects of the UV installation, the UV reactor equipment (e.g., UV sensors), and the monitoring approach.

The most common system of UV contactors commercially available provide an output dosage of 40 mJ/cm^2. This level of output is certainly sufficient for the required 3-log Giardia and 3-log Cryptosporidium inactivation.

The effectiveness of UV light depends largely of the water's UV Transmittance (UVT). The samples in Five Mile Creek indicate excellent UVT. However, UVT can change seasonally and continued sampling is recommended.

It can be seen from the US EPA Draft Guide that viruses are not easily inactivated by UV light, requiring high dosages even for 2-log credit. Viruses and bacteria must therefore be dealt with by Chlorination.

5.8 Secondary Disinfection

A free chlorine residual (minimum 0.2 mg/L) is required to prevent growth of bacteria in the pipe network. Therefore, secondary disinfection with a low chlorine dosage is always required.

5.9 Filtration and Filtration Avoidance

Filtration often represents the greatest component of cost in water treatment. The US EPA (Environmental Protection Agency) provides guidelines for avoidance of filtration under conditions when disinfection alone can deal with micro-organisms.

In brief terms, these conditions can be stated as follows:

- ***Instantaneous Turbidity should not exceed 1.0 NTU for more than 1% of samples.***
- ***Average daily Turbidity at the source (raw water) is not to exceed 5.0 NTU for more than 2 days/year.***
- ***Source water Total Coliform count must be less than 100 per 100 mL in 90% of samples.***
- ***Watershed is protected from human activities and grazing.***

Figure 5.1 presents the results of Turbidity sampling at Mountain Station (Five Mile Creek) and at Kootenay Lake over the period March 2006 to October 2006. In both cases, Turbidity is below 1 NTU from June through September. However, it is greater than 1 NTU from April through May. Previous grab sampling also indicated higher than 1.0 NTU samples during February and March.

None of Nelson's source water options meets the foregoing criteria for filtration avoidance. It is therefore unlikely that a case could be made for avoidance of filtration.

5.10 Meeting IHA Targets

The IHA targets of 4-3-2-1-0 cannot be fully met without implementing both filtration and disinfection on both the primary and secondary sources under consideration. The requirement for two sources to meet the demand, and the requirement for filtration poses the question of utilizing two filtration plants to achieve the objectives.

A brief comparison of utilizing one plant versus two plants follows:

5.10.1 Benefits of Two Plants

- Potential reduction of raw water transmission lengths.
- Facilitates different filtration techniques for different sources.
- Can substitute in case of vandalism or catastrophic malfunction at other plant.

5.10.2 Benefits of Single Plant

- Only a single site is required (lower costs).
- Construction costs for a single facility are lower.
- Infrastructure costs (power and other utilities to site) are lower.
- Operation and maintenance costs are lower.
- Avoids "start up/shut down" procedures for secondary plant since the secondary source may only be used on a periodic basis.
- Reduces the cost of treating and disposing of residuals (sludge).

It is evident that there are many more advantages to utilizing a single filtration plant and this will be used as the preferred option.

5.11 Initial Overview of Filtration Options

5.11.1 Conventional Media Filtration

The most widely used form of filtration for municipal water suppliers is conventional rapid sand filtration. Conventional filtration includes several steps:

a) Application and mixing of a coagulant (usually an Iron or Aluminum - based salt).
b) Coagulation and Flocculation – formations of an easily filterable “floc”.
c) Sedimentation – gravity settling of larger flocs.
d) Filtration – most often carried out with dual media beds of coal and sand.

A variation on conventional media filtration leaves out step (c) Sedimentation when source water Turbidity is consistently below 5 NTU. This is referred to as “Direct Filtration”. Both capital and operating costs can be reduced by the use of Direct Filtration, and piloting should be used to confirm that Direct Filtration will achieve the desired quality.

Table 5.1 indicates that Conventional Filtration is credited with 2.0 log removal of Cryptosporidium and Direct Filtration with 1.0 log removal of Cryptosporidium.

In order to achieve the required IHA targets, Ozone or UV must be employed for disinfection and further micro-organism removals.

5.11.2 Slow Sand Filtration

Slow Sand Filtration has an even longer history of usage than Conventional Filtration. Slow Sand Filtration does not utilize coagulants; the very fine sand employed acts as a biological filter and thereby inactivates micro-organisms.

Hydraulic loading rates on slow sand filters are extremely low in order to enable biological activity. This means that filter surface areas must be large. In the case of Nelson, a design flow of 15 ML/d would require a filter surface area of almost 6,000 m². In mild climates, the filter surface area can be achieved without a superstructure. In Nelson’s case a 6,000 m² filter building would make the plant cost prohibitive.

Slow Sand Filtration will therefore not be considered further.

5.11.3 Diatomaceous Earth

This is sometimes known as "pre-coat" filtration. Diatomaceous earth is a fine powder mined in numerous locations world-wide. The diatoms have the ability to attract particles in the water and bond to DE to form a slurry. This "slurry" is then sieved on a rotating belt. The cake on the belt contains the water's impurities and the permeate is the clean finished water.

DE processes have been used for many years in breweries, wineries and bottling plants where ultra-clean water is required. It is popular for small water systems due to its automated operation and low maintenance. The "cake" can be disposed of to landfill. DE has not been widely used in larger municipal plants because of the large quantities of DE "cake" requiring disposal.

5.11.4 Membrane Filtration

Membrane Filtration is a relatively simple process which consists of filtering raw water through a manufactured membrane with extremely small pores (usually less than 0.1 micron). All particles, including microbes, larger than the membrane pores, are trapped on the membrane.

Small pore size results in trapping of very fine silt and clay particles and the membranes must be backwashed at very frequent intervals to avoid plugging. Typical backwash intervals are 20 – 40 minutes; some manufacturers employ a continuous backwash. The backwash water can be disposed of to a surface drainage course, ditch, or rock soakaway. Membrane filtration requires a relatively small footprint, but inlet water pressure requirements are relatively high. An alternative form of membrane filtration utilizes a reverse flow pattern with vacuum pumps drawing from the water through the fibres.

5.12 Best Apparent Options

The initial overview reveals the following best apparent options for filtration and disinfection that merit more detailed evaluation:

a) Direct Filtration plus UV Disinfection, plus chlorination for secondary disinfection.

b) Membrane Filtration, plus chlorination for secondary disinfection.

In both cases, chlorination is required at the end of the process to ensure a minimum chlorine residual in the distribution network.

5.13 Facility Siting Options

It has been established that a single site is preferable to two sites with two filtration facilities.

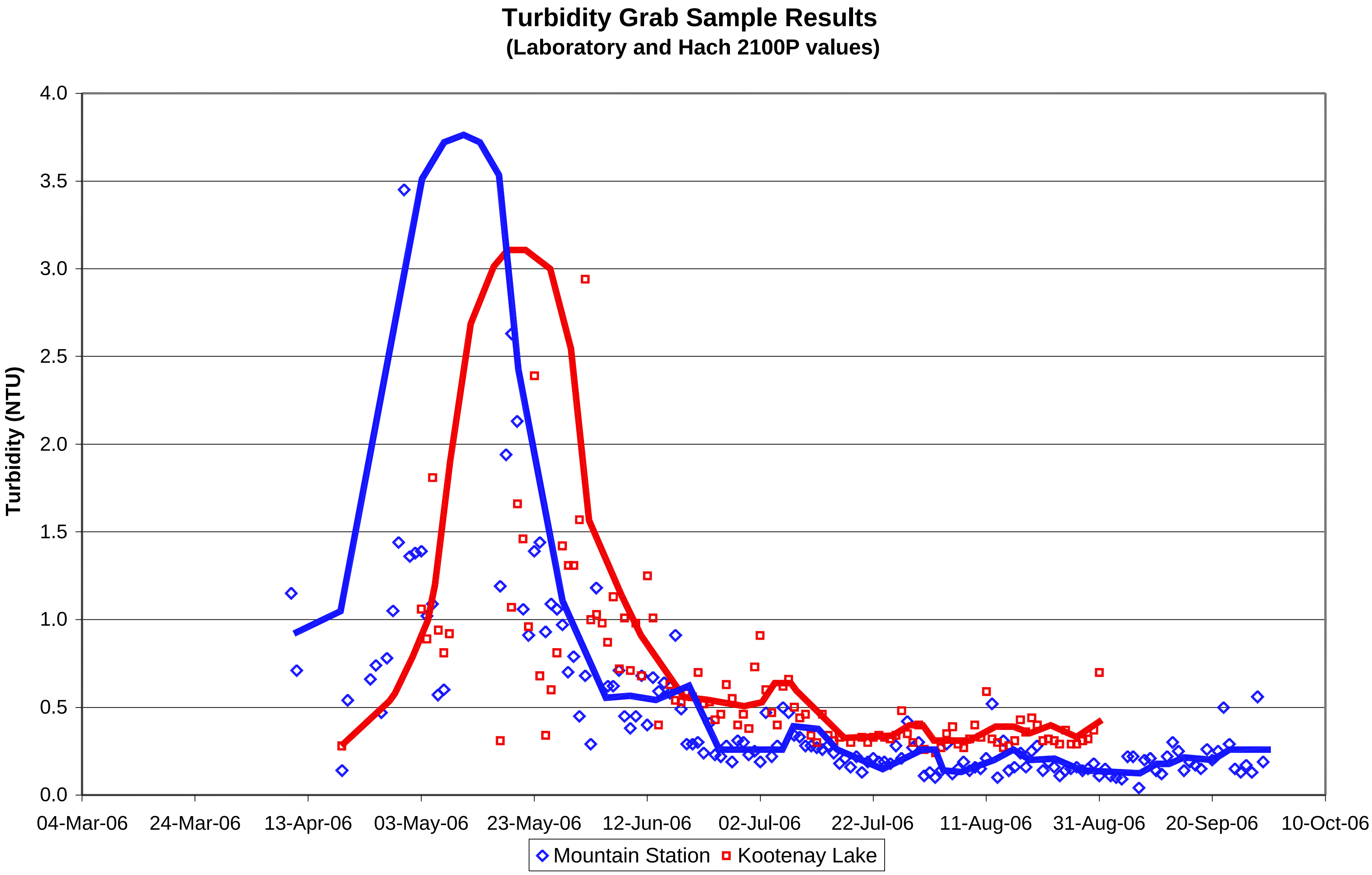
There are several siting options at the lakeshore, in the Fairview area on City-owned land, and at the Mountain Station site.

Given that Five Mile Creek will remain as the primary source of municipal water and it is currently directed to a sedimentation pond and chlorination facility, this site represents the least costly to develop for a filtration facility.

The site's elevation at 800m ASL (above Sea Level) also represents the best location to supply adequate pressure to all zones in the City. Sites at lower elevations would require pumping of filtered water to service the higher zones.

Since the City owns sufficient land at Mountain Station for construction of a filtration facility, this site will be adopted as the longer-term preferred site for treatment.

Figure 5.2 depicts the Mountain Station site and a potential allocation for a filtration facility.



Note: Trendlines drawn to roughly fit moving average trendline.

URBANSYSTEMS

City of Nelson
Water Master Plan

Turbidity Grab Sample Results

NTS

Figure 5.1

0795.0077.01

City of Nelson
Water Master Plan

1:600

Mountain Station Site
WTP Layout

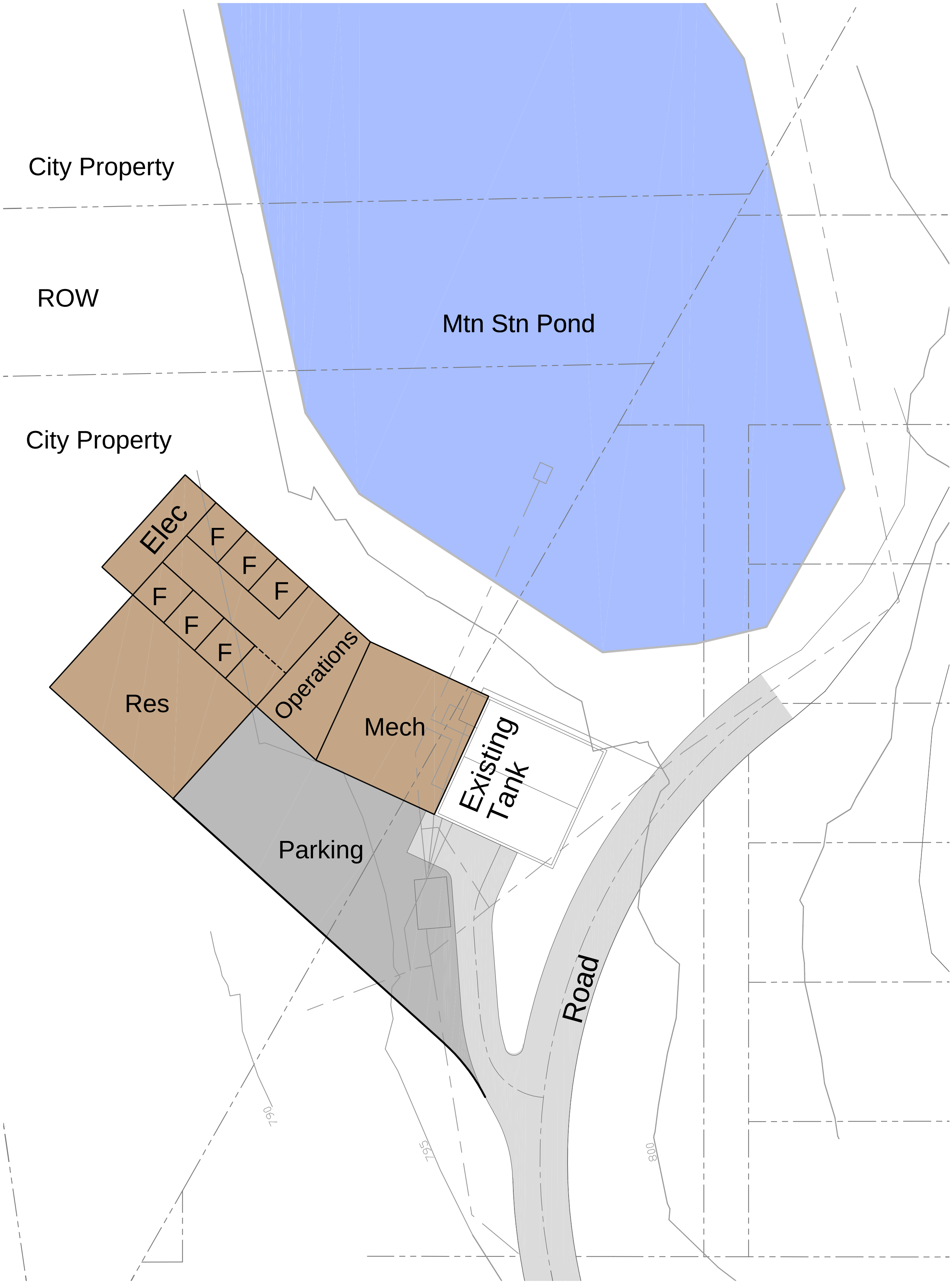


Figure 5.2

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6.0 SOURCE AND TREATMENT COMPARISONS

6.1 Selected Shortlist of Options

Chapter 4 concluded that Five Mile Creek is Nelson's best primary source for numerous reasons.

Identified secondary or supplementary sources identified for further consideration and cost comparison were:

A. Kootenay Lake

B. Grohman Creek

C. Clearwater Creek (with connection of Selous and Apex Creeks, and/or groundwater).

Figure 6.1 depicts these primary/secondary option configurations graphically.

Figures 6.2, 6.3 and 6.4 depict the profiles and relative elevations applicable to each respective option.

Table 6.1 presents the estimated capital construction costs of each option. Table 6.2 presents the estimated annual maintenance and operation costs of each option.

Table 6.1 Capital Construction Cost Estimates			
Item	**Five Mile & Kootenay Lake (a)**	**Five Mile & Grohman (b)**	**Five Mile & Clearwater (c)**
1. Intake Structure & Screen	$200,000	$400,000	$300,000
2. 300mmØ main on BNR Trail – 10 km $470	---	---	4,700,000
3. Settling Pond – Grohman Creek	---	1,800,000	---
4. 300mmØ supply main from Grohman - 6 km @ $880/m	---	5,280,000	---
5. Marine Intake – 700m @ $1,000/m	700,000	---	---
6. Lake Crossing		700,000	---
7. PRV @ Selous and Interconnection	---	---	300,000
8. 450mmØ main on BNR Trail to Mountain Station 2 km @ $600/m	---	---	1,200,000
9. Grohman supply through downtown 3 km @ $900/m	---	2,700,000	---
10. High lift pumphouse at Lakeshore	1,500,000	---	---
11. Forcemain: 6th Street to Mountain Station, 2,100m @ $880/m	1,848,000	---	---
12. Booster station	800,000	---	---
13. WTP @ Mountain Station – 15 ML/d[1]	12,000,000	10,000,000	10,000,000
14. Additional Finished Water Storage	1,500,000	1,500,000	1,500,000
Subtotals	$18,548,000	$22,380,000	$18,000,000
E & C (40%)	$7,420,000	$8,950,000	$7,200,000
Total Capital	$25,968,000	$31,330,000	$25,200,000

Note [1]:

Water Treatment Plant Costs

- First phase sized for 15 ML/d (25% over current MDD).
- $2 M added for Kootenay Lake – treatment for algae if necessary.
- Based on Direct Filtration plus UV.

Table 6.2 Operation and Maintenance Cost Estimates			
Item	**Five Mile & Kootenay Lake (a)**	**Five Mile & Grohman (b)**	**Five Mile & Clearwater (c)**
1. Power – Pumping[1]	$75,000	---	---
2. Power - WTP	26,000	18,000	18,000
3. Labour	250,000	230,000	230,000
4. Chemical	80,000	80,000	80,000
5. Testing	30,000	30,000	30,000
6. Consumables	30,000	30,000	30,000
7. Vehicle	25,000	25,000	25,000
8. Parts/Repairs	50,000	40,000	40,000
Total Annual	$566,000	$453,000	$453,000

Note [1]:
The Kootenay Lake annual pumping cost is derived as follows:

Static Head:	Lake:	530m
	Mountain Station:	800m
	S.H.:	300m
Flow Rate:	½ of MDD:	0.5 x 20 ML/d = 10 ML/d = 116 L/s
Friction Head:	.5/100m x 2,100 = 10.5 m	
Power Requirement:	700 HP = 522 kW	

Usage Period Assumptions:

a) Summer demand exceeds 5-mile supply – 20 days.
b) Winter – 5-mile low flow: 60 days.

Maximum usage per year: 80 d x 24 hr x 522 kW = 1,002,240 kW-hrs

Annual cost at $0.075/kW-hr: **$75,168/year**.

6.2 Discussion of Advantages and Disadvantages

Kootenay Lake

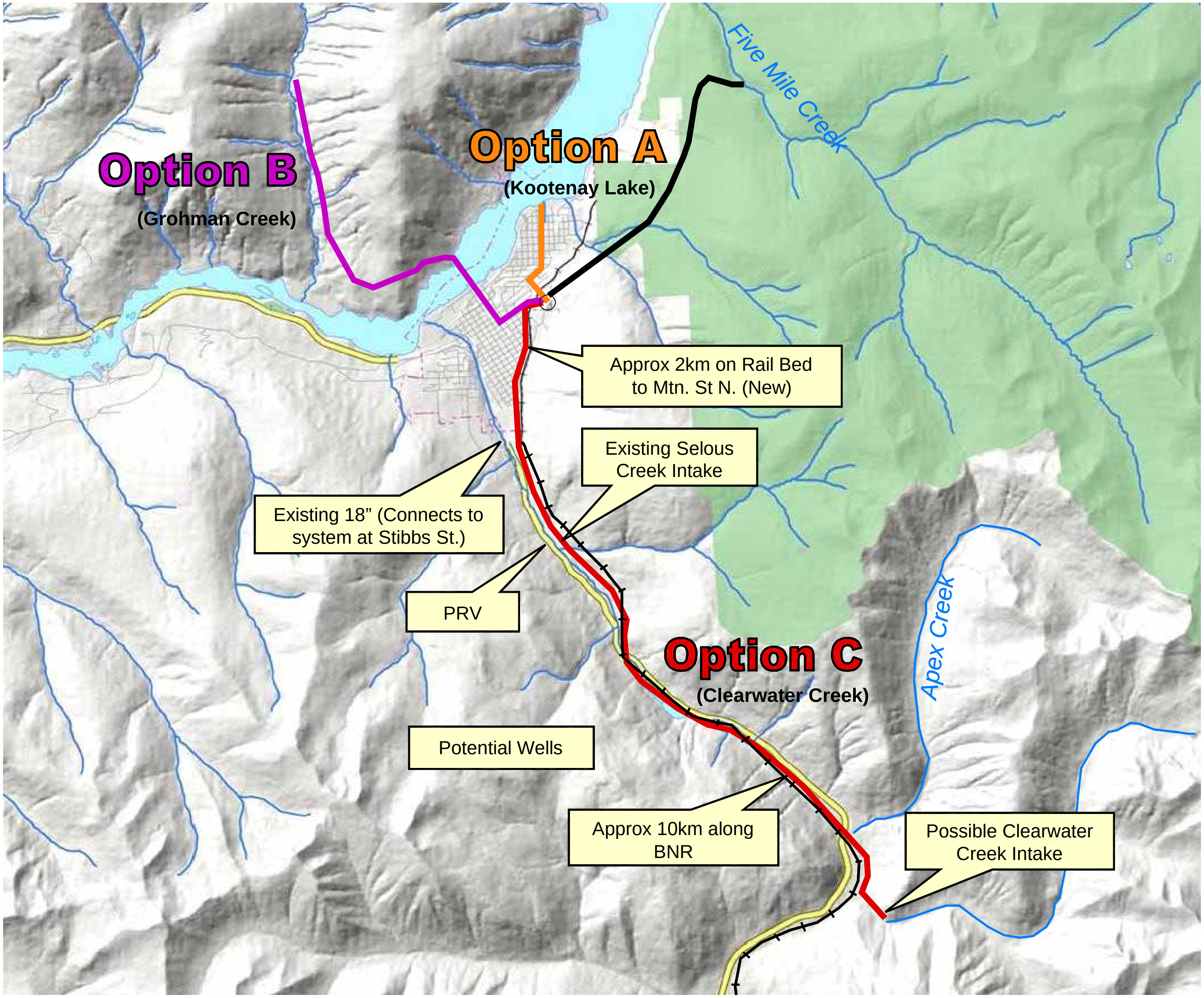
Advantages	*Disadvantages*
• Virtually unlimited supply • Not subject to forest fire danger • Not affected by climate change • Relatively good quality water	• Pumping costs are high ($74,000 per year) • Subject to algae blooms – increased treatment costs • Watershed management is beyond control of City – railway, cottages, etc. • Cannot feed into the system from Zone 4

Clearwater Creek

Advantages	*Disadvantages*
• Gravity supply • Water chemistry likely similar to Five Mile • Potential for adding Selous, Apex and groundwater to supply main • Potential for power generation	• Supply may be marginal during drought years • Watershed subject to forest fire risk • Other stakeholders are involved

Grohman Creek

Advantages	*Disadvantages*
• Largest watershed • Gravity supply • Separate from other watersheds • Potential for power generation	• Highest capital cost to develop • Chemistry/Turbidity unknown • Land acquisition may be required • Lake crossing required – presents risks • South aspect yields rapid snowmelt • Logging in watershed



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City of Nelson Water Master Plan

Supply Options

NTS

Figure 6.1

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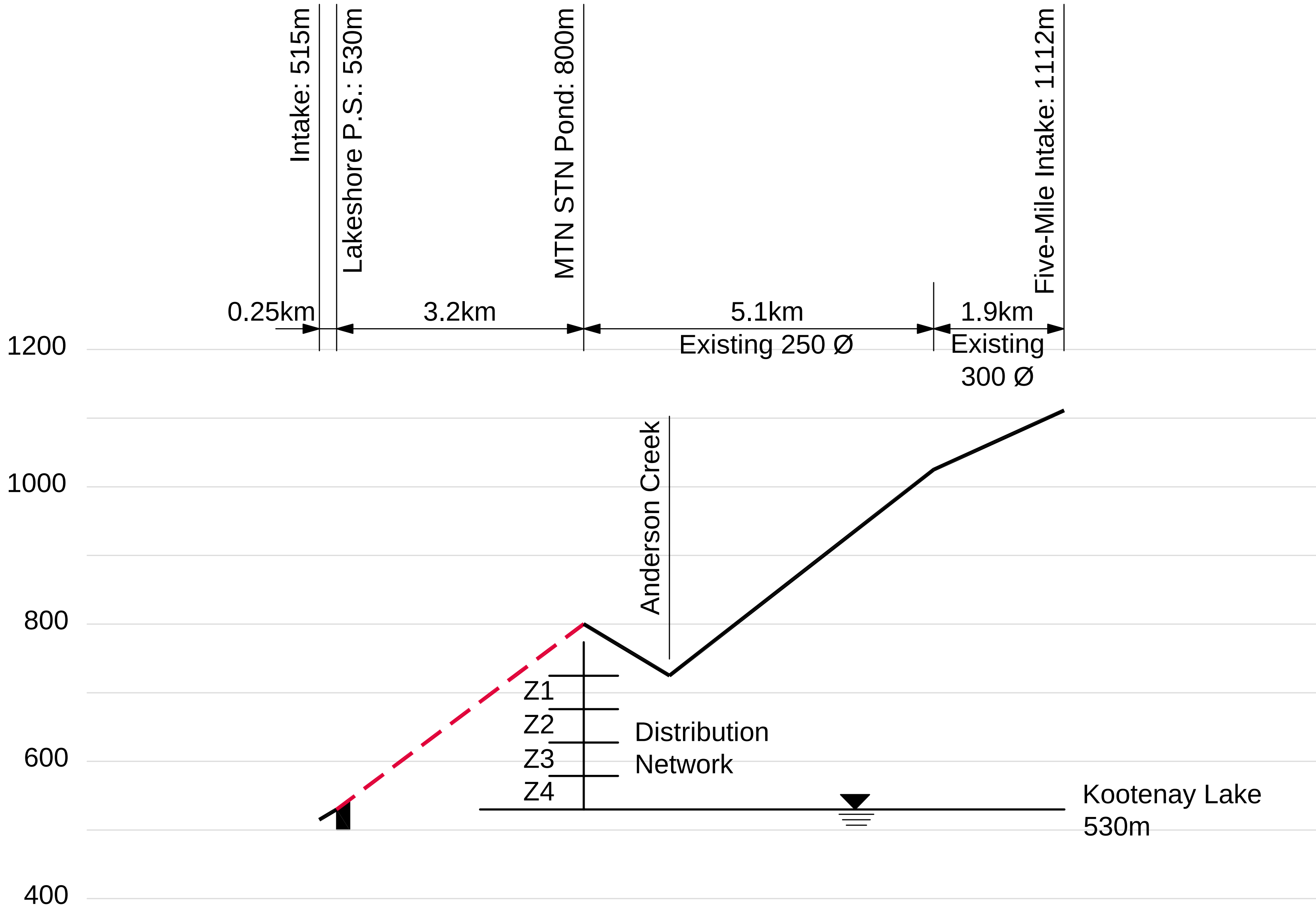

City of Nelson
Water Master Plan

Five Mile & Kootenay Lake Profile
(Option A)

NTS

Figure 6.2

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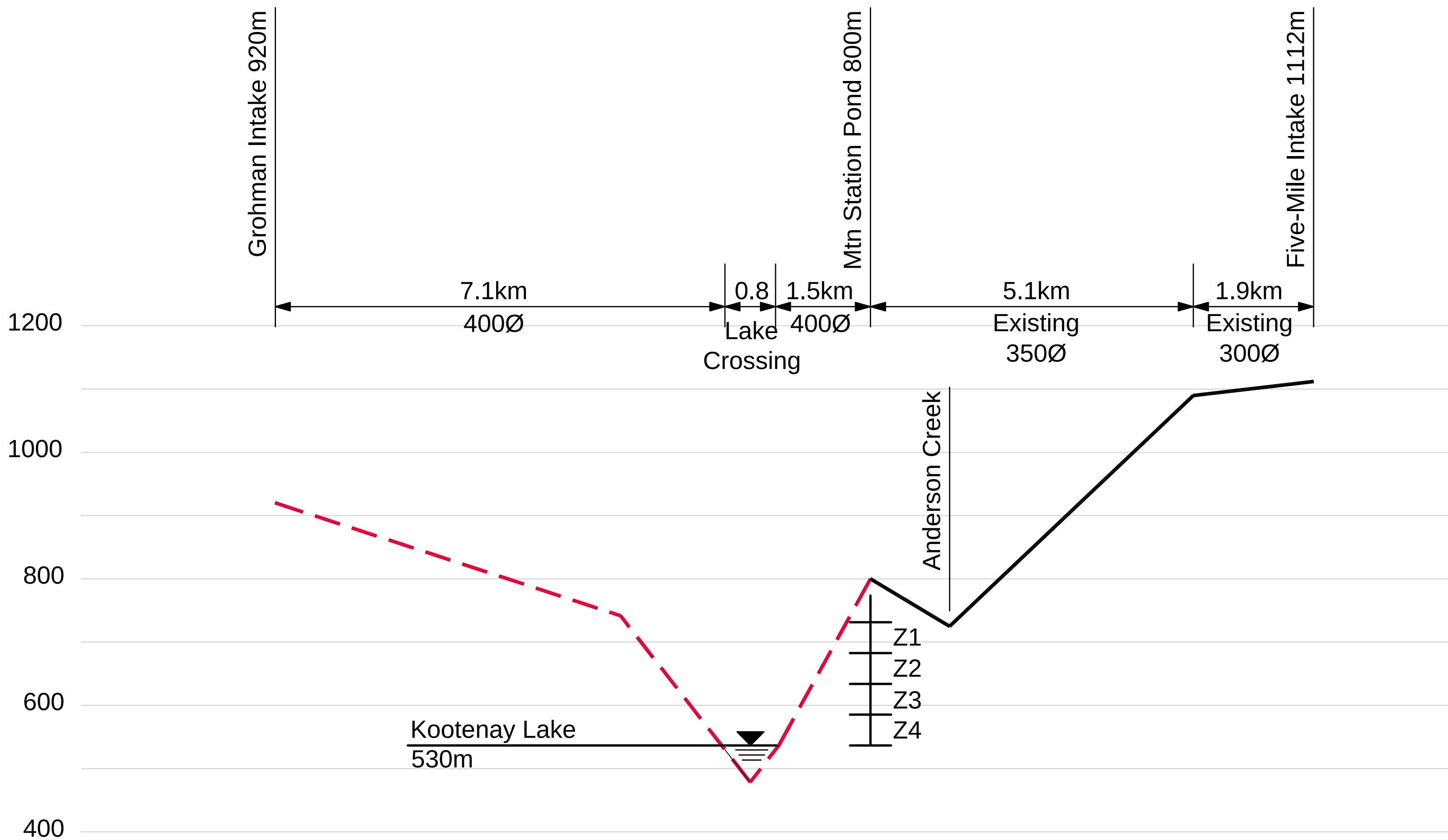

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City of Nelson
Water Master Plan

Five Mile & Grohman Creek Profile
(Option B)

NTS

Figure 6.3

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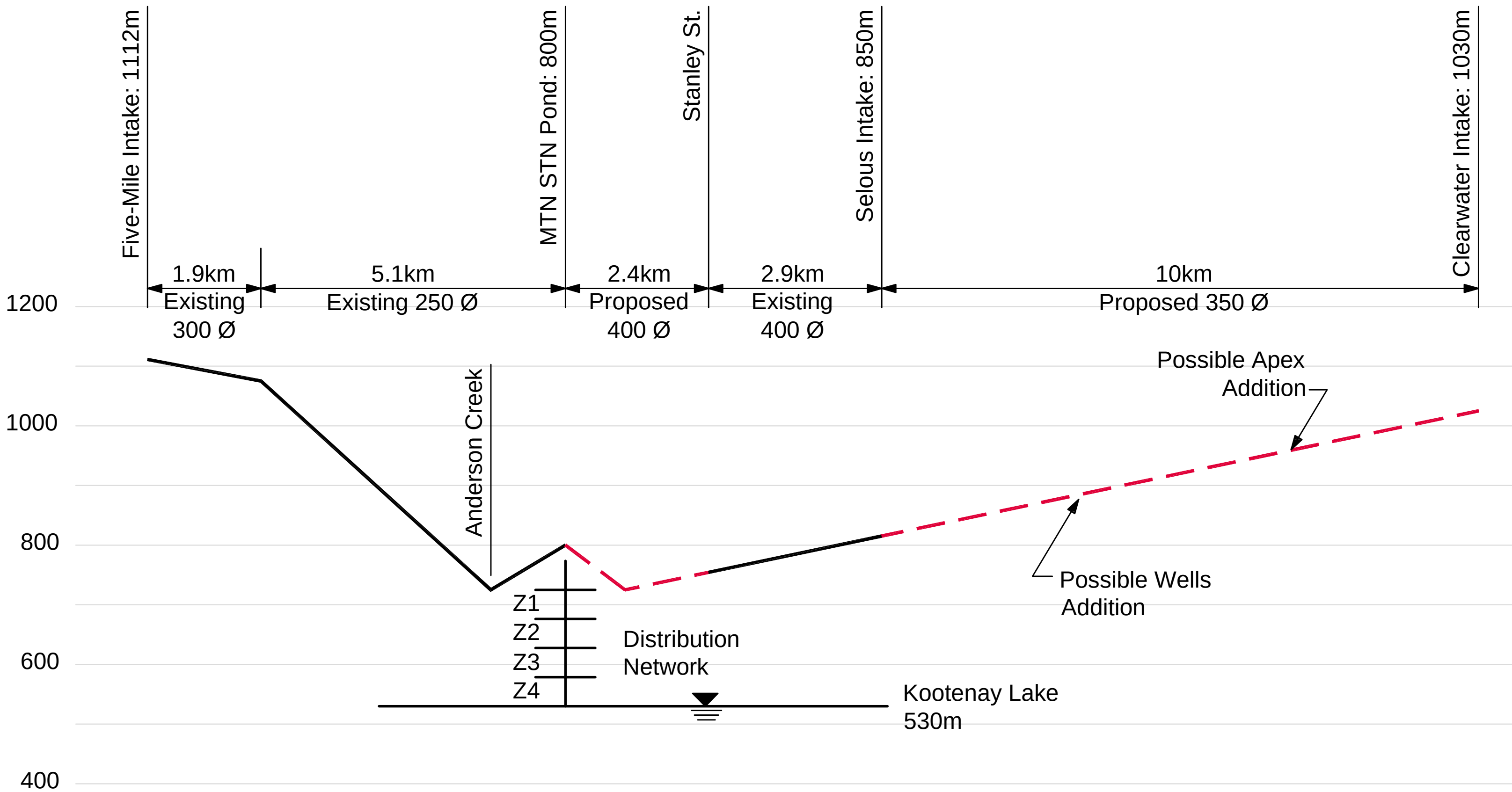

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City of Nelson
Water Master Plan

Five Mile & Clearwater Creek Profile (Option C)

NTS

Figure 6.4

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7.0 DISTRIBUTION NETWORK

7.1 Pipe Age and Condition

The central parts of the distribution network date back to the turn of the century. These older sections consist mainly of cast iron and ductile iron pipe.

The 1960's saw some significant expansion in the water network. Later extensions and replacements saw the advent of PVC (Polyvinylchloride) pipe. PVC pipe has been utilized extensively in recent years.

It is recognized that soil conditions have the greatest influence on exterior pipe corrosion and deterioration. The interior of the pipe is influenced by the source water and its degree of aggressiveness.

Five Mile Creek water is mildly aggressive on the basis of a theoretically calculated index (the Langelier Index) which uses the water's pH, Alkalinity and Hardness.

Nevertheless, pipe samples from the Five Mile Creek supply pipeline were tested and demonstrated surprisingly low corrosion for the number of years in service (refer to Levelton Consultants Ltd., report entitled "Five-Mile Intake Pipeline Corrosion Evaluation" dated January 31, 2006).

While some sampling has been done in recent years, the overall assessment of replacement costs is based on a theoretical evaluation of useful life for the pipe materials, and a calculation of replacement year based on year of installation.

The values for useful life were adopted as follows:

Cast Iron	65 years
Ductile Iron	65 years
Asbestos Cement	65 years
Polyvinylchloride	80 years
Steel	40 years
Galvanized Iron	25 years

The network was then examined and year of installation plotted for each branch. Figure 7.1 presents the network and projected replacement year.

The cost replacement is worked out in year 2007 dollars and includes:

- Pipe
- Trenching, bedding and installation
- Road reinstatement
- Service line replacement
- Line valves and fittings

The unit prices used for replacement costs are as follows:

Diameter (mm)	**Pipe Installation $/m**	**Road Restoration $/m**	**Services $/m**	**Total $/m**
200	225	225	260	710
250	275	225	260	760
300	325	225	260	810
350	400	225	260	885
400	475	225	260	960
450	550	225	260	1,035
600	650	225	260	1,135

The cost of services is based on replacement to the property line at $3,000 per lot, 23m frontage, 10 lots per 115m (both sides), or $30,000/115 = $260 per metre.

The replacement costs are summarized and these are presented on Figure 7.2 for a 20-year timeframe. Each vertical bar relates to the end of the theoretical lifespan from year of installation. The year 2006 incurs the greatest cost since it reflects 80 years from the first major network installation.

It is not practical to undertake wholesale pipe replacements in one year. A summary of the annual replacement expenditures averaged over 10-year intervals is presented on Table 7.1.

Table 7.1 Pipe Replacement Costs at 10-year Intervals			
Period	Replacement Cost $M/year	Period	Replacement Cost $M/year
2006-2016	2.08	2046-2056	0.63
2016-2026	0.77	2056-2066	0.77
2026-2036	1.26	2066-2076	0.15
2036-2046	0.80	2076-2086	0.18

The replacement at the end of the 20-year period will have covered all of the "old" pipe up to the more recent PVC installations. With a theoretical life in excess of 80 years, the PVC pipe should not require replacement until 2055.

The program should be adjusted as more evidence is gathered on pipe condition and remaining life. More extensive soil sampling may reveal that the program can be extended over a longer period. A yearly investment of $2M/year should be considered for the first 10 years, dropping to $1M/year for the subsequent 20 years and $0.5M/year in later years.

7.2 System Hydraulics

The network was checked for its ability to supply Maximum Day Demand (present and future). It was found adequate in all areas.

The network was then checked for its ability to supply fire flow during Maximum Day Demand. The criteria used were:

a) Minimum residual pressure of 20 psi.

b) Fire flows in accordance with fire Underwriters Survey:

Residential:	5,000 L/min.
Multi-family:	7,000 L/min.
School, Hospital:	5,000 L/min.
Commercial:	16,000 L/min.
Industrial:	14,000 L/min.

Figure 7.3 shows the results of the analysis and the calculated available fire flow at the system nodes. The orange and yellow nodes are below the desired rates. These can largely be corrected by addition of supply mains as shown on Figure 7.4.

Other minor deficiencies can be corrected by looping localized dead-end pipes and replacing several 100mm diameter pipes.

There are two areas on the lakeshore which have low available fire flows, the CPR Lands and the KFP Lands. Both areas are undeveloped and fire flows would depend on the type and density of development. These have, therefore, been left out of the current analysis and would be dealt with in the context of development applications.

7.3 Storage and Pressure Zones

Figure 7.5 depicts the existing storage and pressure zones in the network. There are four pressure zones achieved through the use of Pressure Reducing Valve Stations. The zones are:

Zone 4 – Lakeshore – Hydraulic Grade Line (HGL):	640 m
Zone 3 – Downtown – Hydraulic Grade Line (HGL):	709 m
Zone 2 – Residential – Hydraulic Grade Line (HGL):	748 m
Zone 1 – Upper Level – Hydraulic Grade Line (HGL):	769 m

Storage for peak hour demands and for fire protection is achieved in three reservoirs:

1. Mountain Station: 1.44 ML @ 800m
2. Rosemont: 1.36 ML @ 746m
3. Fairview: 1.89 ML (currently under construction) @ 650m

The system layout allows access to the Fairview and Mountain Station storage at the east and central areas; the Rosemont and Mountain Station storage at the west and central areas.

The required storage for a variety of land uses for both fire and peak hour demand is:

Fire:	16,000 L/min. x 3.5 hrs. =	3.36 ML
Peak Hour:	0.25 x 14 ML/d x 3 hrs. =	0.42 ML
	Total	3.78 ML

Given the system configuration, the required storage is:

East Side:	3.78 ML	1.89 ML at Fairview
		1.89 ML at Mountain Station
West Side:	3.78 ML	1.89 ML at Mountain Station
		1.89 ML at Rosemont (add 0.53 ML)

With the provision of 1.89 ML at three locations, all parts of the network have access to 3.78 ML of storage, derived from two sites.

Figure 7.6 depicts the existing and proposed storage as well as the adjusted Pressure Reducing Valve stations to optimize the pressure zones.

The Pressure Reducing Valve Station all require upgrading as they are badly deteriorated, require Confined Space Entry procedures, are poorly lit and ventilated, and the valves need replacement. It is recommended that one station per year be upgraded and an annual budget of $450,000 be set aside for PRV upgrading for a period of 6 years.

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City of Nelson
Water Master Plan

1:18,000

Water Distribution System
Age Analysis

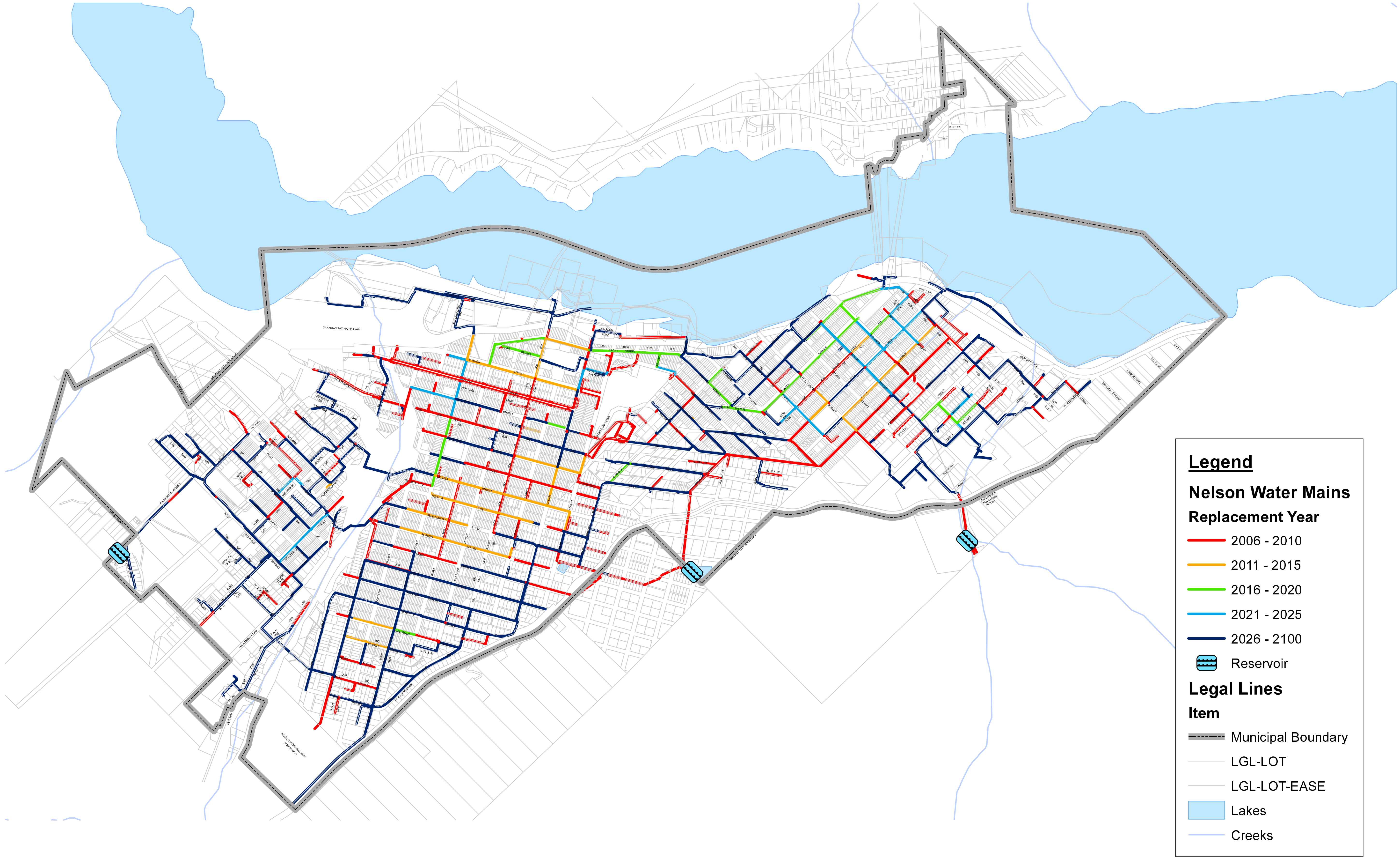

Figure 7.1

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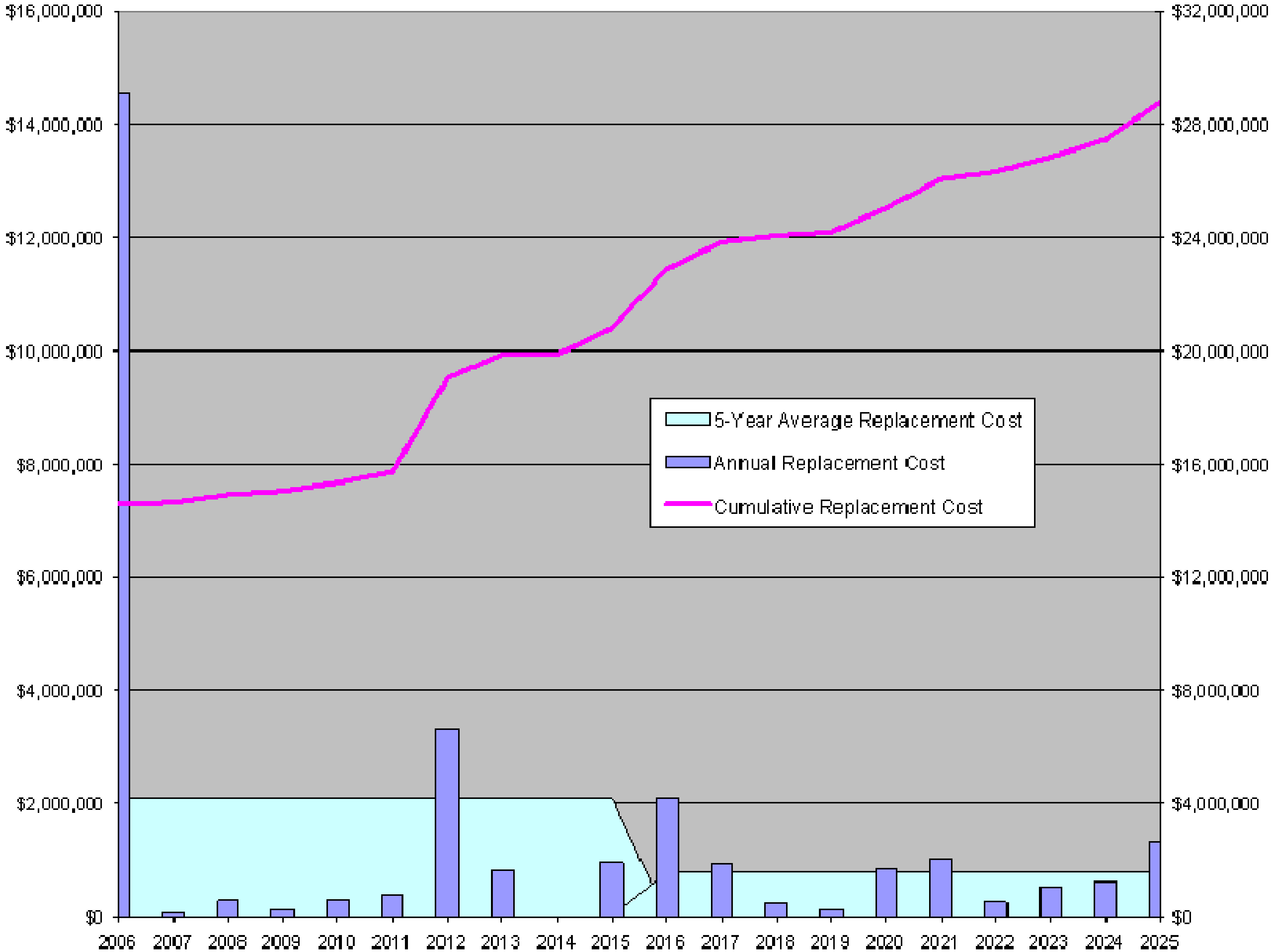

City of Nelson
Water Master Plan

20-Year Pipe Replacement Cost Summary

NTS

Figure 7.2

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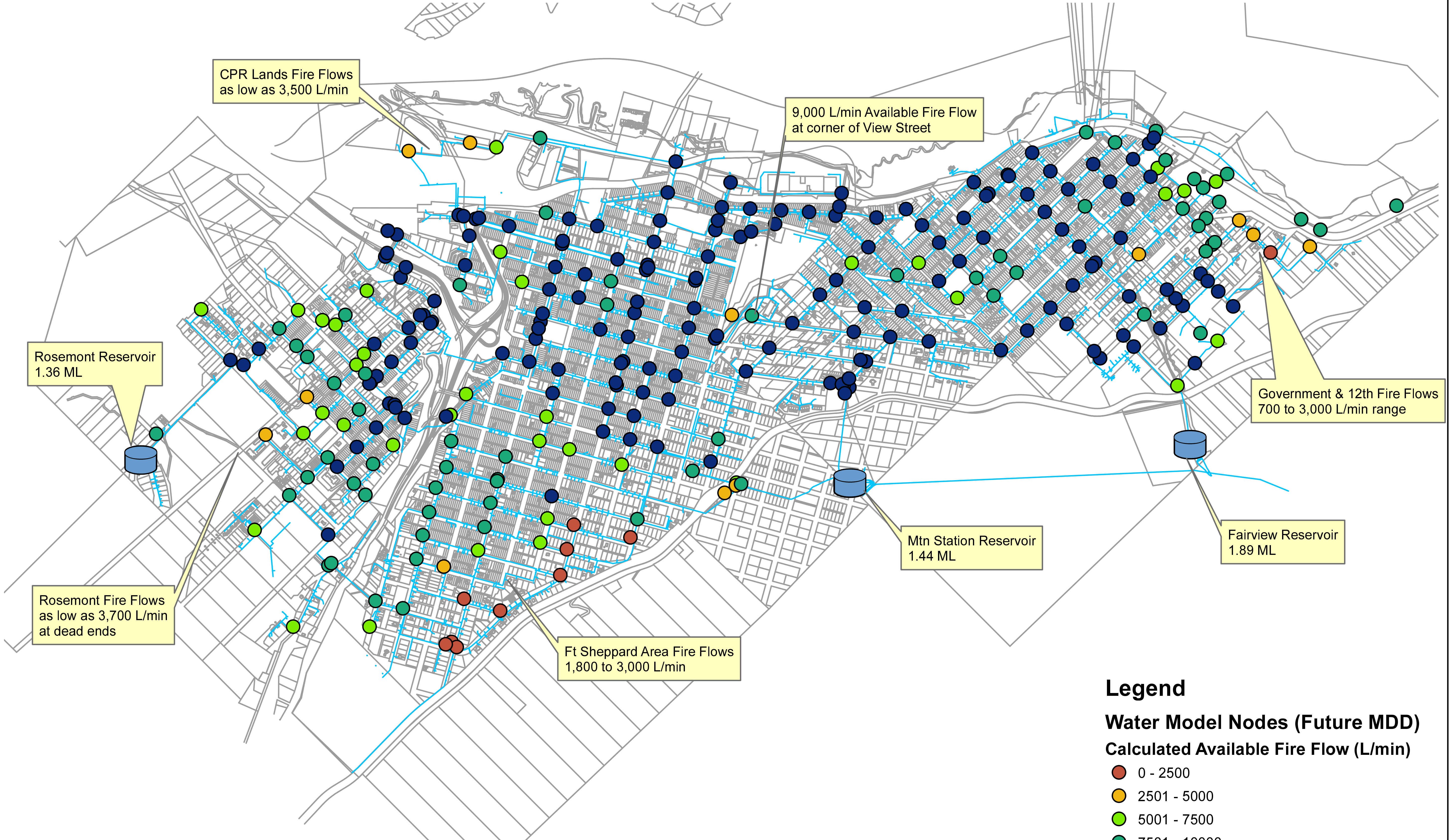
City of Nelson
Water Master Plan

1:15,000

Available Fire Flow Existing System



Legend

Water Model Nodes (Future MDD)

Calculated Available Fire Flow (L/min)

- 0 - 2500
- 2501 - 5000
- 5001 - 7500
- 7501 - 10000
- 10001 - 12000
- Existing Water Distribution System

Figure 7.3

0795.0077.01

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City of Nelson Water Master Plan

1:15,000

Upgraded System - Available Fire Flows

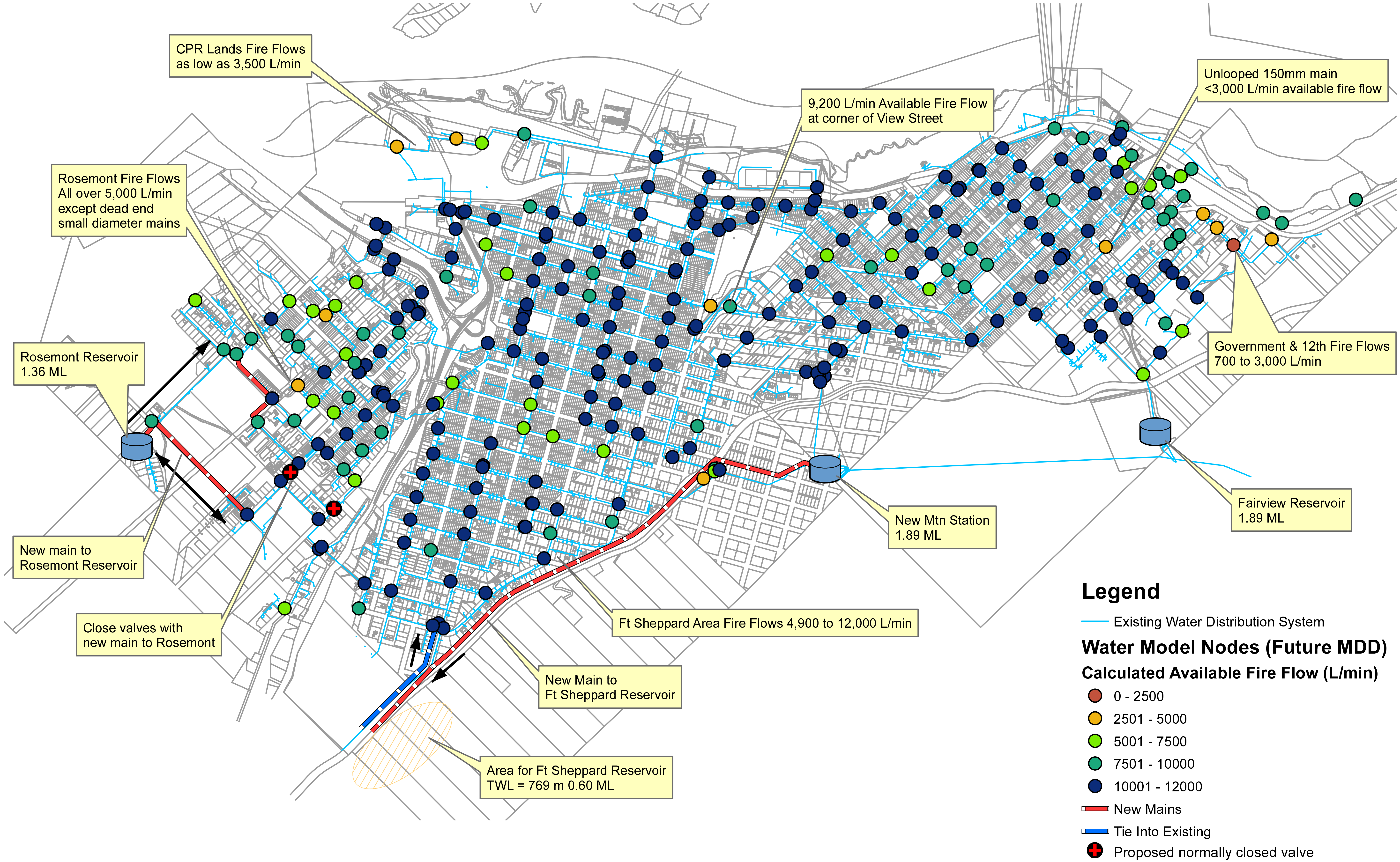

Figure 7.4

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City of Nelson
Water Master Plan

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PRV & Operational Upgrades

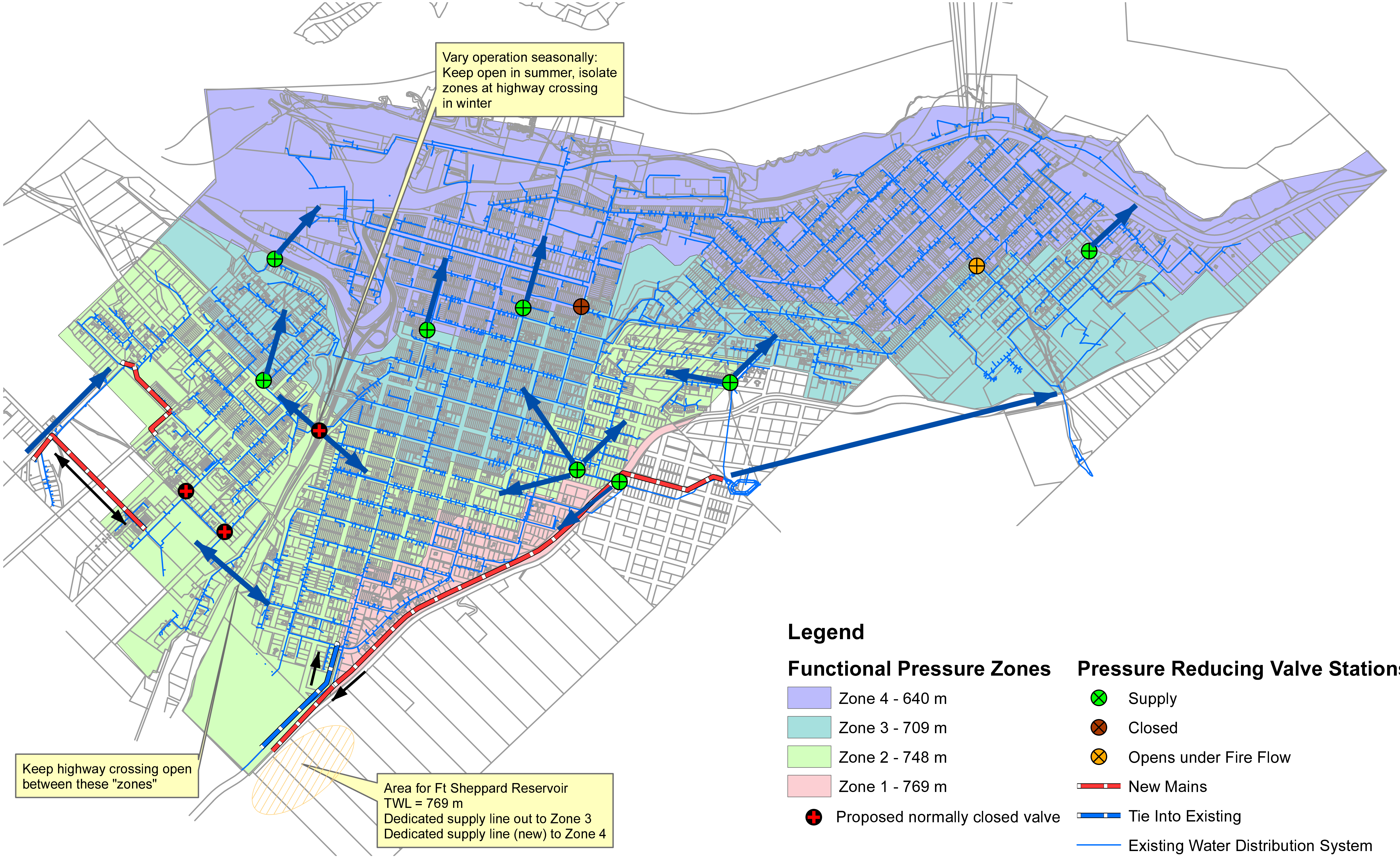

Figure 7.5

0795.0077.01

8.0 WATER CONSERVATION

8.1 Water Conservation and Drought Management

A Water Conservation and Drought Management Study was conducted in 2005 and included as Appendix C. For convenience, the Summary and Recommendations section is repeated here.

8.2 Summary and Recommendations of Study

Nelson's water system is running at capacity in peak periods, and the summer of 2003 demonstrated that serious conservation measures such as watering restrictions are necessary in high demand periods, to bring water demand in line with available supply. At the same time, it must be recognized that at current levels of demand, Nelson residents are fairly water-wise. Nelson's maximum day demand for water is not even twice as high as winter average day demand, and average day demand per capita is near the provincial average. However, if unaccounted for losses could be reduced, Nelson's per capita average day demand could become lower than the provincial average.

Although the City of Nelson is relatively efficient in its water use, there are a number of priority conservation areas that it should focus on. These include the following:

1. **Target an aggressive 50 percent reduction in unaccounted for losses:**
   As described in section 5.4, Nelson loses significantly more water to leakage and other system losses than the average municipality. If the current losses of 1,200 L/min could be reduced to 600 L/min, MDD would drop from 8,000 L/min to 7,350 L/min, providing a much greater cushion for the water system in high-demand periods. To effectively target this area, the City of Nelson should undertake a detailed audit to confirm the cause of losses and determine the most appropriate strategies for loss-reduction.

2. **Target a 10 percent reduction in domestic in-house use, and industrial, commercial, and institutional use:**
   Through consistent public education strategies, it may be possible to achieve small gains in conserving water in the areas of domestic in-house use, and industrial, commercial, and institutional use. To achieve these gains, the City of Nelson should continue with consistent newsletter updates that provide information to citizens, both on the need to conserve water and on opportunities to reduce water use. In addition, the City should publish separate educational materials to be distributed to all residents and businesses, particularly during peak demand periods.

By achieving these conservation targets, Maximum Day Demand could potentially be reduced by 12 percent overall, dropping from 8,000 L/min to 7,055 L/min. This is illustrated in Table 6.1, below.

Table 6.1 – Potential Impact of Conservation on Maximum Day Demand (L/min)

Current Maximum Day Demand	**8,000**
Unaccounted for Losses: 50% Reduction	-600
Domestic In-House Use: 10% Reduction	-204
Industrial, Commercial, Institutional Use: 10% Reduction	-142
Potential MDD After Conservation	**7,055**

Aside from these priority areas, the City of Nelson should give consideration to other opportunities for conservation. These include the following:

1. **Target potential reductions in domestic irrigation:**
   Domestic irrigation is an area in which Nelson residents are already fairly water-wise compared with a number of other BC communities. However, domestic irrigation causes summer demand for water to rise almost twice as high as average day demand, and this is the area of water use that can be most easily regulated and controlled. Further, as demonstrated by the drought in 2003, watering restrictions may be necessary in Nelson during dry periods. Appendix C sets out a potential water conservation bylaw, illustrating four stages of water restrictions that could be used in the City of Nelson.

In addition to staged watering restrictions, the City of Nelson may wish to consider offering consumer incentives to help reduce domestic irrigation demand. These could involve providing organic mulch or water-efficient timers to high-use consumers under a cost-sharing arrangement.

2. **Implement a universal metering program:**
   Water meters come at a relatively high capital cost compared to other conservation strategies, but combined with an appropriate rate structure and other measures such as public education and consumer incentives, they have been shown to have a significant impact on water demand. Should the City of Nelson consider a move towards universal metering, it should complete a metering study that define the socio-economic benefits and costs of metering, and articulates a plan for implementation of a metering program.

Notwithstanding all of the aforementioned opportunities for conservation, the City of Nelson may require water system upgrades and capacity enhancements. Chapter Four of this report illustrates that the existing water system would be unable to sustain consistent population growth of 1.0 percent per annum, given current patterns of water demand. Although this is much higher than Nelson's current growth rate, sudden growth at 1.0 percent per annum or higher could quickly trigger the need for enhanced capacity. While there are a number of tools for conservation to reduce water demand, Nelson is already a relatively water-wise community and the potential for demand-side savings is limited. Thus, if the population starts to grow at even a modest rate, the City should anticipate a need for future water system capacity enhancements.

9.0 OPERATIONAL REQUIREMENTS

9.1 Legislation

The Drinking Water Protection Act mandates the purveyor to engage qualified water system operators to operate and maintain the water system.

In 1992, the British Columbia Water and Wastewater Operators Certification Program Society was incorporated as a non-reporting society pursuant to the Society Act (Certificate of Incorporation #S-28724). In 1995, the name was changed to Environmental Operators Certification Program (EOCP).

9.2 The EOCP

The Environmental Operators Certification Program (EOCP) evolved in British Columbia from a handful of wastewater treatment plant operators who began the Program in 1966. Since then, the Program has grown along with similar programs throughout North America to include over 3,000 British Columbia and Yukon operators of:

- Water distribution (WD)
- Water treatment (WT)
- Wastewater collection (WWC)
- Municipal wastewater treatment (MWWT)
- Industrial wastewater treatment (IWWT)
- Small water systems (SWS), and
- Small wastewater systems (SWWS).

The EOCP's objective is to protect human health, the environment, and the investment in facilities through increased knowledge, skill and proficiency of the members of the Program in all maters relating to water treatment and distribution and wastewater collection, treatment, and disposal.

The EOCP performs two functions:

- It classifies the facility (from Class 1 to Class IV range)
- It certifies the Operator's qualifications (Level 1 to Level IV)

The facility classification system assigns points to the level of complexity of the utility, as follows:

Facility Classification System					
Facility	**Units**	**Class I**	**Class II**	**Class III**	**Class IV**
Water Distribution	Point range	<31	31 – 55	56 - 75	>75
Wastewater Collection	Point range	<31	31 – 55	56 – 75	>75
Water Treatment	Point range	<31	31 – 55	56 – 75	>75
Wastewater Treatment	Point range	<31	31 – 55	56 – 75	>75
Industrial Wastewater Treatment	Point range	<31	31 – 55	56 – 75	>75
Small Water System	Point range	<31	31	N/A	N/A
Small Wastewater System	Point range	<31	31	N/A	N/A

Operator qualifications are assessed on the basis of CEU's (Continuing Education Units). The operator's certification level should, ideally, match the facility class. However, an operator can be operating a higher class facility, but in training for the next level.

9.3 Operator Levels

Small Water System and Small Wastewater System Operator

- Minimum Grade 10 education. If the operator does not have a grade 10 education, experience may be exchanged for education on a year for year basis, and
- Minimum 1.5 continuing education units (CEU's), and
- Minimum of at least six (6) calendar months (minimum 50 hours) of hands-on experience operating the facility/system or one equivalent to it or higher.

Operator-in-Training

- High school diploma, GED, or equivalent, and
- Three (3) months operating experience in a Class I or higher facility or completion of an approved basic operator-training course.

Operator, Level I

- High school diploma, GED, or equivalent, and
- One (1) year operating experience at a Class I or higher system/facility.

Operator, Level II

- High school diploma, GED, or equivalent, and
- Three (3) years operating experience at a Class I or higher system/facility, and
- A Level I certificate.

Operator, Level III

- High school diploma, GED, or equivalent, and
- Nine hundred (900) instructional hours, or ninety (90) CEU's, or ninety (90) quarter credits, or sixty (60) semester credits of post high school training/education in the water or wastewater field, environmental engineering, or related studies, and
- Four (4) years operating experience at a Class II or higher system/facility, and
- For Water Treatment and Wastewater Treatment Operations, two (2) years of direct responsible charge (DRC) operation at a Class II or higher facility, and
- A Level II certificate.

Operator, Level IV

- High school diploma, GED, or equivalent, and
- Eighteen hundred (1,800) instructional hours, or one hundred eighty (180) CEU's, or one hundred eighty (180) quarter credits, or one hundred twenty (120) semester credits of post high school training/education in the water or wastewater field, engineering, or related studies, and
- Four (4) years operating experience at a Class III or higher facility, and
- For Water Treatment and Wastewater Treatment Operations, two (2) years of direct responsible charge (DRC) operation at a Class III or higher facility, and
- A Level III certificate.

Where applicable, training/education may be substituted for operating and direct responsible charge (DRC) experience as specified below:

1. For Level I, no substitution for operating experience shall be permitted.
2. For Level II, a maximum of four hundred fifty (450) instructional hours, or forty five (45) CEU's or forty five (45) quarter credits or thirty (30) semester credits of posh high school training/education in the water or wastewater field, environmental engineering, or related studies may be substituted for up to one (1) year of operating experience.

9.4 Emergency Response Planning (ERP)

An ERP is required from all utilities, public or private, and is to be submitted to the Comptroller's office as well as Interior Health.

The purpose of an ERP is to establish (and regularly update) emergency response procedures in the event of a partial or total loss of service arising from a variety of natural, or accidental circumstances.

The ERP should include a comprehensive contact list, the appropriate authorities and emergency personnel. It should also list available equipment and service contractors that can be called upon to repair equipment or provide spare parts.

9.5 Sampling, Monitoring and Reporting

The DWPA Regulations require the following water sampling frequency for Total Coliform bacteria and Fecal Coliform bacteria (or Escherichia Coli):

Population Served	No. of Samples Per Month
Less than 5,000	4
5,000 to 90,000	1 per 1,000 population

More recent campaigns by Interior Health focus on Turbidity monitoring and provide a Turbidity Tool Kit to water purveyors (available from IHA).

10.0 THE WMP COMPONENTS

10.1 Summary of Findings

The investigations undertaken in the course of this work reveal some important shortcomings in the City of Nelson water system. The most critical major elements are:

a) Insufficiency of primary source (Five Mile Creek) during drought years.

b) Limited capacity of supply pipeline and risk of pipe damage.

c) Insufficient treatment and microbiological protection to meet the current IHA targets

d) Age of the infrastructure.

Less critical, but also important elements are identified as follows:

e) Storage and fire protection.

f) Pressure optimization (PRV Upgrades).

g) Condition of Five Mile intake and Mountain Station Settling Pond.

h) System SCADA, telemetry and alarms.

10.2 Selection of Secondary Source

The work undertaken and the comparison of secondary source options proposes Kootenay Lake as the most secure secondary source in terms of available quantity and risk of contamination. It is not, however, the most cost efficient option due to the high cost of pumping. The annual operating costs are over $100,000 per year more than the gravity options. It was discovered later in the sampling season that algae blooms could adversely impact Kootenay Lake water quality and potentially foul a filtration plant. Further evaluation of the impact of algae blooms is necessary.

Clearwater Creek, in concert with Selous and Apex Creeks could theoretically supply sufficient additional water during drought years. The confidence in the flow projections is low, due to lack of long-term flow records on Clearwater and Apex Creeks.

Grohman Creek is deemed out of contention because of high capital costs and unknown water quality.

The recommended action plan, therefore, is twofold:

a) Continue sampling and monitoring on Kootenay Lake, with particular focus on algae blooms in the warmer months.

   Undertake bench scale jar tests to determine a viable treatment technique for algae, if necessary.

b) Install flow measurement facilities at Clearwater and Apex Creeks to generate a long-term profile of creek flows.

   Sample creeks during freshet and seasonally to determine water quality.

c) Retain the Selous intake for the short-term until a final decision is made for a secondary source.

10.3 Selection of Filtration Facility

It is clear from the sampling on Five Mile Creek water that filtration will be required to meet IHA targets. The initial comparison indicates that two methods would be suitable:

a) Conventional rapid sand filtration.

b) Membrane filtration.

The preliminary (Level D) estimated budget for either method (at 15 ML/d capacity) is $10.0 M. It is recommended that a solicitation be prepared for pilot plants in these two categories, and their performance be evaluated through at least one freshet season.

10.4 Replacement of Infrastructure

It is recommended that a budget of $2 M/year for the next 10 years be set aside to replace aging pipes. It is further recommended that the watermain replacement program be integrated with sewer, drainage and roadway upgrade programs. Further financial analysis would reveal an optimum interval for construction periods.

It is recommended that PRV station upgrades be undertaken at a rate of one per year, with a budget of $400,000/year.

The Five Mile intake structure should also be upgraded in 2007 as it is currently in very poor condition. Funds should be set aside for repair and lining of the Mountain Station pond within 5 years.

10.5 Storage and Fire Protection

The improvements at the west end (Fort Sheppard) would be useful to balance out the system pressures. A dedicated feed line to a Fort Sheppard reservoir can be constructed on the BNR Right-of-way. A parallel main can also be installed on the Right-of-way to allow transmission of Selous Creek water to the Mountain Station site.

10.6 WMP Capital Investment Summary

Component	Estimated Cost $M	Year
1. Secondary Source Investigations	0.05	2007
2. WTP Piloting	0.05	2007
3. Five Mile Intake Structure	0.50	2007
4. PRV Upgrade	0.40	2008
5. Storage and Mains (Fort Sheppard)	3.50	2008
6. Water Filtration Plant	10.00	2009
7. Pipe Replacements	2.00	2008

The costs for accessing, developing and implementing a secondary source should be refined after the source investigations are complete (2008).

10.7 Phase II of the WMP

The second phase of the Water Master Plan should assess a variety of revenue strategies to fund the plan, and solicit public input on these strategies. The outcome should result in an Implementation Plan acceptable to all stakeholders.

APPENDIX A

Five Mile Pipeline Evaluation Summary

City of Nelson
Five-Mile Intake Pipeline
Corrosion Evaluation

Prepared for:

The Corporation of the City of Nelson
502 Vernon Street
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V1L 4E8

Attention: Mr. Peter Hartridge
Director of Operations

Prepared by:

Levelton Consultants Ltd.
#103 - 19292 60th Avenue
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V3S 3M2

I.C. Thornton, AScT.

M.J. Magee, P.Eng.

January 31, 2006

File: 2705-0827

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Executive Summary

Levelton Consultants Ltd. (Levelton) was contracted by the City of Nelson to evaluate the condition of the City's Five-Mile Intake Pipeline. The pipeline route extends from the Five-mile Creek intake to the City's Mountain Station reservoir. The approximate total lineal length of the pipeline is 7700 meters.

The purpose of the assessment was to evaluate the existing condition of the pipeline to project the life expectancy and identify whether there is a requirement for pipeline replacement or corrosion control measures in the future.

The exterior of the 250-mm and 300-mm diameter cast iron sections and the 250 mm diameter steel section of the water supply main are in good to very good condition in the test pit locations after approximately 78 years service.

The soil resistivity survey revealed that the water main transcends similar soil types along its length. The soils are generally sandy in nature with resistivity values that indicate the soils are only mildly corrosive to cast iron or steel pipe.

In total 35 soil samples were taken and tested as per the ANSI/AWWA C105 Standard Appendix A. None of the 35 samples scored over ten points, indicating that the soil environment surrounding the water main is not considered corrosive to iron pipe. These benign soil conditions likely contributed to the minimal degree of corrosion found on the water main.

According to the original specification, the water main was coated by dipping the pipe lengths into a bath of hot coal tar varnish. This type of coating has an excellent performance history when used for buried service. The coating provides a barrier between the pipe surface and the soil, therefore reducing the risk of a corrosion cell developing. From the condition of the coating found in the test pits it is likely that the coating on the water main is on average approximately 80% intact in most locations along the length of the water main thereby continuing to provide corrosion protection to the pipe.

Some corrosion pitting was found on the exterior of the pipe however the pits were shallow in relation to the wall thickness of the pipe. The deepest corrosion pit found had only penetrated the pipe wall by 35%. This pit was found in Test Pit No. 6. Extreme Value Statistical Analysis revealed that no section of the water main is likely to suffer a leak from external corrosion at the present time based on the condition of the pipeline in each test pit.

No stray DC electrical currents were detected at the time of testing that could accelerate corrosion on the water main.

The modulus of rupture of the pipe sample did not meet the minimum 1970 design value of 40,000 psi for 250 mm diameter centrifugally cast iron pipe specified by AWWA Standard C108-70 however the modulus of rupture was 36,385 psi and this was likely acceptable for pipe manufactured in 1925 by pit casting techniques. The pit casting process generally yielded weaker pipe than spun cast pipe.

The pipe sample provided was in good condition except for a hole in the crown of the pipe caused by erosion corrosion and not soil corrosion. The hole developed from the exterior of the pipe, however it appears that the concrete mortar sealed joint adjacent to the hole had failed at some point in time and the water leaking from the joint caused the erosion of the pipe wall. Attempts at repairing the hole were attempted using lead and eventually a stainless steel repair clamp. The repair methods may have slowed the leak but did not stop it. Water leaking from the hole under the repair clamp caused additional erosion of the pipe wall under the clamp.

The interior of the pipe sample showed no signs of corrosion or erosion of the pipe wall. The coal tar coating was estimated to be 95% intact and is serving its purpose as a barrier between the pipe wall and the water. The ultrasonic thickness readings of the pipe wall did not detect serious internal corrosion at the test pit locations. This data combined with the pipe sample condition would suggest that the pipe interior is in good condition. However the single pipe sample tested is insufficient to state unequivocally that the interior of the entire length of the pipeline is in similar condition. There could be locations along the pipeline where the interior condition is worse because of changes in terrain causing turbulence and erosion corrosion on the pipe interior. Inspection and testing of additional pipe sections is warranted if ever there is an opportunity in the future to remove a pipe section.

A significant difference in pipe wall thickness was noted between the two pieces of pipe included in the cast iron pipe sample. The difference in wall thickness between the spigot and the bell is likely attributed to the casting process.

The pipe joints were sealed with cement mortar for most of the water main and appear to have performed well. It is our opinion that the leaking joint found at Test Pit No. 4, likely first occurred early in the life of the pipe. The wall perforation was probably not found until water leaking from the joint, scouring and eroding the pipe, perforated the pipe wall. There is no reason to believe that the joints will not continue to perform as intended however additional failures are possible as the pipeline ages.

According to the specifications, the joints on the steel pipe section were sealed with lead. No joints were found in the three test pits excavated on the steel pipe section to assess their condition. However based on historical performance, the joints appear to be working as designed.

According to the City of Nelson, a slope failure occurred between Fell Creek and Anderson Creek, causing the pipe to break. The steel pipe at this location was replaced with ductile iron pipe. No failures of the ductile iron pipe have been reported.

It is however recommended that the City of Nelson inspect the pipeline right-of-way on a bi-annual basis. Any evidence of leaks should be investigated and proper repair materials should be used. The pipe route should be kept clear of all overhanging trees and brush should be cleared. If slope stabilization is a concern, a geotechnical engineer from Levelton Consultants Ltd. should be contracted to review the site and provide recommendations

In our opinion, the exterior of the pipeline appears to be in good to very good condition and although the information on the pipe interior is limited to one pipe sample and ultrasonic wall thickness readings in the test pits, it also appears to be in good condition. Based on this, the pipeline should continue to provide satisfactory service for the foreseeable future. However if there is an opportunity in the future, inspection and testing of additional pipe sections is warranted to obtain more information on the condition of the supply main interior.

1.0 SCOPE OF WORK

Levelton Consultants Ltd. (Levelton) was contracted by the City of Nelson to evaluate the condition of the City's Five-Mile Intake Pipeline. The pipeline route extends from the Five-mile Creek intake to the City's Mountain Station reservoir. The approximate total lineal length of the pipeline is 7700 meters.

The purpose of the assessment was to evaluate the existing condition of the pipeline to project the life expectancy and identify whether there is a requirement for pipeline replacement or corrosion control measures in the future.

2.0 PROJECT METHODOLOGY

To assess the corrosiveness of the soils and evaluate the condition of the existing piping the following test program was coordinated through Urban Systems Ltd.:

- A survey of the soil electrical conductivity (the inverse of resistivity) was conducted using Geonics EM38 test equipment at intervals of 25 meters to a depth of 1.52m along the length of the pipeline. Due to the remote location of the pipeline, the data was recorded with the instrument parallel to the pipe. Erroneous readings caused by nearby underground utilities were not a concern. This survey provided electrical resistivity data for the soils along the complete length of the pipeline except in locations of steep or forested terrain.

- Fifteen (15) soil samples were then manually excavated in locations based on the results of the soil resistivity survey and to provide an even distribution of samples along the pipeline route. The soil samples were tested as per AWWA Standard C105/A21.5-99 Appendix A for pH, electrical resistivity (soil box), sulfides, redox potential and moisture.

- Terasen Gas was contacted to determine if they operate any impressed current cathodic protection (ICCP) systems near the pipeline. Terasen operates several ICCP systems in the City of Nelson. None of the systems were close enough to the pipeline to cause a concern of stray electrical current corrosion.

- Pipe sample – City of Nelson crews removed one section of the pipeline for laboratory evaluation. The location of the sample was selected based on access for equipment and the fact that the pipe was currently leaking at that location. The following tests were performed on the pipe sample:

- Inspected and photographed the as received condition of the pipe sample;
- Cut one sample for strength testing;
- Sectioned the pipe circumferentially into smaller sections to make the sample more manageable for handling and longitudinally so that the interior could be inspected;
- Abrasive blast cleaned the pipe sections for further inspection;
- Inspected and photographed the condition of the pipe once cleaned;
- Measured and recorded the extent and depth of any corrosion pitting found on the exterior and interior of the pipe sample;
- Measured the remaining wall thickness of the pipe with an ultrasonic thickness gage.

- Test pit excavation – City of Nelson personnel excavated the pipeline in a total of 11 locations. A 1.5-meter section of the pipeline was removed from Test Pit #4 for laboratory evaluation. In each of the eleven test pit excavations, soil samples were extracted from the crown and invert of the pipe for corrosivity testing. In addition, the following tests were conducted to assess the condition of the piping:
    - Visual inspection of the pipe once excavated;
    - Inspection of the condition of the pipe coating;
    - DC potentials on the pipe were measured;
    - Visual inspection of the pipe once it was abrasive blast cleaned with sand;
    - Measurement of deep corrosion pits using a pit depth gage;
    - Measurement of pipe wall thickness using an ultrasonic thickness (UT) gage (only in locations that were sandblasted);
    - Inspection of the electrical continuity across pipe joints;
    - Digital photographs of pipe condition.

It should be noted that due to equipment accessibility difficulties, the pipe in Test Pit No's 5 and 7 was not abrasive blast cleaned and only visual testing was performed.

In addition, the section of pipe, which is installed in the trestle, was inspected in two locations. The pipe was not abrasive blast cleaned so only a visual inspection was performed at these locations.

3.0 Internal Corrosion of Water Mains

Internal corrosion of water mains is dependent on the nature of the environment and the presence and quality of a protective lining.

Corrosion inside the water mains typically occurs by pitting corrosion or graphitization (in the case of cast iron pipe). Rust tubercles typically form over the corrosion pits and cause problems with loss of hydraulic capacity and water quality (discoloration). Erosion corrosion and crevice corrosion can also occur. The former occurs in locations of high velocity and turbulence and can be acerbated by suspended particles in the water. The latter occurs in areas of restricted flow or water circulation such as a pipe/fitting joints.

Water quality is an important factor in determining the rate of corrosion inside water mains. Factors such as pH, dissolved oxygen, total dissolved solids, buffering capacity, hardness, temperature, flow rates and the presence of chloride, sulfate, silica, calcium and phosphates can either increase or decrease the rate of corrosion.

4.0 Soil Corrosion Theory

Underground corrosion on metallic piping systems is dependent on a number of factors including the type of metal, soil type, chemical characteristics of the soil, oxygen content, moisture content, soil bacteria and stray electrical currents. In general soils become more corrosive with the following:

- Poorly draining soils such as clay or muskeg are more corrosive than well-draining soils such as gravelly-sand.
- Soils are corrosive to metallic piping at pH values less than 4 and greater than 8.5.
- An increase in oxygen availability increases the corrosion rates.
- Moist soils are more conductive hence more corrosive than dry soils.

- Soil bacteria such as sulfate-reducing bacteria (SRB) will depolarize corrosion cells and accelerate the corrosion reaction.
- Soils in contaminated sites could be more aggressive because of the presence of chemicals that could attack and cause protective pipe coatings to deteriorate and expose the metal to soil corrosion.
- The presence of stray electrical currents from DC power sources such as foreign utility cathodic protection systems, DC welding equipment, household appliances and electrified transit systems will accelerate corrosion on buried metallic piping.

In the water industry the most commonly used metallic piping materials have been cast iron, ductile iron, copper and steel. Copper is primarily only used for services whereas the other materials have been used for water mains since the early 1900's.

In industry there is the misconception that ductile or cast iron is more corrosion resistant than steel. In our experience, there is very little difference in the manner in which ductile or cast iron or steel corrodes. The myth that ductile or cast iron is more corrosion resistant has been propagated over the years because of the greater wall thickness of cast iron pipe compared to steel pipe. A thicker wall pipe, regardless of whether it is steel or ductile iron will take longer to develop a leak than a thinner wall pipe. In our experience, both pipe materials corrode similarly if they are installed in identical soil conditions.

In soils, the type of corrosion that is common to buried piping is pitting corrosion. Pitting corrosion is a non-uniform type of attack and is random in nature. It occurs where there is coating deterioration and the metal is exposed to the soil. A corrosion cell forms in the area consisting of an anode, cathode, the electrolyte (soil and water) and the metallic circuit (pipe wall). Metal ions go into soil (i.e. the pipe corrodes) at the anodic area on the pipe surface. Electrical current (electrons) flows through the pipe wall to the cathodic area. Either hydrogen ions or hydrogen and oxygen atoms then accept the electrons and either hydrogen gas is evolved or water or hydroxyl ions are formed at the cathodic area on the pipe surface. No corrosion occurs at the location of the cathode.

The rate of corrosion is dependent on a number of factors as previously noted. However in general, soil that is moist, conductive, with either oxygen or SRB present will corrode at a higher pitting rate.

Bimetallic or galvanic coupling of two different metals will also accelerate corrosion on the less noble material particularly if the anodic material is small compared to the surface area of the cathodic material. Typical couplings in the water industry can be the following:

- Copper water service connected to ductile or cast iron water main. In this case, the copper is the cathode and the water main is the anode. The iron main protects the copper service from corrosion and because the surface area of the main is much larger than the service, the surface area ratio of the two is favorable and rapid corrosion of the main does not occur.
- New ductile iron pipe is used to replace an old corroded length of cast iron pipe. In this case, the ductile iron pipe acts as the anode and sacrifices itself to protect the old cast iron pipe (cathode). Accelerated corrosion occurs on the new ductile iron pipe because of the unfavorable surface area (small anode and large cathode). Even though the ductile iron pipe is new it will perforate and develop a leak sooner than the old cast iron pipe.
- New fitting installed on old ductile or cast iron pipe. The fitting will act as the anode in the corrosion cell and corrode preferentially to the old pipe (cathode). Frequently it is the weakest link in the system that fails. If tie-rods/nuts are present, thinning of the rods/nuts occurs because they are highly stressed and more prone to failure. New fittings such as valves are less likely to perforate due to their increased wall thickness compared to that of the old ductile iron pipe.

An exterior coating is intended to provide a buried pipe with a degree of corrosion protection. The quality of the pipe coating is dependent on the purpose of the coating. In the case of ductile iron pipe, the coating is intended for aesthetic reasons during storage of the pipe above ground. The thin asphaltic coating is intended to prevent unsightly rusting of the pipe while in storage. The thin coating can also provide limited protection to the ductile iron pipe underground however the extent of the protection is dependent on the corrosiveness of the soils. According to the Ductile Iron Pipe Research Association (DIPRA), the average life of a ductile iron pipe with the standard shop coating is 24 years in corrosive soils. [1]

Coatings that are intended to provide corrosion protection to buried pipe while in service underground are of higher quality. These include the following:

- AWWA Standard C203 - hot coal tar enamel;
- AWWA Standard C210 - liquid epoxy;
- AWWA Standard C214 – cold-applied polyethylene tape wrap;

- AWWA Standard C216 – heat shrinkable polyolefin (polyethylene)
- AWWA Standard C217 – petrolatum tape wrap;
- AWWA Standard C222 - liquid polyurethane

These generic coatings are superior to the standard ductile iron asphaltic coating and are intended to provide long-term corrosion protection to buried metallic pipe. They will protect the pipe providing that the coating remains intact. If however the coating is damaged during pipe installation or in subsequent service, the metallic pipe will corrode at these locations. The rate of corrosion is dependent on the corrosivity of the soils. That is why cathodic protection is used to supplement the protection provided by a protective coating. Cathodic protection and coatings work in synergy. High quality coatings greatly reduce the surface area of the pipe exposed to the soil. Cathodic protection provides corrosion protection to the areas of the pipe where the coating is damaged and the metal is exposed to the soil and groundwater.

5.0 Soil Electrical Resistivity Survey

A soil electrical resistivity survey using the Geonics EM38 soil conductivity meter was conducted along the length of the pipeline. Some sections of the pipeline were not surveyed due to uneven or uncleared terrain.

Various research organizations have attempted to correlate resistivity to the severity of corrosion on buried pipe. The following table details our interpretation of soil resistivity by eight different organizations and researchers. The various interpretations can be summarized into the following categories:

Table 4.0-1 Relationship of Electrical Resistivity to Soil Corrosiveness

Electrical Resistivity (ohm-cm)	Approximate Soil Corrosiveness
>25,000	Virtually non-corrosive
10,000 to 25,000	Very mildly corrosive
5000 to 9,999	Mildly corrosive
2000 to 4999	Moderately corrosive
1500 to 1999	Corrosive

1000 to 1499	Very corrosive
<1000	Severely corrosive

These classifications are rough approximations, since they take into consideration resistivity only. Other factors can affect the corrosion rate of buried piping in the soil such as pH, moisture content and soil bacteria. These characteristics are tested in AWWA Standard C105.

Test results are summarized below. The complete set of resistivity data for the pipeline route can be found in Appendix A. The pipeline traverses several different types of terrain along its length. For reporting purposes the survey data has been separated into sections as detailed in the table below.

Table 4.0-2 Summary of Electrical Resistivity/Soil Corrosiveness by Section

Section	Approximate Chainage (meters)	Minimum (ohm-cm)	Maximum (ohm-cm)	Average (ohm-cm)	Corrosiveness Classification
Intake to Switchback	0 to 2650	5814	26316	11155	Very mildly corrosive
Switchback to Trestle	2650 to 3520	6329	11494	8080	Mildly corrosive
Trestle to Fell Creek	3575 to 4825	9346	14925	12474	Very mildly corrosive
Fell Creek to Anderson Creek	5050 to 5525	7407	10101	8692	Mildly corrosive
Anderson Creek to Reservoir	5800 to 7700	5208	11494	7733	Mildly corrosive
Total Pipeline	**0 to 7700**	**5208**	**26316**	**9627**	**Mildly Corrosive**

The soil resistivity survey provides an overview of the soils in which the pipeline traverses. The Geonics meter measures conductivity to a depth of approximately 1.52 meters. The pipeline depth varies along its length, therefore the soil resistivity at the actual pipe depth may differ from the resistivities recorded. The resistivity survey is a useful tool for determining areas where the soil environment may be ideal for the formation of corrosion cells. The survey also shows locations where the soil type or soil properties change rapidly, which is also a factor in determining the potential for corrosion. Graph A-1 in Appendix A details the overall trend in the resistivity data recorded. The lower resistivity areas may indicate locations along the pipe route where the soils are moist and the higher readings are indicative of gravel or well-drained areas.

Based on resistivity alone, it would appear that the soils along the pipeline route are generally only mildly corrosive.

6.0 AWWA C105 Soil Sample Analysis

In total 35 soil samples were excavated and tested as per the C105 Standard with 20 of the samples extracted from the Test Pit locations.

The AWWA/ANSI C105/A21.5-99 standard, Appendix A (Polyethylene Encasement for Ductile-Iron Pipe Systems) is a common North American standard used to assist in appraising the soil conditions that affect the corrosion rate of iron pipe. The Standard uses five tests with weighted values for each test. If the weighted score is equal to or greater than 10 points the soil is considered corrosive to ductile iron and protective methods are recommended, according to the Standard. Caution should be exercised if only the Standard C105 procedure is used to test the soils because it assumes the following:

- The pipe is not electrically continuous (this maybe true if only bell and spigot joints are used) and that neither long line currents/corrosion nor differential aeration corrosion will occur;
- Bacteria will only be supported and thrive in a neutral environment.
- The soil environment does not include coal, cinders, muck, peat, landfill areas high in foreign material etc.
- There are no stray electrical currents in the surrounding area from high-voltage AC or DC lines, cathodic protection systems or manufacturing facilities with DC operations;
- The corrosion rate of other buried structures in the area supports these findings.

The Standard also points out that a, "Uniquely Severe Environment" exists when all of the below co-exist:

A. Soil resistivity is less than or equal to 500 ohm-cm;

B. Anaerobic conditions in which SRB's (sulfate-reducing bacteria) thrive (pH of 6.5 to 7.5), low or negative redox and the presences of sulfides;

C. Water table is intermittently or continually above the invert of the pipe.

The test results are appended in Appendices B and D. A summary of the results of the soil sample analysis for each sample tested is detailed in the table below.

Table 5.0-1 Summary of AWWA Standard C105 Test Results

Sample Identification	Chainage (meters)	Electrical Resistivity (ohm-cm)	PH	Redox Potential (mV)	Sulfides	Soil Classification	AWWA C105 Score
S1	100	22,100	6.7	149	Trace	Dry brown loamy sand	2.0
TP1 Crown TP1 Invert	225	16,800 16,200	6.7 6.8	156 172	Trace Trace	Dry brown sand Dry brown sand	2.0 2.0
S2	600	19,500	6.8	131	Trace	Dry brown sand	2.0
TP2 Crown TP2 Invert	875	14,600 13,900	6.8 6.8	132 145	Trace Trace	Dry brown sand Dry brown sand	2.0 2.0
S3	1250	16,300	7.0	119	Trace	Moist brown sandy loam	3.0
TP3 Crown TP3 Invert	1725	21,300 20,500	7.1 6.9	176 184	Negative Negative	Dry brown sand Dry brown sand	0.0 0.0
S4	2075	14,100	6.6	168	Negative	Dry brown loamy sand	0.0
TP4 Crown TP4 Invert	2425	26,200 22,300	6.8 6.9	125 112	Trace Trace	Moist brown sand Moist brown sand	3.0 3.0
S5	2975	24,900	7.1	183	Trace	Dry brown loamy sand	2.0
S6	3500	12,200	6.6	111	Trace	Moist brown loamy sand	3.0
TP5 Crown TP5 Spring line	3600	18,400 17,800	6.8 6.9	122 131	Negative Negative	Dry brown sand Dry brown sand	2.0 2.0
S7	4025	13,500	6.8	118	Trace	Dry grey sandy loam	2.0
TP6 Crown TP6 Invert	4200	9,800 7,900	6.6 6.4	103 98	Trace Trace	Moist brown sand Wet brown sand	3.0 7.5
S8	4550	16,600	6.5	123	Trace	Moist brown loamy sand	3.0
TP7 Crown TP7 Invert	4825	26,300 24,800	7.1 6.9	133 128	Trace Trace	Dry brown sand Dry brown sand	2.0 2.0
S9	5100	22,500	6.8	191	Negative	Dry brown sand	0.0
S10	5500	17,400	6.7	126	Trace	Moist brown sand	3.0
S11	5800	12,200	6.7	99	Trace	Moist brown loamy sand	9.5
TP8 Crown	5875	23,500	6.8	111	Trace	Dry brown sand	2.0

TP8 Invert		22,600	6.9	119	Trace	Dry brown sand	2.0
S12	6175	11,500	6.8	115	Trace	Moist brown loamy sand	3.0
S13	6425	11,300	6.7	118	Trace	Moist brown sand	3.0
TP9 Crown TP9 Invert	6650	28,000 26,700	7.2 7.1	124 135	Trace Trace	Dry brown sand Dry brown sand	2.0 2.0
S14	6975	13,200	6.8	126	Trace	Moist brown sand	3.0
S15	7350	16,300	7.0	136	Trace	Moist brown sand	3.0
TP10 Crown TP10 Invert	7700	23,000 21,300	7.1 7.1	172 164	Trace Trace	Dry brown sand Dry brown sand	2.0 2.0

None of the 35 samples tested scored over ten points. Therefore according to the C105 Standard none of the soil samples tested are considered corrosive to iron pipe. The soil sample taken at the pipe invert in TP6 scored 7.5 points due to the presence of groundwater, a trace of sulfides and a redox potential less than 100 millivolts. Sample S11 scored 9.5 points due to the presence of sulfides in conjunction with low redox potential and a neutral pH. The remaining samples all scored between 0.0 and 3.0 points.

The resistivity results from the soil sampling generally agree with the results from the resistivity survey. The soil box results yielded slightly higher resistivity values than that from the Geonics survey. This slight difference is most likely attributed to the variation in depth and volume of the soil samples versus the Geonics readings. The Geonics readings are averaged over a greater depth and larger soil volume while the soil samples are more location specific representing a small soil volume in a specific location.

7.0 Stray Electrical Currents

Stray DC electrical currents can accelerate corrosion on buried utilities in the vicinity of foreign impressed current cathodic protection (ICCP) systems such as those operated by Terasen Gas. Levelton contacted Terasen Gas and was informed that the nearest rectifier protecting their gas distribution system was located on Innes Street near Stanley Street. Levelton installed an electronic current interrupter on this rectifier and measured the pipe-to-soil potentials on the pipeline at Test Pit #10 near the reservoir.

Stray currents are evident when the pipe-to-soil potentials shift with the interruption cycle of the suspected current source. The magnitude and the polarity of the potential shift determine the amount of stray current and whether it is flowing to or discharging from the piping. Corrosion rates increase at any point where current discharges from a metallic structure.

No indication of stray current interference from the Terasen Gas ICCP system was noted on the pipeline near the reservoir.

The AC potentials recorded at the time of testing were in the range of 1 mV to 5 mV. These potentials do not present a corrosion problem or a shock hazard to the existing pipeline. It is generally accepted that 15 volts AC or greater is cause for concern from a safety standpoint.

Pipe-to-soil potential data for each test pit can be found in Appendix C.

8.0 TEST PIT EXCAVATIONS

City personnel excavated the pipeline in 11 locations. Locations for the excavations were chosen to provide an even distribution of inspection pits along the length of the pipe and possible worst case locations based on the terrain and the soil resistivity survey. In addition the pipe was inspected in two locations within the Bealby Trestle crossing. Complete inspection data for each Test Pit can be found in Appendix D.

After the inspection and testing was completed in each test pit, the exposed pipe was wrapped with Trenton petrolatum tape and primer. One 7.7 kg high potential magnesium anode was thermite welded to the exposed pipe at each test location, excluding Test Pit No's 5, 7 and 7a. Two anodes were installed at Test Pit No. 4. The magnesium anodes will provide some cathodic protection to the pipe in the area of the inspection and possibly beyond. The total length of pipe that will receive protection from the anodes is dependent on the condition of the exterior pipe coating and the electrical continuity along the pipe.

The test results for each test pit are as follows:

8.1 TEST PIT NO. 1

Test Pit No. 1 was excavated at chainage 0+225 meters. The water main was found to be 300 mm diameter cast iron. Samples of the soil were taken from the crown and invert of the pipe and tested as per AWWA Standard C105 Appendix A as detailed in Section 5.0 above. The two soil samples scored 2.0 points according to the Standard and are not considered corrosive to iron pipe. Large rocks approximately 100 to 200mm in diameter were found surrounding the main. No ground water was present in the excavation.

The pipe coating was estimated to be 80% intact and corrosion product was evident on the pipe surface. Image 1 shows the pipe as excavated at this location.

Image 1 – Water Main as Excavated

To allow for further inspection the water main was sand blasted. Image 2 shows the water main after sand blasting. Very small and shallow pits were found on the exterior pipe surface. The pit depths ranged from 10 to 70 mils (0.25 mm to 1.8 mm). The pit depth readings are shown in the field inspection form in Appendix D.

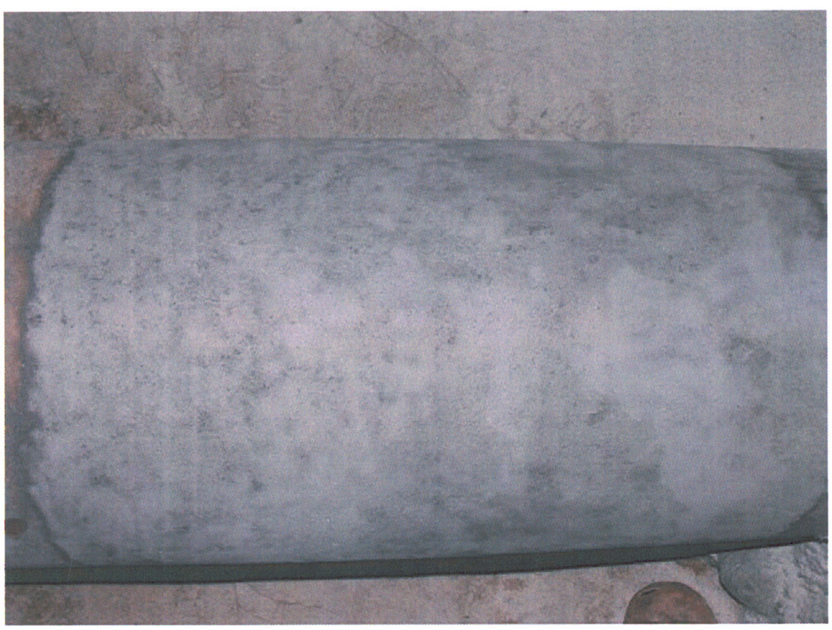


Image 2 – Water Main after Sand Blasting

The wall thickness of the pipe was measured using an ultrasonic thickness gage. The readings are detailed in the field inspection form in Appendix D. The wall thickness ranged from 9.2 to 14.1 mm. The average wall thickness was 12.5 mm. According to the original specification the nominal wall thickness is 14.0 mm. Using this value the deepest external pit found has penetrated approximately 13% through the pipe wall. The wall thickness readings indicated that significant thinning from the inside has not occurred in the area tested, with the lowest measurement only 35% below the nominal thickness.

Extreme Value Statistical Analysis (EVSA) was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D. The pit depth data is plotted on a semi-log scale with the corrosion pits plotted on the "x" axis and ranked in order from 1 (deepest) to whatever number is suitable for designating the shallowest pit. The pit depths are plotted on the "y" axis. By doing this, the data can be subjected to EVSA. This procedure recognizes that the deepest and shallowest corrosion pits on a water main are not likely to be found on a small section of pipe. A much longer section would have to be examined before the deepest and shallowest pits are found. However, the analysis of pit depths on a test section of a given size can demonstrate whether or not deeper pits are likely to be found and the frequency of their occurrence.

The slope of Graph D-1 in Appendix D illustrates the probable difference between the shallowest and deepest pits. Since pit depths follow a Gaussian distribution, a straight-line plot should result. Using Microsoft Excel software, a best-fit line was drawn through the data points for the data.

A very steep slope indicates that much deeper corrosion pits exist on the water main than were found in the test pit. Conversely, a shallow slope indicates that the probability of deeper corrosion pits occurring is much smaller.

The only significance of Rank 1 is that it is the number assigned to the deepest pit measured. This means that the line can be extrapolated to find the probable deepest corrosion pit and the pipe length that must be inspected to find a wall perforation. The extrapolation can be achieved by simply "folding" the plot for each cycle. Each "fold" represents an area ten times as large as that examined.

To project the number of perforations that will occur, a length of water main must be selected. The calculations shown below assume that the pipe condition was applicable to the total length of the 300mm section of the cast iron main. The length of 300mm main estimated was based on the drawing provided by the City.

It should be noted that the projected number of wall perforations and the length of water main that must be inspected to find a wall perforation are only estimates and should not be treated as precise values.

The probability of a wall perforation occurring on the 300 mm diameter cast iron water main based on Graph D-1 in Appendix D is as follows:

Table 7.1-1
Probability of Perforations in
300mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 1600 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	9.7×10^{11}	9.7×10^{11}	0

The analysis revealed that an external corrosion leak in the 300 mm diameter section of the cast iron water main that extends from the intake to the location where the water main changes to 250-mm diameter pipe is extremely unlikely based on the condition of the exterior of the pipe that was examined in Test Pit No.1.

Mathematical equations developed by John R. Rossum can be used to predict the time-to-first leak and the number of leaks that can be expected from external corrosion on a buried metallic pipeline over a given period of time. The equations were based on U.S. National Bureau of Standards empirical relationships and corrosion data developed in a test program for different piping materials placed in a variety of soils over a period of 35 years. Rossum's equations could not be used to predict the number of leaks that could occur in the pipe in a given period of time because the pipe is bell and spigot cast iron with cement mortar joints. The resistance was measured across accessible joints and the resistance readings were high indicating that there is a lack of electrical continuity across the pipe joints where cement mortar was used. Rossum's equations require an electrically continuous pipe before they can be used to predict the number of leaks. This applied to all cast iron water main locations that were inspected during this project.

8.2 Test Pit No. 2

Test Pit No. 2 was excavated at chainage 0+875 meters. The water main was found to be 300 mm diameter cast iron. Samples of the soil were taken from the crown and invert of the pipe and tested as per AWWA Standard C105 Appendix A as detailed in Section 5.0 above. The two soil samples scored 2.0 points according to the Standard and are not considered corrosive to iron pipe. The pipe was found to be lying on a bed of large rocks. No ground water was present in the excavation. The pipe joint within the excavation was cement mortar. The resistance across the joint was measured to be 9.1 ohms, indicating that the joint is not electrically continuous.

The pipe coating was estimated to be 75% intact and corrosion product was evident on the pipe surface. Image 3 shows the pipe as excavated at this location.

Image 3 – Water Main as Excavated

The water main was sand blasted to allow for further inspection and is shown in Image 4. Very small and shallow pits were found on the pipe surface. The pit depths ranged from 10 to 70 mils (0.25 mm to 1.8 mm). The pit depth readings are shown in the field inspection form in Appendix D.

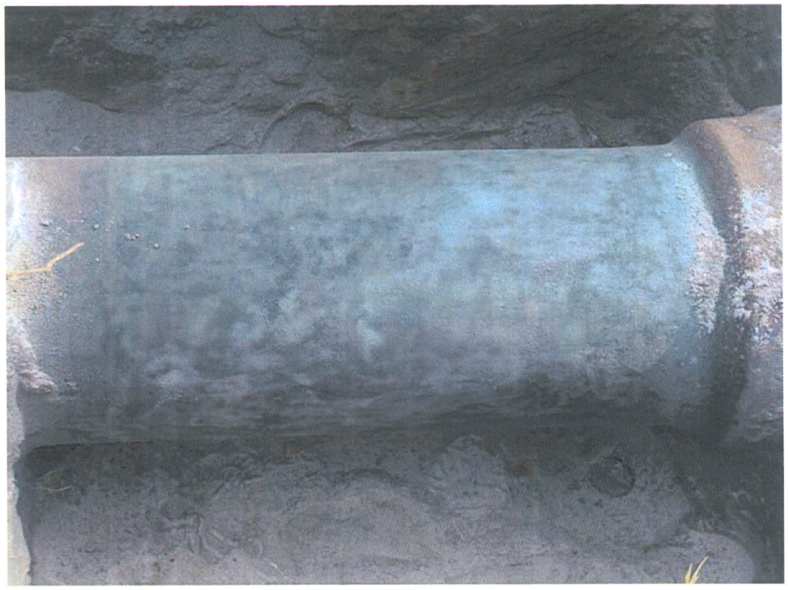


Image 4 – Water Main after Sand Blasting

The wall thickness of the pipe was measured using an ultrasonic thickness gage. The readings are detailed in the field inspection form in Appendix D. The wall thickness ranged from 9.7 to 14.2 mm. The average wall thickness was 12.62 mm. According to the original specification the nominal wall thickness is 14.0 mm. Using this value the deepest external pit found has penetrated approximately 13% through the pipe wall. The wall thickness readings indicated that significant thinning from the inside has not occurred, with the lowest measurement only 31% below the nominal thickness.

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 300 mm diameter cast iron water main based on Graph D-2 in Appendix D is as follows:

Table 7.2-1
Probability of Perforations in
300mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 1600 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	9.4×10^{14}	9.4×10^{14}	0

The analysis revealed that an external corrosion leak in the 300 mm diameter section of the cast iron water main that extends from the intake to the location where the water main changes to 250-mm diameter pipe is extremely unlikely based on the condition of the exterior of the pipe that was examined in Test Pit No.2.

8.3 Test Pit No. 3

Test Pit No. 3 was excavated at chainage 1+725 meters. The water main was found to be 250 mm diameter cast iron at this location. Samples of the soil were taken from the crown and invert of the pipe and tested as per AWWA Standard C105 Appendix A. Both samples scored 0.0 points according to the Standard and are not considered corrosive to iron pipe. The pipe was found to be surrounded by large rocks and the fill material was very dry. No ground water was present in the excavation.

The pipe coating was estimated to be 85% intact and small amounts of corrosion product were evident on the pipe surface. Image 5 shows the water main as excavated.

Image 5 – Water Main as Excavated

The water main was sand blasted to allow for further inspection as shown in Image 6. Very small and shallow pits were found on the pipe surface. The pit depths ranged from 10 to 60 mils

(0.25 mm to 1.5 mm). The pit depth readings are shown in the field inspection form in Appendix D.

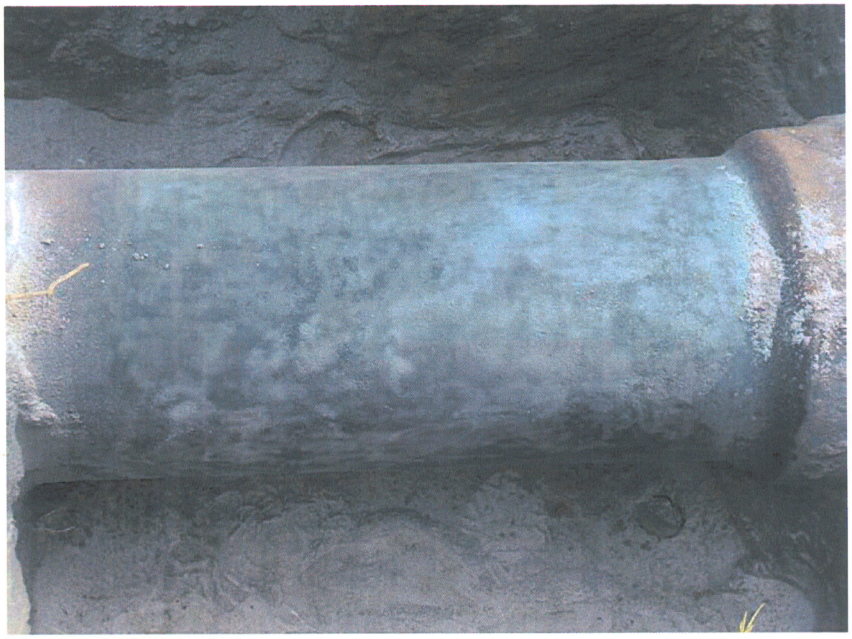


Image 6 – Water Main after Sand Blasting

The wall thickness of the pipe ranged from 9.7 to 13.2 mm. The average wall thickness was 12.3 mm. The readings are detailed in the field inspection form in Appendix D. The original specification stipulated a 13-mm nominal wall thickness. Using this value, the deepest external pit found has penetrated approximately 11.5% through the pipe wall. The wall thickness readings in the locations tested indicate that significant thinning from the inside has not occurred, with the lowest measurement only 25% below the nominal thickness.

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 250 mm diameter cast iron water main, between the locations where the pipe diameter changes to 250 mm and where the pipe material changes to steel, based on Graph D-3 in Appendix D is as follows:

Table 7.3-1
Probability of Perforations in
250mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 3075 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	9.9×10^{13}	9.9×10^{13}	0

The analysis revealed that an external corrosion leak in the 250 mm diameter section of the cast iron water main is extremely unlikely based on the condition of the exterior of the pipe that was examined in Test Pit No.3.

8.4 TEST PIT NO. 4

Test Pit #4 was excavated at chainage 2+425 meters. The pipe at this location was found to be 250 mm diameter. Image 7 below shows the pipe as excavated. The location of this test pit was chosen due to the fact that the pipe was currently leaking. Numerous attempts had been made to repair the leaking joint over time, however all were unsuccessful. Image 7 shows a repair

Image 7 – Water Main as Excavated

clamp on the spigot adjacent to the bell. This location was selected for removal of a pipe section for analysis in the laboratory of Levelton. This would facilitate repairing the leak as well as providing a sample of pipe for analysis. Soil samples were taken from the crown and invert of the pipe and tested as per the C105 Standard. Both samples scored 3.0 points and according to the Standard are not considered corrosive to iron pipe. The pipe was visually inspected and general field observations were noted. A full laboratory analysis was completed on the pipe from this location and the results are discussed in Section 8.0 of this report.

It was estimated that the external coating was 85% intact and only small amounts of corrosion product were visible on the surface of the pipe. The joint within the excavation was sealed with concrete mortar originally and it appeared to have been repaired at some point with lead. The electrical resistance measured across the joint was zero, indicating electrical continuity through the joint, most likely due to the lead used to repair the joint.

8.5 Test Pit No. 5

Test Pit No. 5 was excavated at chainage 3+600 meters. An exposed blow-off valve was found at this location and the top of the main was exposed. Image 8 shows the pipe as found at this location. Attempts were made to excavate around the main however due to large rocks and roots, excavation using hand tools was not practical. The contractor working on site was asked

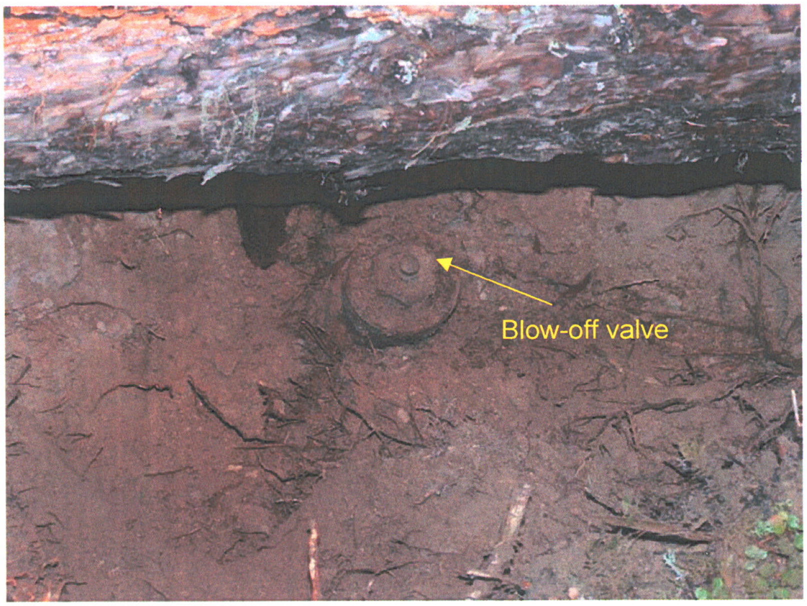


Image 8 – Exposed Blow-off Valve as Found

to install a covered casing around the valve for protection from the elements and/or vandalism.

Soil samples were taken from the crown and spring line at this location, because the invert of the pipe was not exposed. Both samples scored 2.0 points and are not considered corrosive to iron piping, according to the C105 Standard.

The pipe was not sand blasted at this location due to accessibility difficulties after the contractor installed the casing. A visual analysis of the top half of the main was conducted. It was estimated that the coating was 90% intact and no corrosion product was noted. No evidence of significant pitting corrosion was found.

8.6 Test Pit No. 6

Test Pit No. 6 was excavated at chainage 4+200 meters. The location of this test pit was chosen because the terrain indicated that the pipe may be exposed to wet soils as it was a low-lying area. The pipe at this location was 250 mm diameter cast iron. The entire surface of the pipe was covered with tightly adhered corrosion product and no intact coating was evident. Ground water was present at the invert elevation. Image 9 shows the water main as excavated. Soil samples were gathered from the crown and invert of the pipe and tested as per the C105 Standard. The samples scored 3.0 and 7.5 point respectively. The sample at the pipe invert

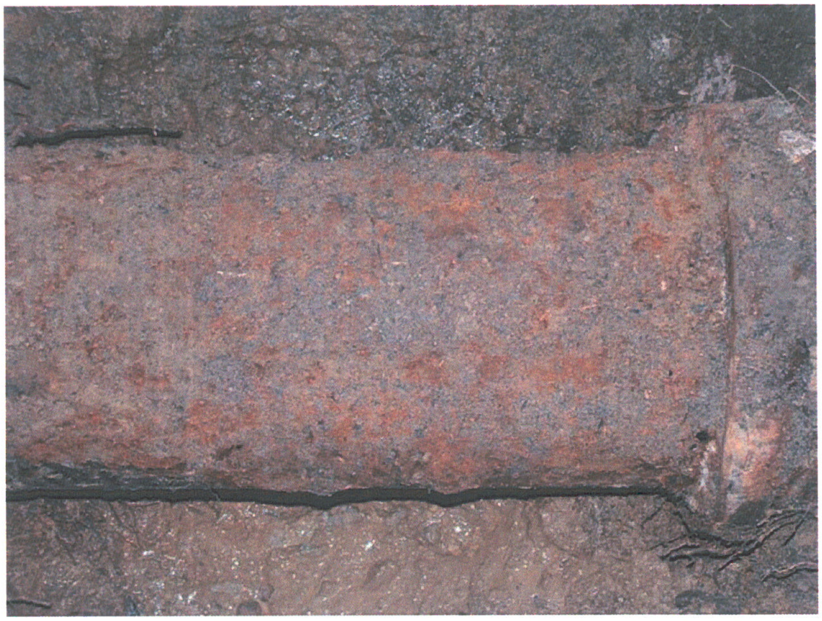


Image 9 – Water Main as Excavated

scored 7.5 points because it was wet, the redox potential was low and sulfides were present. However according to the Standard these soils are not considered to present a corrosion problem to iron piping.

The corrosion product that was present was removed with hand tools prior to sand blasting because the sandblasting unit was unable to remove the corrosion product. Once the corrosion product was removed the pipe was sand blasted again revealing numerous corrosion pits on the pipe surface. Image 19 shows the pipe after sand blasting.

Image 10 – Water Main after Sand Blasting

The pit depths ranged from 20 to 180 mils (0.5 mm to 4.6 mm). The pit depth readings are shown in the field inspection form in Appendix D. Image 11 shows the deep corrosion pitting found on the exterior pipe surface.

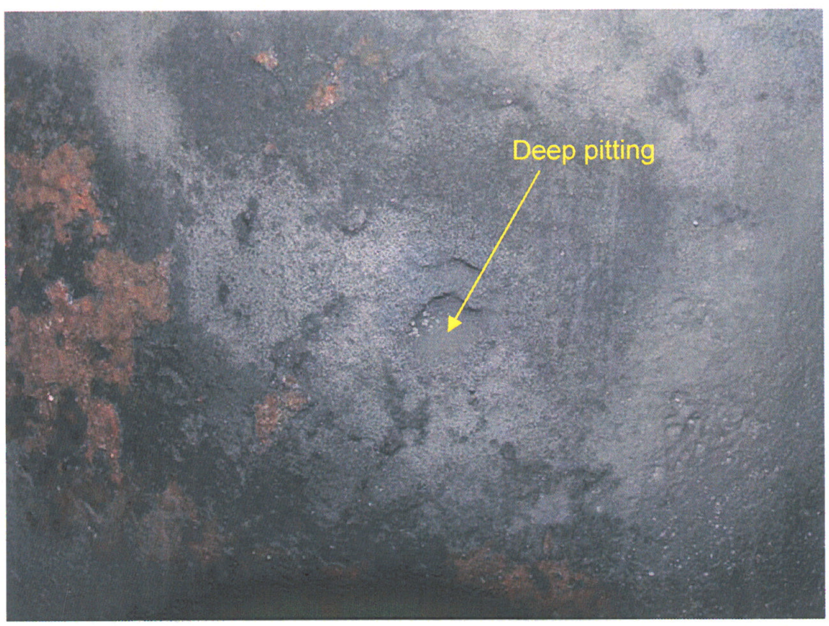


Image 11 – Deep Corrosion Pitting

The wall thickness of the pipe ranged from 8.8 to 12.7 mm. The average wall thickness was 11.2 mm. According to the original specification the nominal wall thickness is 13.0 mm. Using this value the deepest external pit found has penetrated approximately 35% through the pipe wall. The wall thickness readings indicated that significant thinning from the inside has not occurred, with the lowest measurement only 32% below the nominal thickness.

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 250 mm diameter cast iron water main, between the locations where the pipe diameter changes to 250 mm and where the pipe material changes to steel, based on Graph D-6 in Appendix D is as follows:

Table 7.6-1
Probability of Perforations in
250mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 3075 Meters of Water Main from External Corrosion at the Present Time
0.5	Exterior	3.5×10^4	17,500	0

The analysis revealed that an external corrosion leak in the 250 mm diameter section of the cast iron water main is unlikely based on the condition of the exterior of the pipe that was examined in Test Pit No.6. However it should be noted that external corrosion pitting on the pipe was deeper than observed at any other location. If the pipe develops a leak from external corrosion, it is most likely to occur in this area where the soils are wet and more corrosive to cast iron pipe.

8.7 TEST PIT NO. 7

Test Pit No. 7 was excavated at chainage 4+825 meters. The pipe at this location was 250 mm diameter steel. The coating on the steel pipe was found to be 95% intact and tightly adhered to the pipe surface. The coal tar coating was supplemented with a woven fabric impregnated with coal tar to provide greater strength and durability. Image 12 shows the pipe as excavated.

Image 12 – Water Main as Excavated

Soil samples were taken from the crown and invert of the pipe at this location. The soils each scored 2.0 points as per the C105 Standard. According to the Standard these soils are not considered corrosive to iron pipe.

Access for the sand blasting equipment at this location was not practical. A visual examination of the pipe was performed. A small piece of the coating was removed to expose the surface of the steel pipe. The pipe appeared to be in excellent condition with no evidence of corrosion. The rest of the coating was left intact. No corrosion pits were found in the small area where the steel substrate was exposed. Ultrasonic thickness measurements were also recorded in this location. The average of the measurements was 6.84 mm. According to the original project specification the wall thickness of the steel pipe was specified to be 2/3 I.W.G. This value refers to the Imperial Wire Gage (IWG) standard and equates to a thickness range of 6.4 to 7.01 mm. The recorded thickness of the steel pipe at this location falls within the specified range.

8.8 Test Pit No. 7A

Test Pit No. 7A was excavated at chainage 5+100 meters. The pipe at this location was 250 mm diameter steel. The crown of the pipe was exposed and it was estimated that the coating was 95% intact. The coating was tightly adhered to the pipe. Corrosion product was evident at a location where the coating was damaged, however no evidence of pitting was found on the steel.

One soil sample, S9, was taken at this location and scored 0.0 points and is not considered corrosive according to the C105 Standard.

Sand blasting was not practical at this location, nor was it warranted due to the excellent condition of the pipe coating. Image 13 shows the pipe as excavated at this location.

Image 13 – Water Main as Excavated

8.9 Test Pit No. 8

Test Pit No. 8 was excavated at chainage 5+875 meters. The pipe at this location was 250 mm diameter steel. The coating was estimated to be 95% intact and was tightly adhered to the pipe. Soil samples were taken from the crown and invert of the pipe and tested as per the C105 Standard. The samples both scored 2.0 points and are not considered corrosive. Image 14 shows the pipe as excavated at this location.

Image 14 – Water Main as Excavated

The coating was removed with hand tools and then the pipe was sand blasted. Once sand blasted the pipe surface appeared to have a dimple pattern similar to the pattern of the fabric within the coating. Image 15 shows the dimple pattern on the steel pipe surface.

The depth of the surface profile irregularities were measured using a pit depth gage. The depth of the irregularities were very shallow and ranged from 10 to 30 mils (0.5 mm to 0.76 mm). The thickness of the pipe wall was measured using an ultrasonic thickness gage. The wall thickness measurements ranged from 6.05 mm to 7.29 mm. The nominal specified wall thickness was 6.4mm to 7.01 mm. Significant wall thickness loss is not evident from the wall thickness readings.

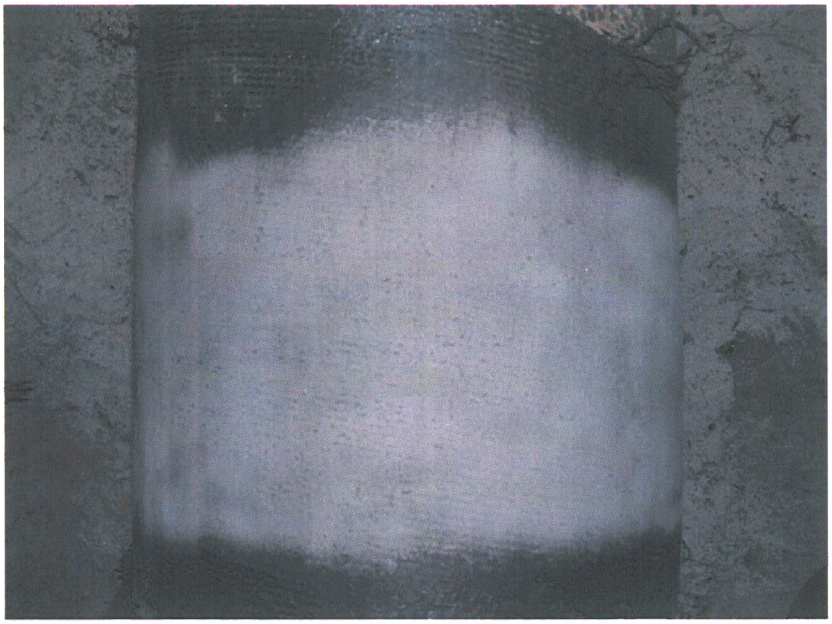


Image 15 – Dimple Pattern on Pipe Surface

EVSA was used to analyze the exterior pit depth data from the steel water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 250 mm diameter steel water main, between chainage 4+ 675 meters, the approximate location where the pipe changes to steel to chainage 6+100 meters, the approximate location where the pipe changes back to cast iron based on Graph D-7 in Appendix D is as follows:

Table 7.8-1
Probability of Perforations in
250-mm Steel Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 1425 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	9.0×10^{13}	9.0×10^{13}	0

The analysis revealed that an external corrosion leak in the 250 mm steel water main is unlikely based on the condition of the exterior of the pipe that was examined at this location.

8.10 Test Pit No. 9

Test Pit No. 9 was excavated at chainage 6+650 meters. The pipe at this location was 250 mm diameter cast iron. It was estimated that the coating was 90% intact and little or no corrosion product was evident on the pipe surface. Large rocks were found surrounding the main at this location. Soil samples were taken from the crown and invert of the main and tested as per the C105 Standard. The samples both scored 2.0 points and are not considered corrosive to iron pipe. Image 16 shows the pipe as excavated.

Image 16 – Water Main as Excavated

The pipe was sand blasted to remove the coating and expose any corrosion on the pipe surface. Image 17 shows the pipe after sand blasting. Very small shallow corrosion pits, ranging in depth from 10 to 50 mils (0.5 mm to 1.27 mm) were measured on the pipe surface.

The wall thickness was measured using an ultrasonic thickness gage. The wall thickness ranged from 9.98 mm to 13.2 mm, with an average thickness of 11.5 mm. The nominal wall thickness for the 250 mm cast iron pipe was 13 mm. The deepest pit that was found represents a wall penetration of approximately 10%. Thinning of the wall from the inside does not appear to be significant in the locations tested; the lowest recorded reading was 9.98 mm representing a thickness loss of approximately 23%.

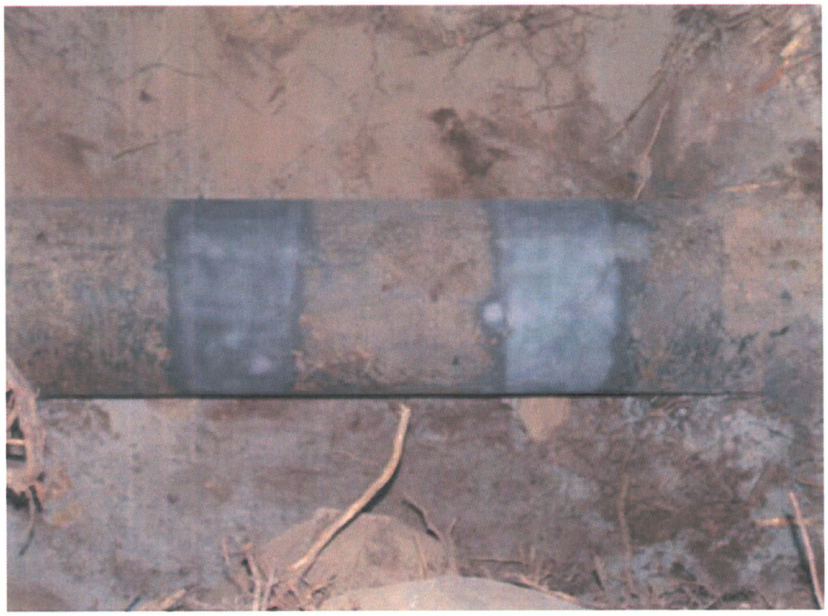


Image 17 – Water Main after Sand Blasting

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 250 mm diameter cast iron water main, between the locations where the pipe material changes from steel at approximately chainage 6+100 meters to the breaker box at chainage 7+650, based on Graph D-8 in Appendix D is as follows:

Table 7.9-1
Probability of Perforations in
250mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 1550 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	7.0×10^{19}	7.0×10^{19}	0

The analysis revealed that an external corrosion leak in the 250 mm diameter section of the cast iron water main is extremely unlikely based on the condition of the exterior of the pipe that was examined.

8.11 TEST PIT NO. 10

Test Pit No. 10 was excavated within the reservoir compound at chainage 7+700 meters. According to the drawing provided by the City, the pipe at this location was supposed to be 250 mm diameter steel when in fact the pipe was found to be 300 mm diameter cast iron. The pipe was exposed revealing a heavy layer of corrosion product on the crown of the pipe between 10 o'clock and 2 o'clock. It was estimated that the pipe coating was 70% intact. Image 18 shows the pipe as excavated. Soil samples were taken from the crown and invert of the pipe and tested as per the C105 Standard. The two samples scored 2.0 points and are not considered corrosive to iron pipe.

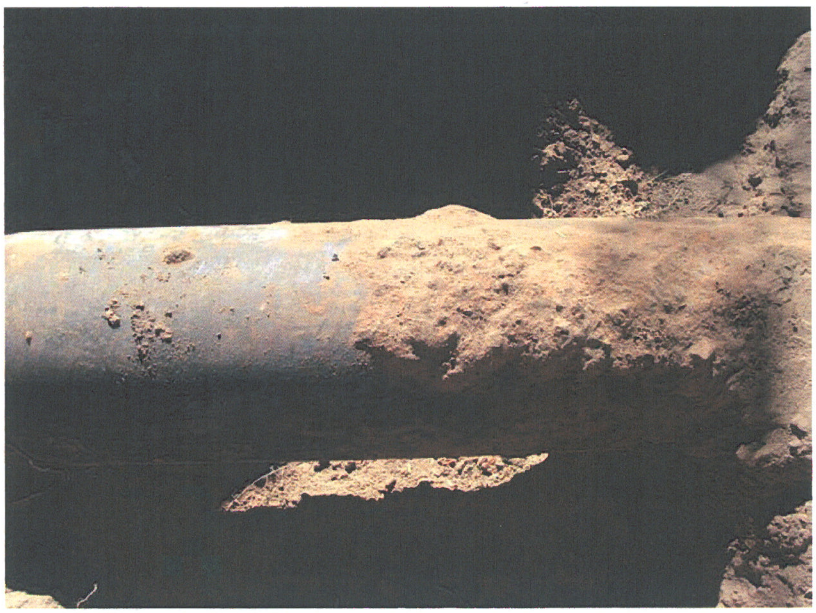


Image 18 – Water Main as Excavated

The corrosion product was removed with hand tools and the pipe was sand blasted. Image 19 shows the pipe after sand blasting. Corrosion pitting was evident on the pipe surface after sand blasting. The depth of the pits were measured using a pit depth gage. The depth of the pits ranged from 10 to 170 mils (0.25 to 4.38mm). The wall thickness of the pipe was measured and ranged from 10.9 mm to 13.9 mm with an average thickness of 12.4 mm. The nominal wall thickness of the 300 mm diameter cast iron pipe was specified to be 14 mm. Therefore the deepest recorded pit has penetrated the wall by approximately 31%. Thinning of the wall from the interior did not appear to be significant from the thickness readings. The lowest thickness measurement indicated thinning of the wall by approximately 22.5%.

Image 19 – Water Main after Sand Blasting

Image 20 shows the deep corrosion pitting found on the crown of the pipe at this location.

Image 20 – Deep Corrosion Pitting

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D.

The probability of a wall perforation occurring on the 300 mm diameter cast iron water main, between the breaker box at chainage 7+650, where the pipe diameter changes from 250 mm to 300 mm to the reservoir, based on Graph D-9 in Appendix D is as follows:

Table 7.11-1
Probability of Perforations in
300mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in Approximately 50 Meters of Water Main from External Corrosion at the Present Time
1.0	Exterior	4.0×10^5	4.0×10^5	0

The analysis revealed that an external corrosion leak in the 300 mm diameter section of the cast iron water main is extremely unlikely based on the condition of the exterior of the pipe that was examined in Test Pit No. 10.

8.12 Trestle Crossing

The pipe transcends through a concrete coffin under the walkway of the Bealby Trestle between chainage 3+525 meters and 3+550 meters. According to the City of Nelson, the pipe was

Image 21 – Exposed Water Main within Trestle

originally backfilled with sand to prevent damage from frost. At some point the sand was removed due to loading concerns and the space was filled with pearlite insulation. The pearlite had since been removed and the pipe was wrapped in fiberglass insulation. Image 21 on the previous page shows the pipe and insulation within the trestle.

The insulation was removed in two locations approximately 300 mm in width. The pipe was cleaned with power tools to allow for further inspection. No corrosion was evident on the exterior surface of the pipe in either location. The coating appeared to be approximately 95% intact in both locations.

Ultrasonic thickness measurements were attempted, however stable and repeatable measurements were difficult to obtain due to inadequate cleaning of the pipe surface for the thickness gage. The data set for the thickness measurements can be found in the field inspection form in Appendix D. The measured thickness ranged from 7.56 mm to 12.81 mm with an average of 9.84 mm. The pipe at this location is 250 mm diameter cast iron with a specified wall thickness of 13 mm. The accuracy of these wall thickness values is suspect based on the instability of the instrument and the results gathered from the other test pits along the pipeline.

9.0 PIPE SAMPLE LABORATORY ANALYSIS

9.1 VISUAL INSPECTION OF THE PIPE SAMPLE

The length of pipe removed from Test Pit No. 4 was approximately 1.8 meters. Image 22 shows

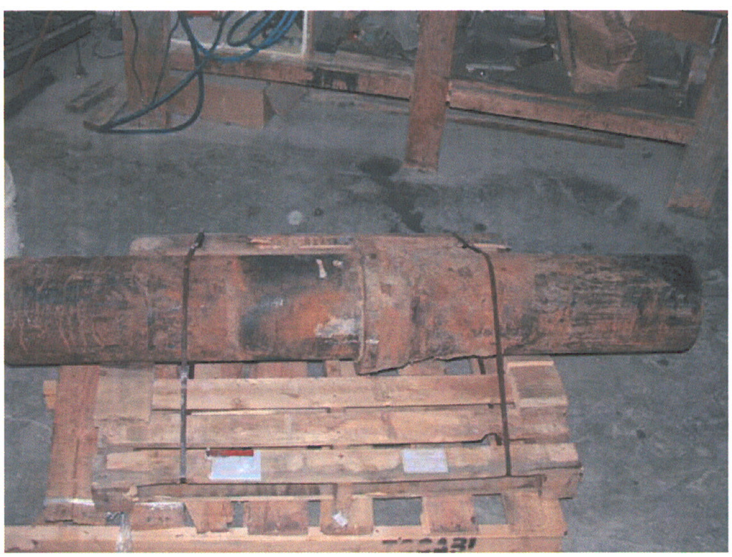


Image 22 – Pipe Sample as Received

the pipe in the as-received condition. The pipe was covered with a layer of dirt however there was some evidence of corrosion on the exterior.

The pipe was sectioned into smaller pieces for ease of handling and to allow for inspection of the interior. Image 23 shows the pipe after sectioning. The 200-mm long section shown on the right was sent to the Levelton metallurgical laboratory for physical testing to determine the crush strength of the pipe.

Image 23 – Pipe Sample after Sectioning

After sectioning the pipe was washed with high-pressure water to remove dirt and any corrosion product that was present. It was evident that a black coating was present on both the exterior and interior surfaces of the pipe. In areas where the coating had failed on the exterior, corrosion was evident on the pipe. Images 24 and 25 show the typical appearance of the pipe surface after washing. According to the original project specification provided by the City of Nelson, the pipe was dipped in hot coal tar pitch.

Image 24 – Typical Exterior **Image 25 - Typical Interior**

The sections of pipe were then sandblasted both externally and internally. Image 26 below shows the condition of the sectioned pipe after sandblasting.

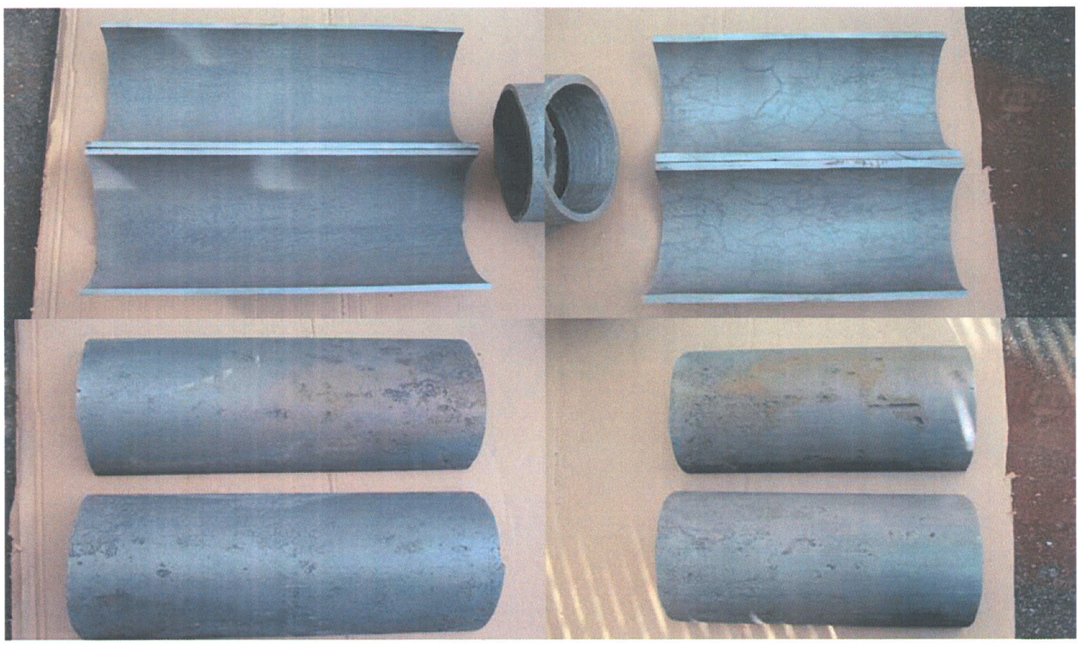


Image 26 – Sectioned Pipe after Sand Blasting

The worst corrosion was found on the exterior surface of the water main. Virtually no corrosion was evident on the interior surface. Image 27 shows the typical corrosion pitting found on the exterior of the pipe.

Image 27 – Corrosion Pitting on Exterior Surface

Corrosion pitting was evenly distributed around the circumference of the pipe, indicating a fairly uniform soil environment surrounding the pipe. The corrosion pits were generally shallow in depth. The corrosion pits found on the spigot section of pipe ranged from 20 to 100 mils (0.5 to 2.5 mm). The pits found on the bell section of pipe ranged from 20 to 130 mils (0.5 to 3.3 mm). The original specification stipulated a 13-mm nominal wall thickness. Using the deepest pit found, 3.3 mm, this represents a penetration through the wall of approximately 25%. The actual measured thickness of the pipe wall in the location adjacent to the 3.3 mm deep pit was 15.2 mm. The complete set of corrosion pit measurements can be found in the Test Pit No. 4 inspection form in Appendix D.

EVSA was used to analyze the exterior pit depth data from the cast iron water main detailed in the field inspection form in Appendix D. Both the spigot end and bell end section of main were subjected to the analysis.

The probability of a wall perforation occurring on the 250 mm diameter cast iron water main, between the locations where the pipe diameter changes to 250 mm and where the pipe material changes to steel, based on Graphs D-4 and D-5 in Appendix D is as follows:

Table 8.1-1
Probability of Perforations in
250mm Cast Iron Water Main

Pipe Length Inspected (meter)	Pipe Surface	Approximate Extrapolation Factor	Approximate Pipe Length that Must be Inspected to Find Perforation (meters)	Projected Number of Leaks in 3075 Meters of Water Main from External Corrosion at the Present Time
0.5 (bell end)	Exterior	1.0×10^{10}	5.0×10^{9}	0
0.5 (spigot end)	Exterior	9.2×10^{6}	4.6×10^{6}	0

The analysis revealed that an external corrosion leak in the 250 mm diameter section of the cast iron water main is extremely unlikely based on the condition of the exterior of the pipe sample.

An ultrasonic thickness survey was conducted on both the spigot section of pipe and bell section. The thickness readings measured on the spigot section ranged from 11.11 mm to 13.07 mm, with an average reading of 12.0 mm. The thickness readings measured on the bell section of the pipe ranged from 12.55 mm to 15.88 mm, with an average thickness of 14.3 mm. It is interesting to note that the thickness of the pipe at the spigot end is on average more than 2 mm

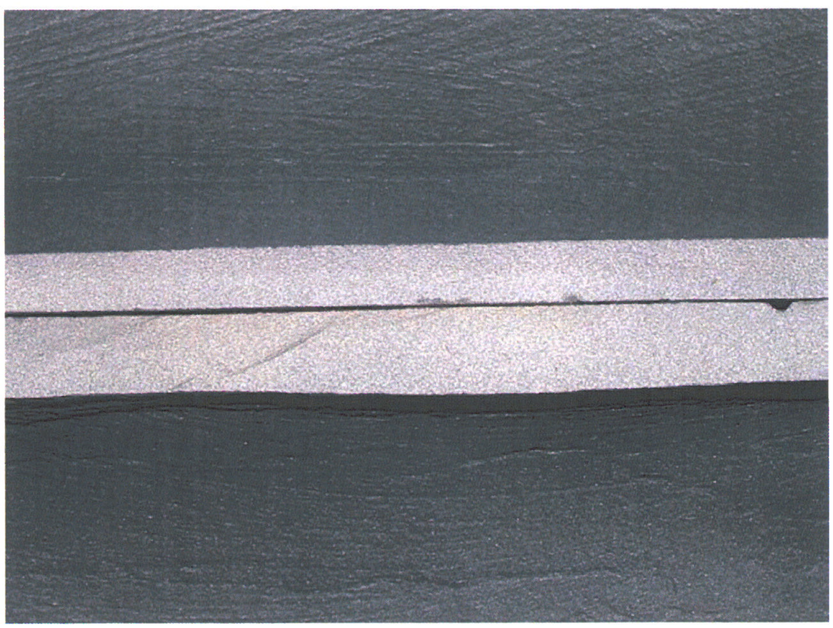


Image 28 – Difference in Wall Thickness between Spigot and Bell

thinner than the pipe at the bell end. Image 28 on the previous page shows the profile of the two sections of pipe side by side. The difference in thickness is very apparent. This variation in wall thickness is likely due to the casting process that was used to manufacture the pipes. The specified thickness for the 250 mm diameter cast iron pipe was 13 mm.

9.2 Mechanical Testing of Pipe Sample

One section of the pipe underwent ring testing to assess the crush strength of the pipe. The test was conducted as per AWWA Standard C108-1970. According to the Standard the minimum modulus of rupture is 40,000 psi. The results of the testing on the pipe sample indicated the modulus of rupture of the sample was 36,385 psi. Therefore, the pipe did not meet the 1970 standard design modulus of rupture for 10-inch cast iron pipe. The failure of the pipe under load was at the 3 o'clock and 9 o'clock positions.

The original specification states that the pipe was manufactured in France, in 1925 in accordance with the "City of Paris Standard". An unsuccessful attempt to find information on this standard was conducted, however due to the vintage of the pipe it is likely that the pipe was pit cast or poured in sand lined molds rather than centrifugally or spun cast. Pit cast pipes tend to have much larger graphite flakes than spun cast pipes (see Image 29).[2] The graphite flakes are much larger thereby weakening the structure. Therefore smaller flakes and their more uniform distribution in spun cast pipes mean that the pipes are generally significantly stronger than pit cast pipes.

Sand Cast Iron

Spun Cast Iron

Image 29 – Difference in Graphitic Structure between Sand & Spun Cast Pipe

Therefore the modulus of rupture measured on the pipe sample is probably representative and reasonable for pipe from that era.

Image 30 shows the profile of the fracture at the point of failure. Note the apparent voids and defects within the casting.

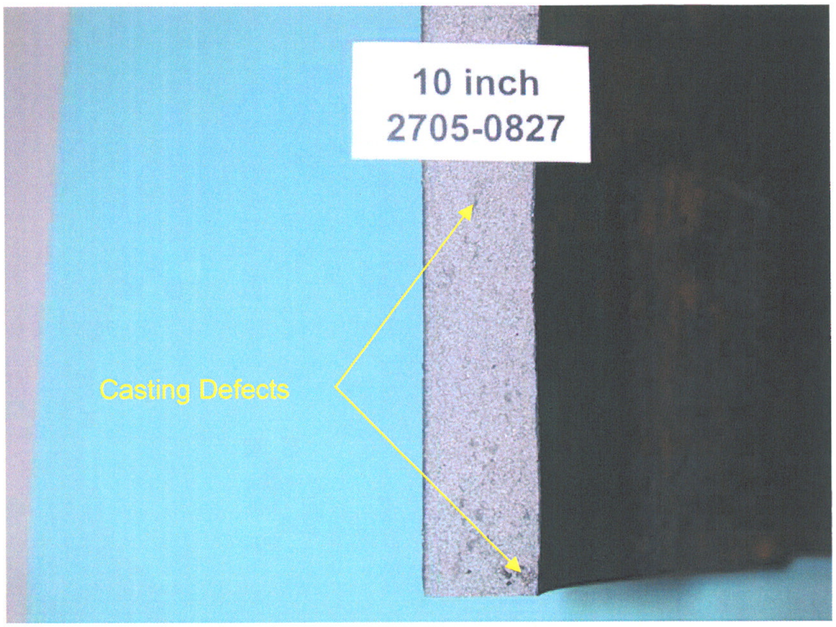


Image 30 – Defects in Fracture Surface

9.3 EXAMINATION OF PIPE JOINT

An examination of the pipe joint showed that it was generally in good condition. The joint was a typical bell and spigot, however it appeared that the spigot end was not a factory spigot due to the uneven, rough appearance and the absence of a lip. Image 31 shows the spigot end of a pipe that was never installed, note the lip at the end.

Image 31 – Factory Spigot End

Image 32 below shows the spigot end of the pipe within the joint. Note the missing lip and uneven surface.

Image 32 – Spigot End of Pipe Sample

The joint seal was originally made with concrete mortar, however it appears that the mortar failed at some point in time and a repair was attempted with lead. Due to the apparent failure at the joint, the leaking water, under pressure caused erosion corrosion on the spigot end from the external side. It is not known how long the joint was leaking prior to the erosion hole penetrating through the pipe wall. Images 33 and 34 show the erosion hole from the external and internal surfaces. It is clear that the hole originated from the outside of the pipe and not the inside. Due to the shape and appearance and location of the hole, soil corrosion is not considered to be the cause.

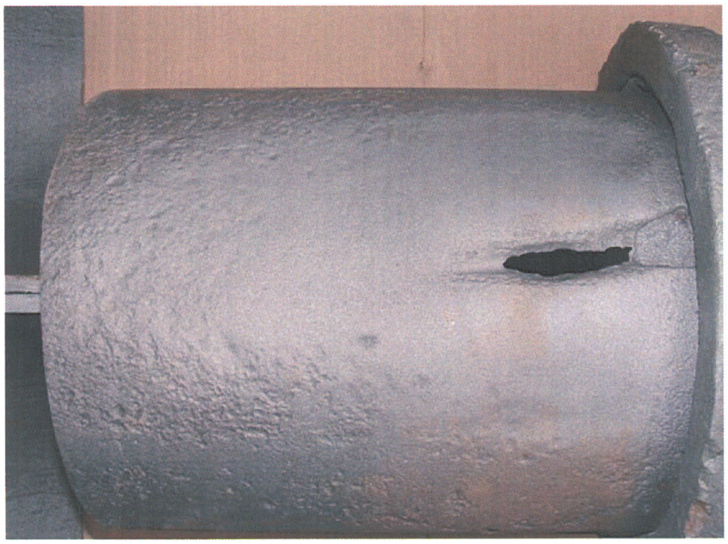


Image 33 – Erosion Hole from Exterior

Image 34 – Erosion Hole from Interior

The City of Nelson apparently attempted to repair the erosion hole with lead and then covered it with a circumferential stainless steel repair clamp. The repair failed and additional erosion causing general thinning of the pipe wall under the repair clamp. Image 35 shows the pipe surface under the repair clamp. Note the smooth appearance and metal loss due to erosion.

Image 35– Erosion under Repair Clamp

The bell of the pipe joint is heavily pitted from corrosion, however because of the thickness of the bell, the corrosion has not weakened the pipe in this area. Image 36 shows the typical appearance of the surface of the bell.

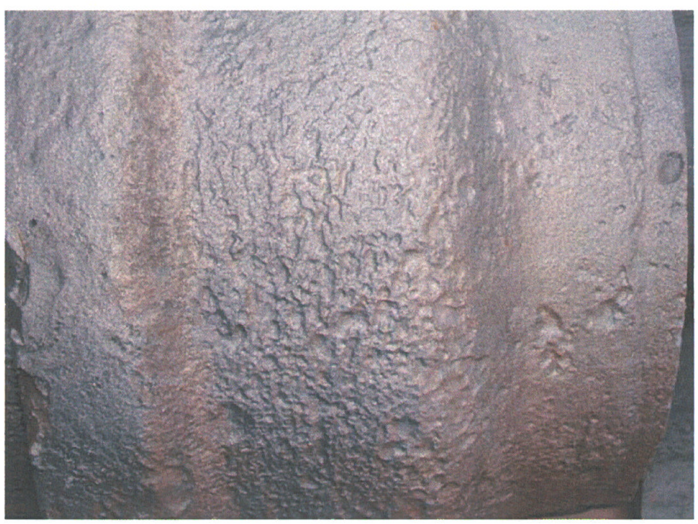


Image 36 – Typical Appearance of the Bell Surface

9.4 COMPARISON TO PREVIOUS CORROSION STUDY

In 2001, Levelton Consultants Ltd. evaluated the condition of a section of pipe removed from Carbonate Street in downtown Nelson. The pipe section was from a 150-mm diameter cast iron water main installed in 1937. The exterior of the pipe was found to be a fairly good condition with some pitting corrosion, mostly on the invert. However the interior of the pipe was found to be in poor condition with extensive graphitic corrosion and deep corrosion pits penetrating up to 80% of the pipe wall.

The condition of the pipe sample from the Carbonate Street water main is not consistent with the condition of the pipe section from the Five-Mile supply main. The reasons are most likely due to the following:

- Operating conditions - as noted in Section 3.0, internal pitting corrosion is more prevalent under stagnant or low flow conditions. It is probable that the flow rates in the Carbonate Street water main were much lower than the flow rates in the supply main. Low flow rates could promote pitting corrosion.
- Lining condition – the lining in the interior of the Carbonate Street pipe was in poor condition. It was the standard thin bituminous lining that was commonly used on cast iron pipe as per AWWA Standard C106. The lining is specified as being only 1 mil (0.025 mm) thick and therefore offers minimal protection to the metal. In contrast, the lining on the supply main was a thicker coal tar that was in much better condition and provided a superior level of corrosion protection to the pipe.
- Water quality – chlorination of raw water has been shown to increase corrosion rates in iron piping carrying soft water. Chlorine lowers the pH by reacting with water to form hydrochloric and hypochlorous acids.[3] In water with low alkalinity, the impact of chlorine on pH is greater because of the water's lower buffering capacity. The water in the City once it has been chlorinated is likely more corrosive than the raw water carried by the Five-Mile supply main.

In addition, differences in the pipe condition can be attributed to the sample sizes. On Carbonate Street, only two meters of pipe were inspected from nearly 250 meters of water main. Similarly, only 1.8 meters of pipe was inspected from the 7700-meter long supply main. It is highly improbable that a single pipe sample is representative of the internal condition of the supply main along its entire length. Inspection and testing of additional pipe samples is warranted.

10.0 SUMMARY

The exterior of the 250-mm and 300-mm diameter cast iron sections and the 250 mm diameter steel section of the water supply main are in good to very good condition in the test pit locations after approximately 78 years service. The condition of the water supply main can be attributed to the following factors:

- The soil resistivity survey revealed that the water main transcends similar soil types along its length. The soils are generally sandy in nature with resistivity values that indicate the soils are only mildly corrosive to cast iron or steel pipe.
- Soil samples taken along the pipeline route were not considered to be corrosive to cast iron pipe based on ANSI/AWWA C105 Standard Appendix A. These benign soil conditions likely contributed to the minimal corrosion found on the water main.
- According to the original specification, the water main was coated by dipping the cast iron pipe lengths into a bath of hot coal tar varnish. This type of coating has an excellent performance history when used for buried service by providing a barrier between the pipe surface and the soil. On average, approximately 80% of the coating is intact in most locations along the length of the water main thereby continuing to provide corrosion protection to the pipe. As noted in Section 4.0, the performance of an external coating is dependent on the quality of the coating and the corrosiveness of the soils. The coating performed very well because of the quality of the hot coal tar varnish and the relatively benign nature of the soils along the majority of the pipe route.
- Corrosion pitting was found on the exterior of the pipe however the pits were shallow in relation to the wall thickness of the pipe. The deepest corrosion pit found in the test pits had only penetrated the pipe wall by 35%. Extreme Value Statistical Analysis revealed that no section of the water main is likely to be perforated from external corrosion at the present time.
- No stray DC electrical currents were detected at the time of testing that could accelerate corrosion on the water main.

- The modulus of rupture of the pipe sample did not meet the minimum 1970 design value of 40,000 psi for 250 mm diameter centrifugally cast iron pipe specified by AWWA Standard C108-70 however the modulus of rupture was 36,385 psi and this was likely acceptable for pipe manufactured in 1925 by pit casting techniques. The pit casting process generally yielded weaker pipe than spun cast pipe.

- The cement mortar joints appear to be performing satisfactorily in those test pits where they were exposed however failures have occurred in the past and it is possible that more could occur in the future as the pipeline ages.

  The pipe sample that was removed for laboratory analysis had a hole in the crown of the pipe caused by erosion corrosion related to a leak at the adjacent joint. The hole developed from the exterior of the pipe because it appears that the concrete mortar sealed joint adjacent to the hole had failed at some point in time and the water leaking from the joint caused erosion corrosion of the pipe wall.

The interior of the pipe sample showed virtually no signs of corrosion or erosion of the pipe wall. The coal tar coating was estimated to be 95% intact and is serving its purpose as a barrier between the pipe wall and the water. However it should be noted that the sample size was small and it is unlikely to be representative of the internal condition everywhere along the supply main. Inspection and testing of additional pipe sections is warranted if ever there is an opportunity in the future to remove a pipe section.

11.0 Conclusions and Pipe Exterior Condition Rating

Based on the aforementioned information, the exterior of the overall pipeline appears to be in very good condition. It can be summarized and assigned a condition rating as follows:

Table 10-1 Summary of Pipe Exterior Condition Based on Test Pits

Material	Location	Diameter (mm)	Approximate Length (m)	Test Pit No.	Date Installed	Exterior Condition Rating
Cast Iron	Intake to pipe size change at ~1+600 m	300	1600	1,2	1925	1
Cast Iron	~1+600 to ~4+675 m	250	3075	3,4,5, 6	1925	2
Steel	~4+675 to ~6+100 m	250	1425	7,7A, 8	1925	1

Cast Iron	~6+100 to 7+650 m	250	1550	9	1925	1
Cast Iron	Breaker box at 7+650 to reservoir	300	50	10	1925	2

The classification of the pipe condition can be described as follows:

1. Very good – sound physical condition.
2. Good – acceptable physical condition. Potential for failure in long term (25+ years). Only minor work required at pipe joints, if any.
3. Fair – some deterioration evident. Failure unlikely to occur in short term, but repair, rehabilitation or replacement will likely be required in 10 to 25 years. Still functions safely at adequate level of service.
4. Poor – failure likely in short term. Repair or rehabilitation required in less than 10 years. No immediate risk to health or property.
5. Very poor – failed or failure imminent.

It should be noted that the condition ratings do not include external factors unrelated to corrosion. According to the City of Nelson, a slope failure occurred between Fell Creek and Anderson Creek, causing the pipe to break. The steel pipe at this location was replaced with ductile iron pipe. No failures of the ductile iron pipe have been reported to date.

The interior of the pipe is also in very good condition on the single pipe sample that was available for examination however the number of pipe samples tested is insufficient to state unequivocally that the interior of the entire length of the pipeline is in similar condition. However the ultrasonic thickness readings of the pipe wall did not detect serious internal corrosion at the test pit locations. This data combined with the pipe sample condition would suggest that the pipe interior is in good condition. That said, there could be locations along the pipeline where the interior condition is worse because of changes in terrain causing turbulence and erosion corrosion on the pipe interior. Inspection and testing of additional pipe sections is warranted if ever there is an opportunity in the future to remove a pipe section.

In our opinion, the exterior of the pipeline appears to be in good to very good condition and although the information on the pipe interior is limited to one pipe sample and ultrasonic wall thickness readings in the test pits, it also appears to be in good condition. Based on this, the pipeline should continue to provide satisfactory service for the foreseeable future.

It is however recommended that the City of Nelson inspect the pipeline right-of-way on a bi-annual basis. Any evidence of leaks should be investigated and proper repair materials should be used. The pipe route should be kept clear of all overhanging trees and brush should be cleared. If slope stabilization is a concern, a geotechnical engineer from Levelton Consultants Ltd. should be contracted to review the right-of-way and provide recommendations.

12.0 REFERENCES

1. The Design Decision Model for Corrosion Control of Ductile Iron Pipelines. Ductile Iron Pipe Research Association Brochure 2004.
2. Failures in Grey Cast Iron Distribution Pipes. National Research Council of Canada Urban Infrastructure/Research website.
3. Corrosion Control for Operators. American Water Works Association publication.

APPENDIX B

Water Quality Sampling Summary

REPORT

City of Nelson

Master Water Plan

Source Water Data Collection Results

0795.0079.02 / March 23, 2007

URBANSYSTEMS®
515E Vernon Street
Nelson BC V1L 4E9
Telephone: 250-352-9774
Fax: 250-352-5322

TABLE OF CONTENTS

1.0 INTRODUCTION

This monitoring program was designed to provide necessary data to assist in determining the best long-term water source for the City of Nelson which can most economically meet the Interior Health Authority's directives. The information was collected to support the City of Nelson Water Master Plan. The water sources considered were Five Mile Creek and Kootenay Lake.

At present, the water system operates with chlorination for primary disinfection and to maintain a residual in the distribution system. With sufficient contact time, this treatment is effective in deactivating viruses, bacteria, and *Giardia*. However, at the normal dosages applied, chlorine is ineffective at deactivating *Cryptosporidium*.

Ultraviolet (UV) treatment, the next most economical treatment option, has been proven effective at deactivating *Cryptosporidium* oocysts provided that the light can adequately penetrate the water. Turbidity or colour compounds in the water can absorb UV light and thus protect micro organisms, allowing them to escape deactivation. For this reason, it is critical to know the frequency and magnitude of turbidity events prior to recommending UV treatment. If UV treatment will not be effective, the next treatment option to consider would involve a filtration technology at considerably higher cost.

2.0 SAMPLING SITES

Samples were collected from two sites for laboratory analyses: from a line supplied via a submersible pump installed in Kootenay Lake and from a sample line installed at Mountain Station which collected raw Five Mile Creek water as it entered the settling pond. The locations of sample sites are shown in Figure 1 on page 3.

To estimate effectiveness of the Five Mile Creek settling pond, samples of settled and chlorinated water were compared with the raw sample line for Five Mile Creek using a hand-held turbidimeter (Hach 2100P).

3.0 SAMPLING PROGRAM AND METHODOLOGIES

3.1 Sampling Plan

The sampling program collected baseline data over a 9 month program focusing on parameters which would differentiate the two water sources in terms of their treatment requirements. One parameter of utmost concern for determining the level of treatment required and the scope of treatment required is turbidity; this parameter was analyzed by online turbidity analyzers, a hand held-turbidimeter, and periodically with laboratory analyses.

Monthly and semi monthly samples were collected for laboratory analysis of the following parameters.

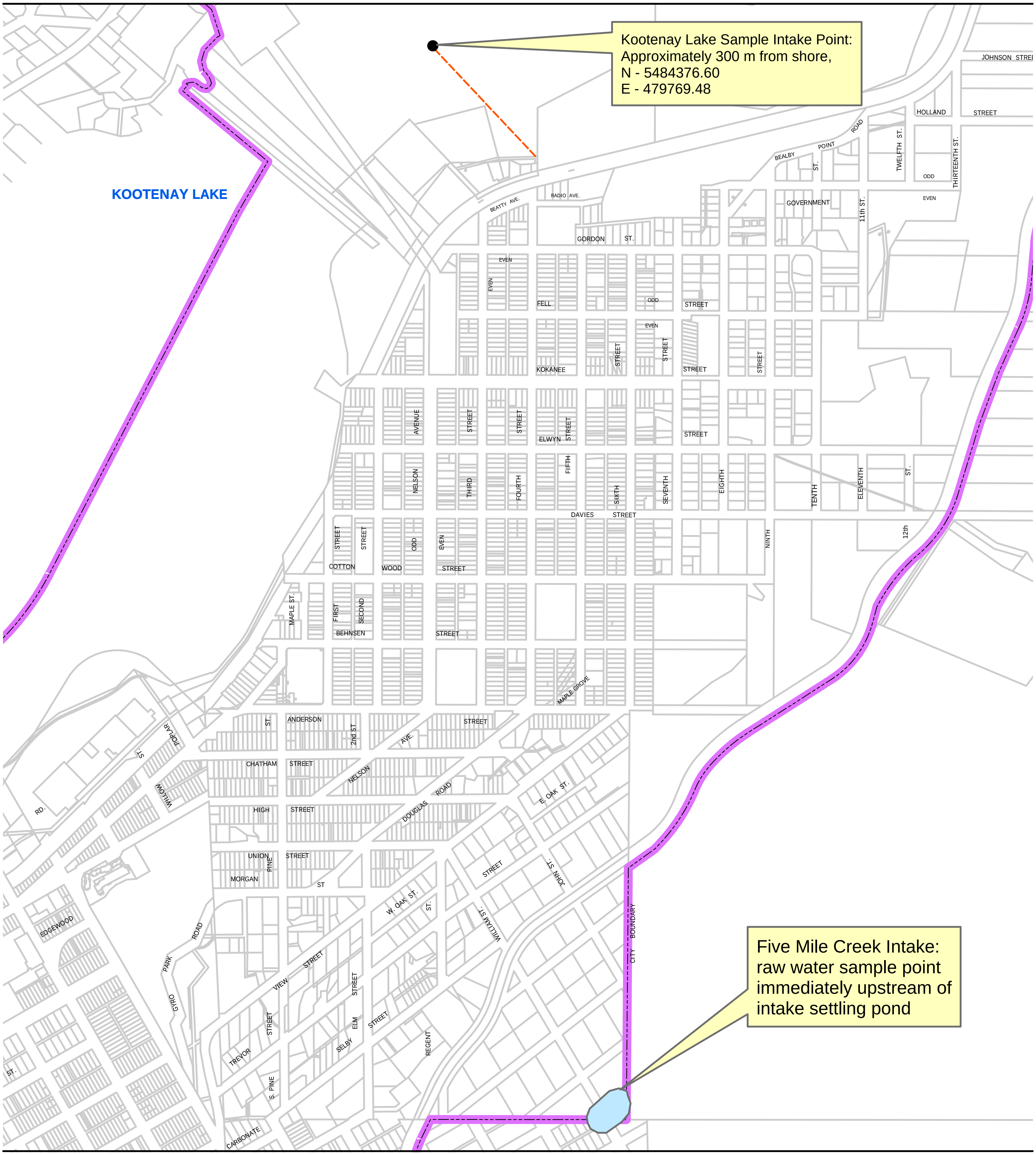
- Total organic carbon
- Dissolved organic carbon
- Hardness
- Alkalinity
- UV transmittance

In addition, samples were collected for comprehensive analysis which screens for wide variety of chemical, physical, and biological parameters, for modified total trihalomethane formation potential, and one sample to analyze the algal concentration.

URBANSYSTEMS.

City of Nelson

Water Master Plan Data Collection Report



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DATE: OCTOBER 2006
0795.0079.02

Legend

City of Nelson

- Municipal Boundary
- Legal Lot Lines

Water Quality Monitoring Locations

Figure 1

3.2 Sample Collection

Samples of raw water from both Kootenay Lake and Five Mile Creek (Mountain Station) were collected from piped sample lines constructed by City of Nelson public works.

3.3 Field Analyses

Field analyses consisted of turbidity measurements using a Hach 2100P turbidimeter, performed and recorded by City of Nelson public works staff and USL. These measurements were intended to ensure proper function and calibration of the online analyzers and were logged in conjunction with records of online analyzer calibrations and weather conditions.

3.4 Lab Analyses

All parameters requiring laboratory analyses were determined by Cantest of Burnaby BC, or by Caro Environmental Services of Kelowna, BC. A summary of analytical lab results is contained in Appendix A. Analyses were performed in accordance with Standard Methods for the Examination of Water and Wastewater with the exception of Total Trihalomethane Formation Potential (TTHMFP). The TTHMFP tests were modified to better match conditions that might realistically occur in the distribution system in terms of chlorine dosage, temperature, and reaction time.

4.0 PARAMETERS

A list of key parameters and their importance follows:

Turbidity

Turbidity is a measure of the clarity of water and is caused by suspended materials including organic and inorganic matter (silts, clays, microscopic organisms, etc.). Turbidity is a concern for both health and aesthetic reasons. It can be associated with suspended materials that impart taste and odour problems and can hide pathogenic organisms thereby interfering with disinfection processes.

Alkalinity

Alkalinity can be defined as the ability of water to neutralize acid without significant changes in pH. In other words, alkalinity is an indication of the buffering ability of water. Alkalinity is a complex parameter, but generally occurs when dissolved Carbon Dioxide (CO_2) combines with proton donating elements such as Calcium (Ca), Magnesium (Mg.), or Sodium (Na).

Hardness

Hardness is related to alkalinity in that it is caused by the presence of Calcium and Magnesium. Hard waters are generally not found to be corrosive because they have the ability to precipitate (deposit) a protective scale. However, excessively hard waters can be problematic because of scaling and reduced effectiveness of soap in cleaning. Waters with less than 50 mg/l hardness are considered soft, up to 150 mg/l moderately hard, and in excess of 300 mg/l very hard.

Phosphorus

Phosphorus is a nutrient essential to the growth of organisms. Phosphorus is often the limiting factor for primary production in surface water bodies. This means that phosphorus is usually the nutrient that is in short supply which limits the ability of plant life to continue to grow. Phosphorus is found in free form readily available for assimilation by primary producers (plants) in the form of ortho phosphate. Phosphorus is also present as organically bound phosphate which must first be broken down before it can be assimilated by an organism.

Nitrogen Compounds

Nitrogen compounds are major cellular components of organisms. Thus, nitrogen in the aquatic environment acts as an essential nutrient to plant and animal production. Total nitrogen concentration is the sum of ammonia and organic nitrogen and nitrate and nitrites. The sum of ammonia and organic nitrogen is referred to as Total Kjedal Nitrogen (TKN). Ammonia can be toxic to aquatic life at higher concentrations but is not generally a concern from a human health perspective. Ammonia is used as an indicator for contaminates.

Organic nitrogen is nitrogen that is bound up in organic materials such as proteins. Nitrates and nitrites are oxidized forms of nitrogen. Elevated levels of nitrate and nitrite are often caused by human activities, especially fertilizer runoff from agriculture or sewage.

Coliform Bacteria

Coliform bacteria are used as indicator organisms for the bacteriological quality of water. Total coliforms are ubiquitous bacteria that can be found throughout the natural environment. Fecal Coliform as represented by *Escherica coli* are a subset of the coliform group that reside in the intestinal tract of warm blooded animals, including humans. It is important to understand that fecal coliforms and *E. coli* are not necessarily disease causing themselves but rather only indicate that fecal contamination is present and therefore, there is a chance that pathogenic organisms (disease-causing) may be present.

Trihalomethanes (THMs)

THMs are suspected carcinogens (cancer causing substances). Studies have linked elevated THMs with an increased risk of gastrointestinal cancers and birth disorders. THMs are chlorination by-products caused when chlorine compounds react with organic material present in the source water. THM production is enhanced with high chlorine dosage, high temperature, long contact time, and high pH.

The typical method for determining a theoretical THM formation potential involves determining THM concentration after storing samples at a pH of 7 for 7 days at 25°C with a final residual chlorine concentration of between 1 and 5 mg/l at the time of analysis. This test is representative of an absolute worst case scenario and does not represent a situation that would occur in normal water distribution system.

The THM formation test performed for this program was a modified test intended to represent realistic conditions anticipated for the City of Nelson water system based on seasonal temperature and the normal maximum residence time as estimated using the City's water distribution system model. The THM formation potential test was performed once in May and once in September 2006. The May samples were held at approximately 4 to 6 Celcius, at pH 7, for 5 days with targeted residual chlorine at the end of the analysis between 0.5 mg/L and 2 mg/L. The samples collected in September were treated similarly except for the reaction temperature; these samples were held at 20 Celcius to reflect the higher temperatures at the end of summer. Total trihalomethanes were then measured at the end of the 5 day reaction in each case. The instructions to the lab to carry out the modified TTHMFP testing are included in Appendix D.

Total Organic Carbon (TOC) and Dissolved Organic Carbon (DOC)

TOC is a measure of the amount of organic matter in the water body. TOC provides an easy way of determining the degree of organic contamination. Total organic carbon and dissolved organic carbon can typically be correlated with colour and chlorination byproduct formation. Where formation of trihalomethanes is a concern, treatment prior to chlorination is typically designed to reduce TOC as much as possible.

Chlorophyl a

Chlorophyl a is the green photosynthetic pigment found in the cells of plants. The intent of measuring *chlorophyl a* is to quantify how much algae is present. This enables the identification of algae blooms that are often associated with taste and odour problems and can also be problematic for some water treatment operations, requiring special consideration when designing a water treatment plant. Due to past concerns with algae in Kootenay Lake, this parameter was tested in September 2006 in conjunction with an analysis of algal cells present.

5.0 RESULTS DISCUSSION

Online turbidity monitoring at Kootenay Lake was extremely variable due to air entrainment, algal growth in the sample line, and drift in calibration. However, with treatment testing using the handheld turbidimeter, a reasonable characterization and turbidity profile was possible.

Online turbidity monitoring at Five Mile Creek was less erratic than at Kootenay Lake. There was a 10 day period in May where turbidity spiked above 5 NTU. Aside from the spring melt, turbidity was generally below 1 NTU in the Five Mile Creek source.

UV transmittance was lowest in May in Five Mile Creek at 72.7%; at this same time, transmittance in Kootenay Lake was 92.6%. The lowest UV transmittance measured in Kootenay Lake occurred in June when it reached 88.8%.

Trihalomethane Formation Potential tests in May and September showed that there were more disinfection by-product precursors present in Five Mile Creek during freshet than in Kootenay Lake but by September the two sources were similar.

In terms of inorganic chemical analyses, both sources met the GCDWQ guidelines for all parameters tested. Five Mile Creek water was considerably softer than Kootenay Lake and would likely require pH stabilization if chemical coagulants were used in future treatment.

6.0 RECOMMENDATIONS

- Filtration technology should be incorporated in the long term planning for treatment of either Five Mile Creek water or Kootenay Lake water as both sources demonstrate susceptibility to turbidity events.
- Conduct additional monitoring to confirm the potential of algae problems in Kootenay Lake water; this will be of particular importance in water treatment design.

APPENDIX A

Laboratory Analysis Results Summary Tables

			Five Mile Creek									
Parameter	**Unit**	**GCDWQ***	14-Dec-05	19-Jan-06	16-Feb-06	29-Mar-06	19-Apr-06	17-May-06	25-May-06	14-Jun-06	28-Aug-06	19-Sep-06
Alaklinity (total)	mg/L as CaCO3		15.6	15.4	16.1	18.4	15.5	9.1	8.6	10	20.8	16.0
Aluminum (total)	mg/L											0.02
Antimony (total)	mg/L	0.006										<0.0006
Aresenic (total)	mg/L	0.025										<0.001
Barium (total)	mg/L	1										0.0119
Boron (total)	mg/L	5										<0.002
Cadmium (total)	mg/L	0.005										0.00004
Calcium (total)	mg/L											5.7
Chloride (total)	mg/L	≤ 250 AO										0.15
Chromium (total)	mg/L	0.05										0.002
Colour (true)	TCU	≤ 15 AO	<	<	<	<	7	13	8	6	<	13
Conductivity	umhos/cm											45
Copper (total)	mg/L	≤ 1.0 AO										0.0006
Cyanide	mg/L	0.2										<0.01
Fluoride	mg/L	1.5										0.15
Hardness	mg/L as CaCO3		12	11	14	13	13	7	6	7	14	17
Iron (total)	mg/L	≤ 0.3 AO										0.03
Lead (total)	mg/L	0.01										0.0002
Magnesium (total)	mg/L											0.6
Manganese (total)	mg/L	≤ 0.05 AO										0.0006
Mercury (total)	mg/L	0.001										0.00005
Molybdenum (total)	mg/L											0.0008
Nitrate	mg/L as N	45										<0.01
Nitrite	mg/L as N											<0.01
pH	pH units	6.5 - 8.5										6.8
Potassium (total)	mg/L											0.8
Selenium (total)	mg/L	0.01										<0.001
Sodium (total)	mg/L	≤ 200 AO										1.7
Sulphate	mg/L	≤ 500 AO										1.3
Total Dissolved Solids	mg/L											40
Turbidity	NTU	1					0.15	1.2	0.94	0.6	0.15	0.13
Uranium (total)	mg/L	0.02										0.0006
Zinc (total)	mg/L	≤ 5.0 AO										0.006
Total Coliform	Colonies/100mL	0										8[1]
E. coli	Colonies/100mL	0										1
TOC	mg/L		1.6	1.6	1.6	2	2.9	4.1	3.7	2.7	<	<
DOC	mg/L								3.0	2.1		1[2]
UV Transmittance @254nm	%		90.2	93.2	90.0	89.8	82.6	72.7	77.3	82.2	90.4	90
Chlorophyll-a	ug/L											
TTHMFP	ug/L	100							91			49

* AO indicates the guideline is an aesthetic objective rather than a health based MAC (maximum acceptable concentration)

[1] with unidentified bacterial background greater than 200 colonies/100mL

[2] Detection limit is 1mg/L

			Kootenay Lake									
Parameter	**Unit**	**GCDWQ***	14-Dec-05	19-Jan-06	16-Feb-06	29-Mar-06	19-Apr-06	17-May-06	25-May-06	14-Jun-06	28-Aug-06	19-Sep-06
Alaklinity (total)	mg/L as CaCO3		67.7	66.6	67.6	66.1	65.9	63	62.3	57.8	70.0	66.0
Aluminum (total)	mg/L											0.04
Antimony (total)	mg/L	0.006										<0.0006
Aresenic (total)	mg/L	0.025										<0.001
Barium (total)	mg/L	1										0.0301
Boron (total)	mg/L	5										<0.002
Cadmium (total)	mg/L	0.005										0.00001
Calcium (total)	mg/L											21.8
Chloride (total)	mg/L	≤ 250 AO										1.05
Chromium (total)	mg/L	0.05										0.002
Colour (true)	TCU	≤ 15 AO	<	<	<	<	<	<	<	<	<	<5
Conductivity	umhos/cm											159
Copper (total)	mg/L	≤ 1.0 AO										0.0146
Cyanide	mg/L	0.2										<0.01
Fluoride	mg/L	1.5										0.15
Hardness	mg/L as CaCO3		64	70	74	66	73	69	66	56	68	77
Iron (total)	mg/L	≤ 0.3 AO										0.10
Lead (total)	mg/L	0.01										0.0003
Magnesium (total)	mg/L											5.6
Manganese (total)	mg/L	≤ 0.05 AO										0.0016
Mercury (total)	mg/L	0.001										0.00005
Molybdenum (total)	mg/L											0.0007
Nitrate	mg/L as N	45										0.02
Nitrite	mg/L as N											<0.01
pH	pH units	6.5 - 8.5										7.6
Potassium (total)	mg/L											0.5
Selenium (total)	mg/L	0.01										<0.001
Sodium (total)	mg/L	≤ 200 AO										1.9
Sulphate	mg/L	≤ 500 AO										12
Total Dissolved Solids	mg/L											93
Turbidity	NTU	1					0.29	0.32	0.35	0.41	0.32	1.9
Uranium (total)	mg/L	0.02										0.0006
Zinc (total)	mg/L	≤ 5.0 AO										0.021
Total Coliform	Colonies/100mL	0										1
E. coli	Colonies/100mL	0										1
TOC	mg/L		1.4	1.2	1.2	1.2	1.7	1.4	1.8	1.9	1.0	1.6
DOC	mg/L								1.3	1.7		1.0
UV Transmittance @254nm	%		94.2	95	94.8	93.5	93.1	92.6	92.6	88.8	90.4	91
Chlorophyll-a	ug/L											1.0
TTHMFP	ug/L	100							25			50

* AO indicates the guideline is an aesthetic objective rather than a health based MAC (maximum acceptable concentration)

APPENDIX B

Laboratory Reports

L.B

CARO ENVIRONMENTAL SERVICES

102 - 3677 Highway 97N
Kelowna, B.C. V1X 5C3
Telephone (250) 765-9646
Fax (250) 765-3893
Email caroenvironmental@shaw.ca

RECEIVED
OCT 10 2006
URBANSYSTEMS.

CERTIFICATE OF ANALYSIS

October 3, 2006

Urban Systems
#500 - 1708 Dolphin Avenue
KELOWNA,BC
V1Y 9S4

Sample ID: **City of Nelson, Kootenay Lake, Raw**

Date sampled: Sept 19/06, 9:30am **Received: Sept.20/06, 10:30am, 13C**

Parameter	units	Result
Alkalinity (total)	mg/L as CaCO3	66.0
Aluminum (total)	mg/L	0.04
Antimony (total)	mg/L	<0.0006
Arsenic (total)	mg/L	<0.001
Barium (total)	mg/L	0.0301
Boron (total)	mg/L	<0.002
Cadmium (total)	mg/L	0.00001
Calcium (total)	mg/L	21.8
Chloride	mg/L	1.05
Chromium (total)	mg/L	0.002
Colour (true)	TCU	<5
Conductivity	umhos/cm	159
Copper (total)	mg/L	0.0146
Cyanide	mg/L	<0.01
Fluoride	mg/L	0.15
Hardness	mg/L as CaCO3	77
Iron (total)	mg/L	0.10
Lead (total)	mg/L	0.0003
Magnesium (total)	mg/L	5.6
Manganese (total)	mg/L	0.0016
Mercury (total)	mg/L	0.00005
Molybdenum (total)	mg/L	0.0007

...2

Page 2
Urban Systems
October 3, 2006 (cont)

Sample ID: **City of Nelson, Kootenay Lake, Raw**

Parameter	units	Result
Nitrate	mg/L as N	0.02
Nitrite	mg/L as N	<0.01
pH	pH units	7.6
Potassium (total)	mg/L	0.5
Selenium (total)	mg/L	<0.001
Sodium (total)	mg/L	1.9
Sulphate	mg/L	12
Total Dissolved Solids	mg/L	93
Turbidity	NTU	1.9
Uranium (total)	mg/L	0.0006
Zinc (total)	mg/L	0.021
Total Coliform	Colonies/100mL	1
E.coli	Colonies/100mL	1
Transmissivity @254	%/cm, as rec.	91
Chlorophyll a	ug/L	1.0

Certified by: ____________________
for
CARO Environmental Services
Jennifer Shanko, AScT, Lab Manager

FAX: (250) 763-5266 Invoice

CARO ENVIRONMENTAL SERVICES

CARO ENVIRONMENTAL SERVICES

102 - 3677 Highway 97N
Kelowna, B.C. V1X 5C3
Telephone (250) 765-9646
Fax (250) 765-3893
Email caroenvironmental@shaw.ca

CERTIFICATE OF ANALYSIS

October 3, 2006

Urban Systems
#500 - 1708 Dolphin Avenue
KELOWNA,BC
V1Y 9S4

Sample ID: **5 Mile Creek, Raw**

Date sampled: Sept 19/06, 12:15 **Received: Sept.20/06, 10:30am, 13C**

Parameter	units	Result
Alkalinity (total)	mg/L as CaCO3	16.0
Aluminum (total)	mg/L	0.02
Antimony (total)	mg/L	<0.0006
Arsenic (total)	mg/L	<0.001
Barium (total)	mg/L	0.0119
Boron (total)	mg/L	<0.002
Cadmium (total)	mg/L	0.00004
Calcium (total)	mg/L	5.7
Chloride	mg/L	0.15
Chromium (total)	mg/L	0.002
Colour (true)	TCU	13
Conductivity	umhos/cm	45
Copper (total)	mg/L	0.0006
Cyanide	mg/L	<0.01
Fluoride	mg/L	0.15
Hardness	mg/L as CaCO3	17
Iron (total)	mg/L	0.03
Lead (total)	mg/L	0.0002
Magnesium (total)	mg/L	0.6
Manganese (total)	mg/L	0.0006
Mercury (total)	mg/L	0.00005
Molybdenum (total)	mg/L	0.0008

...2

Sample ID: **5 Mile Creek, Raw**

Parameter	units	Result
Nitrate	mg/L as N	<0.01
Nitrite	mg/L as N	<0.01
pH	pH units	6.8
Potassium (total)	mg/L	0.8
Selenium (total)	mg/L	<0.001
Sodium (total)	mg/L	1.7
Sulphate	mg/L	1.3
Total Dissolved Solids	mg/L	40
Turbidity	NTU	0.13
Uranium (total)	mg/L	0.0006
Zinc (total)	mg/L	0.006
Total Coliform	Colonies/100mL	*8
E.coli	Colonies/100mL	1
Transmissivity @254	%/cm, as rec.	90

*with unidentified bacterial background greater than 200 colonies/100mL

Certified by:______________________ for
CARO Environmental Services
Jennifer Shanko, AScT, Lab Manager

FAX: (250) 763-5266 Invoice

CARO ENVIRONMENTAL SERVICES

Larratt Aquatic Consulting heather@larratt.net
2994 Ensign Way, Westbank, B.C. V4T 1V1 250-769-5444 Fax:250-769-3233

West Kootenay Lake & 5-Mile Res. Algae Samples: September 19, 2006

Samples Received Sept. 20/06

Genera/species Sept 19/06	5-Mile Reservoir 0795.00079.02	15 m Kootenay Lk 0795.0079.02	Cell size um3; Toxicity
Diatoms			
Asterionella formosa		**30**	[illegible]
Cocconeis sp.	**2**		[illegible]
Cyclotella sp.		**20**	[illegible]
Cymbella sp.	**1**		[illegible]
Fragilaria crotonensis		**240**	[illegible]
Gomphonema sp.	**2**		[illegible]
Hantzschia sp.	**1**		[illegible]
Melosira sp.		**56**	[illegible]
Navicula spp.	**2**		[illegible]
Synedra acus		**9**	[illegible]
Tabellaria fenestrate	**1**	**4**	[illegible]
Flagellates			
Cryptomonads	**2**		[illegible]
Small flagellates	**3**	**1**	[illegible]
Ciliate, colorless	**2**		[illegible]
Cyanobacteria			
Lyngbya limnetica	**(10)**		[illegible]
Other Microflora			
Bacteria	**Low**	**Dominant**	
Aquatic fungus	**None**	**Low**	

Comments: The sample from the 5-Mile Reservoir has very low algae counts and is very clean. The sample from Kootenay Lake 15 m shows a diatom bloom that would affect filter media performance. The risk from algal toxins in both cases is negligible.

Ideally, monthly algal assessments during the growing season (April – October) would accurately forecast algal impacts on a future intake. If sampling staff is deployed, they could also do plankton hauls, collect water chemistry samples from discrete depths, etc.

Heather Larratt

Heather Larratt

Aquatic Biologist; R.P. Bio

Analysis Report

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 197209
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 3

REPORT DATE: October 2, 2006

DATE SUBMITTED: September 20, 2006

GROUP NUMBER: 70921036

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Dissolved Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Trihalomethane Formation Potential - analysis was performed using procedures based on Method 5710 B, Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995). Samples were buffered at pH 7.0, chlorinated with an excess of free chlorine, and stored at 25C for seven days. THM concentration was determined using procedures based on U.S. EPA Method 624/8240, involving sparging/collection with a Purge and Trap apparatus, and analysis using GC/MS.

COMMENTS:

Samples were received at 11.3 degrees Celsius. Determination of THMFP was initiated from a 2L raw plastic bottle.

TEST RESULTS:

(See following pages)

CANTEST LTD.

Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

REPORTED TO: Urban Systems Ltd.

REPORT DATE: October 2, 2006

GROUP NUMBER: 70921036

CANTEST®

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:	SAMPLE DATE	CANTEST ID	Dissolved Organic Carbon C	Total Organic Carbon C
5 Mile Raw (amber glass TOC)	Sep 19/06	609210182	-	1.0
Kootenay Raw (amber glass TOC)	Sep 19/06	609210183	-	1.6
Kootenay Raw	Sep 19/06	609210184	1.0	1.3
DETECTION LIMIT			1	1
UNITS			mg/L	mg/L

mg/L = milligrams per liter

REPORTED TO: Urban Systems Ltd.

REPORT DATE: October 2, 2006

GROUP NUMBER: 70921036

CANTEST®

Trihalomethane Formation Potential in Water

CLIENT SAMPLE IDENTIFICATION:	Kootenay Raw (amber glass TOC)		
DATE SAMPLED:	Sep 19/06	DETECTION LIMIT	UNITS
CANTEST ID:	609210183		
Chlorine Demand	1.62	0.2	mg/L
Chlorine Residual	1.42	0.2	mg/L
Bromodichloromethane	2.6	0.5	µg/L
Bromoform	<	1	µg/L
Chloroform	47	1.5	µg/L
Dibromochloromethane	<	0.5	µg/L
Total Trihalomethanes	50	0.5	µg/L
Surrogate Recovery			
1,2-Dichloroethane-d4	115	-	%
Toluene-d8	107	-	%
Bromofluorobenzene	101	-	%

mg/L = milligrams per liter
< = Less than detection limit

µg/L = micrograms per liter

Analysis Report

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 197033
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: September 7, 2006

DATE SUBMITTED: August 29, 2006

GROUP NUMBER: 70829129

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Turbidity in Water - was performed based on Method 2130 in Standard Methods (20th Edition) and Method X164 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in the most current editions of "British Columbia Environmental Laboratory Manual for the Analysis of Water, Wastewater, Sediment and Biological Materials", Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater", published by the American Public Health Association.

COMMENTS:

Sample temperature at time of arrival was 15.4 degrees Celsius.

TEST RESULTS:

(See following page)

CANTEST LTD.

Tim Matsushita
Coordinator, Water Laboratory

REPORTED TO: Urban Systems Ltd.

REPORT DATE: September 7, 2006

GROUP NUMBER: 70829129

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		**5 Mile Raw**	**Kootenay Raw**		
DATE SAMPLED:		Aug 28/06	Aug 28/06	DETECTION LIMIT	UNITS
CANTEST ID:		608290505	608290506		
True Color		<	<	5	CU
Turbidity		0.15	0.32	0.1	NTU
Hardness (Total)	CaCO3	14	68	1	mg/L
Total Alkalinity	CaCO3	20.8	70.0	0.5	mg/L
Bicarbonate Alkalinity	HCO3	25.4	85.4	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	<	1.0	1	mg/L
% Transmittance @ 254 nm		90.4	90.4	-	% Trans.

CU = color units
mg/L = milligrams per liter
< = Less than detection limit

NTU = nephelometric turbidity units
% Trans. = Percent Transmittance

Analysis Report

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 198853
PROJECT NAME: Water Master Plan
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: June 27, 2006

DATE SUBMITTED: June 15, 2006

GROUP NUMBER: 70616014

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Dissolved Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Turbidity in Water - was performed based on Method 2130 in Standard Methods (20th Edition) and Method X164 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: June 27, 2006

GROUP NUMBER: 70616014

CANTEST®

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		Kootenay Raw	5Mile Raw	DETECTION LIMIT	UNITS
DATE SAMPLED:		Jun 14/06	Jun 14/06		
CANTEST ID:		606160053	606160054		
True Color		<	6	5	CU
Turbidity		0.41	0.60	0.1	NTU
Hardness (Total)	CaCO3	56	7	1	mg/L
Total Alkalinity	CaCO3	57.8	10.0	0.5	mg/L
Dissolved Organic Carbon	C	1.7	2.1	1	mg/L
Total Organic Carbon	C	1.9	2.7	1	mg/L
% Transmittance @ 254 nm		88.8	82.2	-	% Trans.

CU = color units
mg/L = milligrams per liter
< = Less than detection limit

NTU = nephelometric turbidity units
% Trans. = Percent Transmittance

Analysis Report

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

RECEIVED
JUN 26 2006
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CHAIN OF CUSTODY: 181488
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: June 12, 2006

DATE SUBMITTED: May 26, 2006

GROUP NUMBER: 70527045

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Dissolved Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Turbidity in Water - was performed based on Method 2130 in Standard Methods (20th Edition) and Method X164 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

(Continued)

CANTEST LTD.

Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

REPORTED TO: Urban Systems Ltd.

REPORT DATE: June 12, 2006

GROUP NUMBER: 70527045

Trihalomethane Formation Potential - analysis was performed using procedures based on Method 5710 B, Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995). Samples were buffered at pH 7.0, chlorinated with an excess of free chlorine, and stored at 25C for seven days. THM concentration was determined using procedures based on U.S. EPA Method 624/8240, involving sparging/collection with a Purge and Trap apparatus, and analysis using GC/MS.

COMMENTS:

As per client's request, sample 605270225 for THM formation potentail was incubated at 4 centigrade plus or minus 2 degrees for a period of 5 days.

TEST RESULTS:

(See following pages)

REPORTED TO: Urban Systems Ltd.

REPORT DATE: June 12, 2006

GROUP NUMBER: 70527045

CANTEST®

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		5 Mile Raw	Kootenay Raw		
DATE SAMPLED:		May 25/06	May 25/06		
CANTEST ID:		605270224	605270225	DETECTION LIMIT	UNITS
True Color		8	<	5	CU
Turbidity		0.94	0.35	0.1	NTU
Hardness (Total)	CaCO3	6	66	1	mg/L
Total Alkalinity	CaCO3	8.6	62.3	0.5	mg/L
Bicarbonate Alkalinity	HCO3	10.5	76.0	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Dissolved Organic Carbon	C	3.0	1.3	1	mg/L
Total Organic Carbon	C	3.7	1.8	1	mg/L
% Transmittance @ 254 nm		77.3	92.6	-	% Trans.

CU = color units
mg/L = milligrams per liter
< = Less than detection limit

NTU = nephelometric turbidity units
% Trans. = Percent Transmittance

REPORTED TO: Urban Systems Ltd.

REPORT DATE: June 12, 2006

GROUP NUMBER: 70527045

CANTEST®

Trihalomethane Formation Potential in Water

CLIENT SAMPLE IDENTIFICATION:	**Kootenay Raw**		
DATE SAMPLED:	May 25/06		
CANTEST ID:	605270225	DETECTION LIMIT	UNITS
Chlorine Demand	0.95	0.2	mg/L
Chlorine Residual	1.00	0.2	mg/L
Bromodichloromethane	2.4	0.1	µg/L
Bromoform	<	0.2	µg/L
Chloroform	23	0.3	µg/L
Dibromochloromethane	<	0.1	µg/L
Total Trihalomethanes	25	0.1	µg/L
Surrogate Recovery			
1,2-Dichloroethane-d4	92	-	%
Toluene-d8	94	-	%
Bromofluorobenzene	81	-	%

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

L Brandle

Analysis Report

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REPORT ON: Analysis of Water Sample

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

RECEIVED
JUN 26 2006
URBANSYSTEMS

CHAIN OF CUSTODY: 181487
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 1

REPORT DATE: June 12, 2006

DATE SUBMITTED: May 26, 2006

GROUP NUMBER: 70527044

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Trihalomethane Formation Potential - analysis was performed using procedures based on Method 5710 B, Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995). Samples were buffered at pH 7.0, chlorinated with an excess of free chlorine, and stored at 25C for seven days. THM concentration was determined using procedures based on U.S. EPA Method 624/8240, involving sparging/collection with a Purge and Trap apparatus, and analysis using GC/MS.

COMMENTS:

As per client's resquest, the sample for THM formation potential was incubated at 4 centigrade plus or minus 2 degrees for a period of 5 days.

TEST RESULTS:

(See following page)

CANTEST LTD.

Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

REPORTED TO: Urban Systems Ltd.

REPORT DATE: June 12, 2006

GROUP NUMBER: 70527044

CANTEST®

Trihalomethane Formation Potential in Water

CLIENT SAMPLE IDENTIFICATION:	5 Mile Raw		
DATE SAMPLED:	May 25/06	DETECTION LIMIT	UNITS
CANTEST ID:	605270223		
Chlorine Demand	3.01	0.2	mg/L
Chlorine Residual	0.89	0.2	mg/L
Bromodichloromethane	2.0	0.1	µg/L
Bromoform	<	0.2	µg/L
Chloroform	89	0.3	µg/L
Dibromochloromethane	<	0.1	µg/L
Total Trihalomethanes	91	0.1	µg/L
Surrogate Recovery			
1,2-Dichloroethane-d4	99	-	%
Toluene-d8	93	-	%
Bromofluorobenzene	82	-	%

mg/L = milligrams per liter

< = Less than detection limit

µg/L = micrograms per liter

Analysis Report

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 500
1708 Dolphin Avenue
Kelowna, B.C.
V1Y 9V4

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 195888
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: May 28, 2006

DATE SUBMITTED: May 19, 2006

GROUP NUMBER: 70519115

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Turbidity in Water - was performed based on Method 2130 in Standard Methods (20th Edition) and Method X164 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

COMMENTS:

Samples were received at 15.6 degrees Celsius.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: May 28, 2006

GROUP NUMBER: 70519115

CANTEST

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		5 Mile Raw	Kootenay Raw	DETECTION LIMIT	UNITS
DATE SAMPLED:		May 17/06	May 17/06		
CANTEST ID:		605190409	605190413		
True Color		13	<	5	CU
Turbidity		1.2	0.32	0.1	NTU
Hardness	CaCO3	7	69	1	mg/L
Total Alkalinity	CaCO3	9.1	63.0	0.5	mg/L
Bicarbonate Alkalinity	HCO3	11.1	76.9	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	4.1	1.4	1	mg/L
% Transmittance @ 254 nm		72.7	92.6	-	% Trans.

CU = color units
mg/L = milligrams per liter
< = Less than detection limit

NTU = nephelometric turbidity units
% Trans. = Percent Transmittance

Analysis Report

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REPORT ON: Analysis of Water Sample

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 187773
PROJECT NUMBER: 0795.007.02

NUMBER OF SAMPLES: 1

REPORT DATE: May 4, 2006

DATE SUBMITTED: April 20, 2006

GROUP NUMBER: 70420150

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Trihalomethane Formation Potential - analysis was performed using procedures based on Method 5710 B, Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995). Samples were buffered at pH 7.0, chlorinated with an excess of free chlorine, and stored at 25C for seven days. THM concentration was determined using procedures based on U.S. EPA Method 624/8240, involving sparging/collection with a Purge and Trap apparatus, and analysis using GC/MS.

COMMENTS:

Samples were received at 12.3 degrees Celsius.

TEST RESULTS:

(See following page)

CANTEST LTD.

Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

REPORTED TO: Urban Systems Ltd.

REPORT DATE: May 4, 2006

GROUP NUMBER: 70420150

CANTEST®

Trihalomethane Formation Potential in Water

CLIENT SAMPLE IDENTIFICATION:	5-Mile Raw		
DATE SAMPLED:	Apr 19/06		
CANTEST ID:	604200498	DETECTION LIMIT	UNITS
Chlorine Demand	2.1	0.2	mg/L
Chlorine Residual	1.8	0.2	mg/L
Bromodichloromethane	1.8	0.1	µg/L
Bromoform	<	0.2	µg/L
Chloroform	49	0.3	µg/L
Dibromochloromethane	<	0.1	µg/L
Total Trihalomethanes	51	0.1	µg/L
Surrogate Recovery			
1,2-Dichloroethane-d4	84	-	%
Toluene-d8	96	-	%
Bromofluorobenzene	83	-	%

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

Analysis Report

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REPORT ON: Analysis of Water Sample

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

RECEIVED
MAY 29 2006
URBANSYSTEMS

CHAIN OF CUSTODY: 192692
PROJECT NAME: Water Master Plan
PROJECT NUMBER: 0795.0079-02

NUMBER OF SAMPLES: 1

REPORT DATE: May 4, 2006

DATE SUBMITTED: April 20, 2006

GROUP NUMBER: 70420151

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Trihalomethane Formation Potential - analysis was performed using procedures based on Method 5710 B, Standard Methods for the Examination of Water and Wastewater, 19th Edition (1995). Samples were buffered at pH 7.0, chlorinated with an excess of free chlorine, and stored at 25C for seven days. THM concentration was determined using procedures based on U.S. EPA Method 624/8240, involving sparging/collection with a Purge and Trap apparatus, and analysis using GC/MS.

TEST RESULTS:

(See following page)

CANTEST LTD.

Zhenyong Gao, M.Sc.
Coordinator, Trace Organics

REPORTED TO: Urban Systems Ltd.

REPORT DATE: May 4, 2006

GROUP NUMBER: 70420151

Trihalomethane Formation Potential in Water

CLIENT SAMPLE IDENTIFICATION:	**Kootenay Raw**	DETECTION LIMIT	UNITS
DATE SAMPLED:	Apr 19/06		
CANTEST ID:	604200499		
Chlorine Demand	0.7	0.2	mg/L
Chlorine Residual	1.25	0.2	mg/L
Bromodichloromethane	2.0	0.1	µg/L
Bromoform	<	0.2	µg/L
Chloroform	15	0.3	µg/L
Dibromochloromethane	<	0.1	µg/L
Total Trihalomethanes	17	0.1	µg/L
Surrogate Recovery			
1,2-Dichloroethane-d4	82	-	%
Toluene-d8	94	-	%
Bromofluorobenzene	81	-	%

mg/L = milligrams per liter

µg/L = micrograms per liter

< = Less than detection limit

Analysis Report

L Brandle

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RECEIVED
MAY 23 2006
URBAN SYSTEMS

REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 195887
PROJECT NAME: Water Master Plan
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: April 28, 2006

DATE SUBMITTED: April 20, 2006

GROUP NUMBER: 70420131

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Turbidity in Water - was performed based on Method 2130 in Standard Methods (20th Edition) and Method X164 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

COMMENTS:

Samples were received at 10.8 degrees Celsius.

TEST RESULTS:

(See following page)

CANTEST LTD.

Tim Matsushita
Coordinator, Water Laboratory

REPORTED TO: Urban Systems Ltd.

REPORT DATE: April 28, 2006

GROUP NUMBER: 70420131

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		**Kootenay Raw**	**5-Mile Raw**		
DATE SAMPLED:		Apr 19/06	Apr 19/06	DETECTION LIMIT	UNITS
CANTEST ID:		604200418	604200420		
True Color		<	7	5	CU
Turbidity		0.29	0.15	0.1	NTU
Hardness	$CaCO_3$	73	13	1	mg/L
Total Alkalinity	$CaCO_3$	65.9	15.5	0.5	mg/L
Total Organic Carbon	C	1.7	2.9	1	mg/L
% Transmittance @ 254 nm		93.1	82.6	-	% Trans.

CU = color units
mg/L = milligrams per liter
< = Less than detection limit

NTU = nephelometric turbidity units
% Trans. = Percent Transmittance

Analysis Report

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Tel: 604 734 7276

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

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APR 2 7 2006
URBAN SYSTEMS

CHAIN OF CUSTODY: 195889
PROJECT NAME: WMP
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: April 6, 2006

DATE SUBMITTED: March 29, 2006

GROUP NUMBER: 70329102

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: April 6, 2006

GROUP NUMBER: 70329102

Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		5 Mile Raw	Kootenay Raw	DETECTION LIMIT	UNITS
DATE SAMPLED:		Mar 28/06	Mar 28/06		
CANTEST ID:		603290368	603290370		
True Color		<	<	5	CU
Hardness (Total)	CaCO3	13	66	1	mg/L
Total Alkalinity	CaCO3	18.4	66.1	0.5	mg/L
Bicarbonate Alkalinity	HCO3	22.4	80.6	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	2.0	1.2	1	mg/L
% Transmittance @ 254 nm		89.8	93.5	-	% Trans.

CU = color units

% Trans. = Percent Transmittance

< = Less than detection limit

mg/L = milligrams per liter

Analysis Report

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MAR - 9 2006

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REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 181467
PROJECT NAME: Water Master Plan
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: February 28, 2006

DATE SUBMITTED: February 17, 2006

GROUP NUMBER: 70218010

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: February 28, 2006

GROUP NUMBER: 70218010

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Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		**5 Mile Raw**	**Kootney Raw**		
DATE SAMPLED:		Feb 16/06	Feb 16/06		
CANTEST ID:		602180015	602180016	DETECTION LIMIT	UNITS
True Color		<	<	5	CU
Hardness (Total)	$CaCO_3$	14	74	1	mg/L
Total Alkalinity	$CaCO_3$	16.1	67.6	0.5	mg/L
Bicarbonate Alkalinity	HCO_3	19.7	82.5	0.5	mg/L
Carbonate Alkalinity	CO_3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	1.6	1.2	1	mg/L
% Transmittance @ 254 nm		90.0	94.8	-	% Trans.

CU = color units
% Trans. = Percent Transmittance
< = Less than detection limit

mg/L = milligrams per liter

Analysis Report

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Fax: 604 731 2386

Tel: 604 734 7276

1 800 665 8566

REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

Att'n: Lorelei Brandle

CHAIN OF CUSTODY: 181468
PROJECT NAME: Water Master Plan
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: January 30, 2006

DATE SUBMITTED: January 20, 2006

GROUP NUMBER: 70120123

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: January 30, 2006

GROUP NUMBER: 70120123

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Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		**5 - Mile Raw**	**Kootenay Raw**		
DATE SAMPLED:		Jan 19/06	Jan 19/06	DETECTION LIMIT	UNITS
CANTEST ID:		601200469	601200470		
True Color		<	<	5	CU
Hardness (Total)	CaCO3	12	64	1	mg/L
Total Alkalinity	CaCO3	15.6	67.7	0.5	mg/L
Bicarbonate Alkalinity	HCO3	19.1	82.6	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	1.6	1.4	1	mg/L
% Transmittance @ 254 nm		90.2	94.2	-	% Trans.

CU = color units

mg/L = milligrams per liter

% Trans. = Percent Transmittance

< = Less than detection limit

Analysis Report

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Professional Analytical Services
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Burnaby, B.C.
V5G 1K5
Fax: 604 731 2386
Tel: 604 734 7276
1 800 665 8566

REPORT ON: Analysis of Water Samples

REPORTED TO: Urban Systems Ltd.
Suite 104A
1815 Kirschner Road
Kelowna, B.C.
V1Y 4N7

CHAIN OF CUSTODY: 181486
PROJECT NAME: Master Water Plan
PROJECT NUMBER: 0795.0079.02

NUMBER OF SAMPLES: 2

REPORT DATE: December 22, 2005

DATE SUBMITTED: December 15, 2005

GROUP NUMBER: 61215113

SAMPLE TYPE: Water

NOTE: Results contained in this report refer only to the testing of samples as submitted. Other information is available on request.

TEST METHODS:

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Alkalinity in Water - was performed based on Method 2320 in Standard Methods (20th Edition).

Colour (True) in Water - was determined based on Method 2120 in Standard Methods (20th Edition) and Method X321 in the BC Laboratory Manual (1994 Edition).

Total Organic Carbon in Water - was determined based on Method 5310 A and B in Standard Methods (20th Edition) and Method X314 in the BC Laboratory Manual (1994 Edition).

Conventional Parameters - analyses were performed using procedures based on those described in "British Columbia Environmental Laboratory Manual For the Analysis of Water, Wastewater, Sediment and Biological Materials" (1994 Edition), Province of British Columbia and "Standard Methods for the Examination of Water and Wastewater" 20th Edition, (1998), published by the American Public Health Association.

TEST RESULTS:

(See following page)

CANTEST LTD.

Richard S. Jornitz
Supervisor, Inorganic Testing

REPORTED TO: Urban Systems Ltd.

REPORT DATE: December 22, 2005

GROUP NUMBER: 61215113

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Conventional Parameters in Water

CLIENT SAMPLE IDENTIFICATION:		5-Mile Raw	Kootenay Raw	DETECTION LIMIT	UNITS
DATE SAMPLED:		Dec 14/05	Dec 14/05		
CANTEST ID:		512150601	512150606		
True Color		<	<	5	CU
Hardness (Total)	CaCO3	11	70	1	mg/L
Total Alkalinity	CaCO3	15.4	66.6	0.5	mg/L
Bicarbonate Alkalinity	HCO3	18.8	81.3	0.5	mg/L
Carbonate Alkalinity	CO3	<	<	0.5	mg/L
Hydroxide Alkalinity	OH	<	<	0.5	mg/L
Total Organic Carbon	C	1.6	1.2	1	mg/L
% Transmittance @ 254 nm		93.2	95.0	-	% Trans.

CU = color units

% Trans. = Percent Transmittance

< = Less than detection limit

mg/L = milligrams per liter

Larratt Aquatic Consulting heather@larratt.net
2994 Ensign Way, Westbank, B.C. V4T 1V1 250-769-5444 Fax:250-769-3233

West Kootenay Lake & 5-Mile Res. Algae Samples: September 19, 2006

Samples Received Sept. 20/06

Genera/species Sept 19/06	**5-Mile Reservoir 0795.00079.02**	**15 m Kootenay Lk 0795.0079.02**	**Cell size um3; Toxicity**
Diatoms			
Asterionella formosa		**30**	270
Cocconeis sp.	**2**		610
Cyclotella sp.		**20**	200
Cymbella sp.	**1**		890
Fragilaria crotonensis		**240**	530
Gomphonema sp.	**2**		470
Hantzschia sp.	**1**		n/a
Melosira sp.		**56**	500
Navicula spp.	**2**		350
Synedra acus		**9**	630
Tabellaria fenestrate	**1**	**4**	1130
Flagellates			
Cryptomonads	**2**		1885
Small flagellates	**3**	**1**	164
Ciliate, colorless	**2**		1700
Cyanobacteria			
Lyngbya limnetica	**(10)**		8 toxin possible
Other Microflora			
Bacteria	**Low**	**Dominant**	
Aquatic fungus	**None**	**Low**	

Comments: The sample from the 5-Mile Reservoir has very low algae counts and is very clean. The sample from Kootenay Lake 15 m shows a diatom bloom that would affect filter media performance. The risk from algal toxins in both cases is negligible.

Ideally, monthly algal assessments during the growing season (April – October) would accurately forecast algal impacts on a future intake. If sampling staff is deployed, they could also do plankton hauls, collect water chemistry samples from discrete depths, etc.

Heather Larratt

Aquatic Biologist; R.P. Bio

APPENDIX C

Modified Total Trihalomethane Formation Potential Analysis Instructions

#500 - 1708 Dolphin Avenue, Kelowna, BC V1Y 9S4
Telephone: 250-762-2517 Fax: 250-763-5266

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MEMORANDUM

date:	September 18, 2006
to:	**Tim Matsushita, CANTEST**
cc:	Anthony Comazzetto
from:	Lorelei Brandle
file #:	0795.0079.02
subject:	**MODIFIED TTHMFP TEST – REQUESTED PROCEDURE**

Please perform a modified TTHMFP test on the two samples (4L each) submitted as "5-Mile Raw" and "Kootenay Raw" with the following desired target conditions:

REACTION TIME:	**5 DAYS**
REACTION TEMPERATURE:	**20 CELCIUS (+/- 1C)**
TARGET CHLORINE RESIDUAL:	**0.5 mg/L to 2 mg/L (or closest result to this range)** **Target residual of 1 mg/L**

If you have any questions, please contact me at the number above, or 250-215-6995.

Thank you,

URBAN SYSTEMS LTD.

Lorelei Brandle

/lb

U:\Projects_NEL\0795\0079\02\C-Correspondence\C2-Sub-Consultant\2006-09-18_TMatsushita_TTHMFP_procedure.doc

APPENDIX C

Water Conservation and Drought Management Study

City of Nelson

Water Conservation and Drought Management Study

URBANSYSTEMS.

#500 - 1708 Dolphin Avenue
Kelowna, BC V1Y 9S4
Phone: (250) 762-2517
Fax: (250) 763-5266

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PLANNERS • ENGINEERS • LANDSCAPE ARCHITECTS

February 15, 2005

File: 0795.0076.01

City of Nelson
502 Vernon Street
NELSON, B.C., V1L 4E8

Attention: Peter Hartridge, Director of Operations

RE: NELSON WATER CONSERVATION AND DROUGHT MANAGEMENT STUDY

Enclosed, you will find a copy of the Nelson Water Conservation Drought Management Study, completed by Urban Systems Ltd. as part of the provincial "Dealing with Drought" Initiative. As per the work program, we have also included a brochure that can be used to educate the public on water conservation issues.

Please do not hesitate to call if you have any questions or comments.

Sincerely,

Reviewed

James Klukas
Community Planner
Urban Systems Ltd.

Greg Buchholz

/JK

U:\Projects_KEL\0795\0076\01\X-Single-File\2005-02-15 Report Cover Letter.doc

TABLE OF CONTENTS

APPENDICES

LIST OF ABBREVIATIONS

L/min	Litres per Minute
USGPM	US Gallons per Minute
Winter ADD	Winter Average Day Demand
ADD	Average Day Demand
MDD	Maximum Day Demand
PHD	Peak Hour Demand

1.0 INTRODUCTION

Water is the lifeblood of the planet, as it is essential to the survival of all living things. In Canada, we are fortunate to have an abundance of fresh water. However, there are increasing signs that our water supplies are coming under strain. Between 1972 and 1996, Canada's rate of water withdrawals increased by almost 90 percent, while our population increased by only 34 percent in the same period.[1] In British Columbia, over 17 percent of our surface water sources have reached, or are nearing their capacity to reliably supply water in a normal year. Groundwater levels are also declining in some areas, making it more difficult to draw water from aquifers.[2]

British Columbia's hot, dry summer in 2003 made us realize that our water supplies are not infinite. Drought can have a significant impact on the reliability of these supplies. It is typically caused by a combination of low snowpacks from the previous winter, hot and dry conditions in the summer, or a delay in the onset of fall rains. In 2003, all three of these conditions aligned to produce record drought in many areas of the province, causing a number of water use conflicts. A study by the province indicated that in this time, 25 percent of the province's water systems were stressed, and 20 percent of those surveyed experienced unusual or increased expenditures resulting from the drought conditions.[3] In addition, the study revealed that less than a quarter of the province's water suppliers are well prepared to deal with a long term reduced supply of water.

This study was funded by the provincial "Dealing with Drought" Initiative. The goals of this initiative are to aid water suppliers in examining their water management policies and practices, managing their water supplies at an operational level, and increasing public awareness of their need to use less water. Although our water sources are coming under increasing strain, we can make a significant contribution to solving supply problems by reducing unnecessary levels of water use. Canadians are among the highest water users in the world,[4] and there is a growing recognition that the supply-side solution of increasing system capacity must be complemented by

---

[1] Environment Canada. "Water Conservation: Every Drop Counts." http://www.ec.gc.ca/water/en/manage/effic/e_sustws.htm

[2] Land and Water British Columbia. "Status of Community Water Supplies in British Columbia: 2003 Drought Survey." www.lwbc.bc.ca

[3] Land and Water British Columbia. "Dealing with Drought: A Handbook for Water Suppliers in British Columbia." 1. www.lwbc.bc.ca

[4] Oliver Brandes and Tony Maas. "Urban Water Demand Management: Planning for an uncertain future." *Municipal World.* July 2004. 5-24.

demand-side management strategies to reduce system requirements. For these reasons, conservation opportunities are the focus of this study.

This report identifies water conservation opportunities and priority targets for conservation in the City of Nelson. Conservation strategies have been determined based on analysis of Nelson's water supply, current demand among all land use types, and potential future demand. This study is based on underlying assumptions that:

- more water is used than needed;
- attention to water demand is as important as water supply; and,
- water can be used more efficiently.

Numbers presented in this study are typically estimates. These estimates are researched and educated, but they should only be used for qualitative assessment, and they should not be understood as factual.

This report has been organized into the following sections:

Section 1: Introduction
Section 2: Background
Section 3: Current Demand Analysis
Section 4: Future Demand Forecasts
Section 5: Possible Conservation Strategies
Section 6: Summary and Recommendations

2.0 BACKGROUND

The City of Nelson is located in the West Kootenays, on the south shore of Kootenay Lake. Aside from the North Shore, which operates on an independent system, Nelson is supplied by surface water systems on Five Mile Creek, Anderson Creek, and Selous Creek. However, because Anderson Creek and Selous Creek do not have reliable quality or quantity, Five Mile Creek is the primary water source for the City of Nelson.

The watershed yield for Nelson's Five Mile source is identified in Table 2.1, below. This table draws on data from the 1996 Water Supply Review, and the listed watershed yields represent the statistically estimated low stream flow for the given time periods. The low stream flow for each period is anticipated to be equal to or less than the indicated value (e.g. on a 50 year return, Nelson will experience a summer low stream flow of 7,222 L/min or less).

Table 2.1 - Watershed Yield for the Five Mile Source (L/min)

	Winter Yield	Summer Yield
1 Year Flow	9,583	35,972
5 Year Flow	4,792	15,625
50 Year Flow	2,847	7,222

In practice, the Five Mile system is capable of providing an average daily flow of 8,000 L/min, due to hydraulic capacity constraints of the Five Mile pipe line.

As in many BC communities, the City of Nelson experiences challenges in keeping up with water demands. If average daily flows exceed the 8,000 L/min capacity of the Five Mile system, the system is put into a deficit situation, which obviously cannot be allowed to continue. The City has experienced such events in the past, most notably so during the drought conditions of 2003, when average day demands reached approximately 9,500 L/min, and peak demands exceeded 15,000 L/min. During this period, the City was forced to impose strict watering bans. Fundamentally, there is nothing wrong with implementing watering bans when warranted by drought conditions. However, it would be preferable to avoid crisis situations by taking proactive demand-side management strategies. Thus, this study aims to improve the understanding of how water is being used in Nelson, and identifies strategies to better manage the water system.

3.0 CURRENT DEMAND ANALYSIS

3.1 Context

This section identifies Nelson's water demand characteristics in order to identify appropriate opportunities for water conservation. The data is drawn primarily from the 2004 Water Model Update. The following water demand characteristics are assessed:

- Winter average day demand (Winter ADD)
- Average day demand (ADD) and its distribution between uses
- Maximum daily demand (MDD) and its distribution between uses
- Peak hour demand (PHD)

Table 3.1 presents a summary of Nelson's demand characteristics, which are discussed below.

Table 3.1 - Nelson's water demand characteristics

Demand Scenario	Water Demand (L/min)
Winter Average Day Demand (Winter ADD)	4,300
Average Day Demand (ADD)	5,500
Maximum Day Demand (MDD)	8,000
Peak Hour Demand (PHD)	12,500

3.2 Winter Average Day Demand (Winter ADD)

Winter ADD figures provide an indication of basic water requirements for domestic in-house, institutional, commercial, and industrial uses, all of which are assumed to have consistent water requirements over the course of the year.

In Nelson, winter ADD is approximately 4,300 L/min. While this is under the Five Mile source 5 year winter low of 4,792 L/min, it is well over the statistically determined 50 year winter low of 2,847 L/min. Thus, the City of Nelson should monitor winter supply closely and be prepared to take emergency measures such as enhancing supply, should a 50 year event occur.

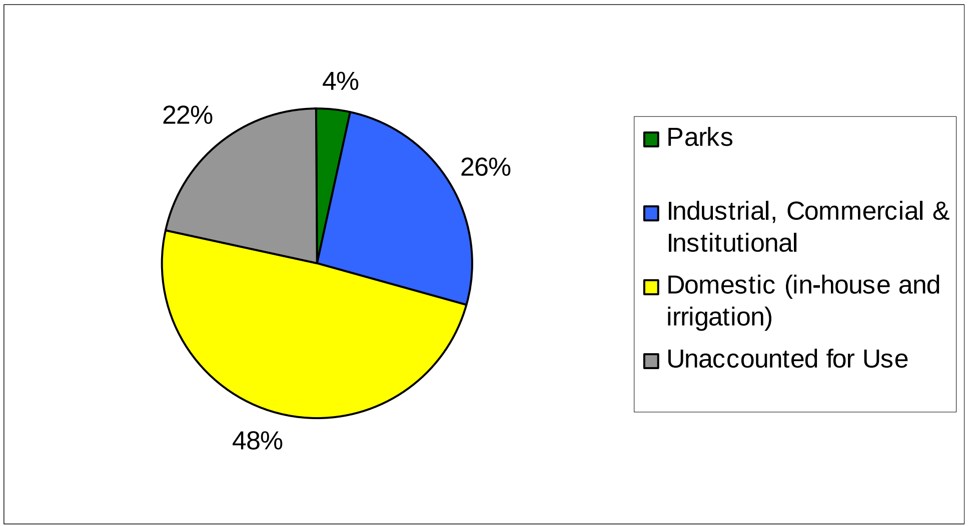
3.3 Average Day Demand (ADD)

Taken throughout the year, average day demand is approximately 5,500 L/min, representing an increase of only 27 percent over winter average day demand. On a per capita basis, this is approximately 0.6 L/min per user, which is just slightly higher than the 1999 provincial average of 0.5 L/min per user.[5] The 2004 Water Model Update Report provides a breakdown of water demands by land use, researched through the use of aerial photography and land use data. According to this report, average daily demand is roughly distributed as follows:

- 2,694 L/min are for domestic use, including both domestic in-house use and domestic irrigation (i.e. sprinkling) use.
- 1,417 L/min are for industrial, commercial, and institutional use.
- 205 L/min are for irrigation of park lands.
- 1,200 L/min are unaccounted for. These losses represent the difference between daily water demand and the daily volume of wastewater on a winter day when irrigation water demand is negligible. Examples of unaccounted for use could include leaks in the system, water lost from food processing, and water to waste refrigerant systems connected to the storm sewer. This unaccounted for volume is likely the primary reason that Nelson's average per capita daily demand for water is slightly higher than the provincial average. While leakage in the average Canadian water system is 13 percent, Nelson's unaccounted for losses represent 22 percent of average day demand.

[5] BC Ministry of Water, Land and Air Protection. "Status and Trends in Water Use." http://wlapwww.gov.bc.ca/soerpt/8surfacewateruse/municipal.html

Figure 3.1 - Distribution of Average Day Demand



3.4 Maximum Day Demand (MDD)

Nelson's maximum day demand reaches approximately 8,000 L/min, as calculated in the 2004 Water Model Update Report. While this is almost twice as high as the winter average day demand of 4,300 L/min, this peak demand on the system is relatively low compared to a number of other BC communities.

Nelson's relative success in achieving a reasonable MDD to winter ADD ratio may be due to the fact that the City's water needs are focused on domestic, industrial, commercial, and institutional use, rather than agricultural use. The success may also be attributable to good conservation efforts in the past during peak periods. However, the ratio is also influenced by the fact that winter ADD is slightly higher than it ought to be due to significant unaccounted for losses, which are consistent throughout the year.

Despite Nelson's good MDD to winter ADD ratio, the maximum day demand is roughly equal to the 8,000 L/min capacity of the Five Mile pipe line. This line draws from the Five Mile watershed, which has a statistically estimated 50 year summer low of 7,222 L/min.

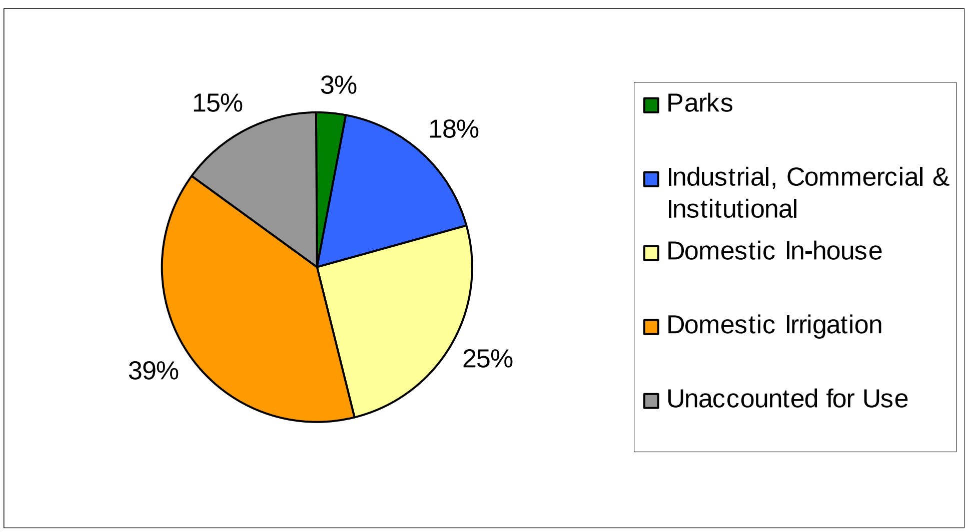
Maximum day demand is distributed as follows:

- 2,038 L/min are for domestic in-house use. This figure is calculated by multiplying the number of users on the Five Mile system (8,630, as determined in the 2004 Water Model

Update) by an average of 340 L/day per person, and it is based on the assumption that this use remains constant over the course of the year.

- 3,100 L/min are for domestic irrigation. This figure is calculated by subtracting out all other uses from the total MDD of 8,000 L/min. Using 2,647 single family dwelling water connections in Nelson, this means that the average household uses approximately 1,685 L/day (1.17 L/min or 0.3 USGPM) for domestic irrigation. This is a reasonable amount, which approximates an hour of watering per day for the average household. This indicates that the average Nelson resident is fairly water-wise in terms of domestic irrigation use.
- 1,417 L/min are for industrial, commercial, and institutional use. This figure is based on the assumption that water demand for these uses remains constant over the course of the year.
- 245 L/min are for irrigation of park lands. This figure is based on an estimate provided by the City of Nelson, detailed in Appendix A.
- 1,200 L/min are unaccounted for. This figure is based on the assumption that unaccounted for losses remain constant over the course of the year.

Figure 3.2 - Distribution of Maximum Day Demand



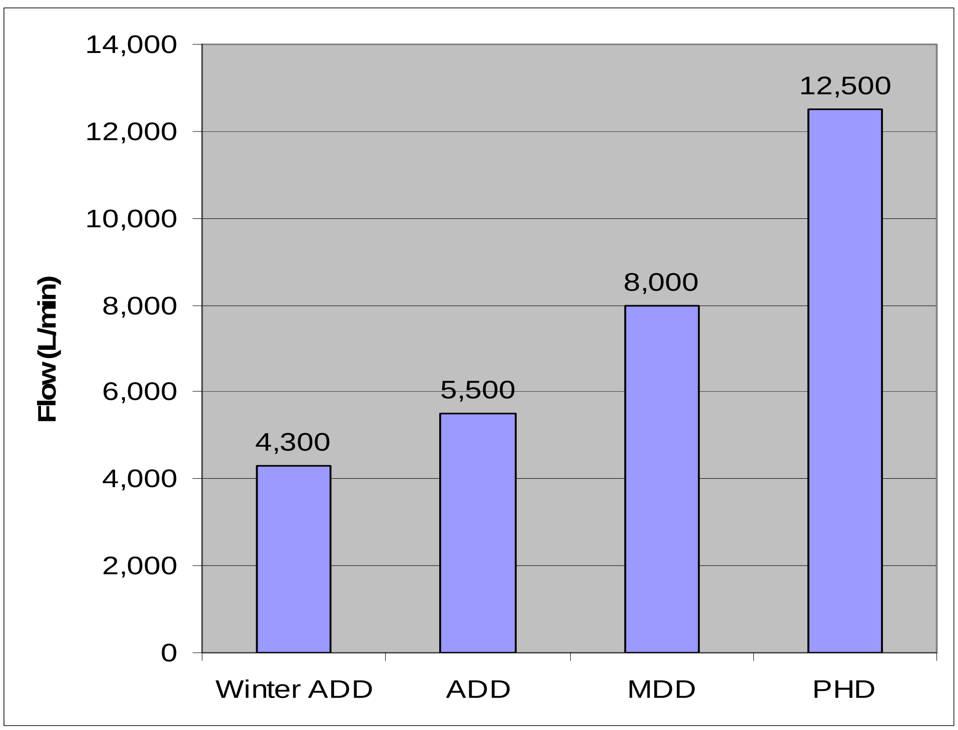
3.5 Peak Hour Demand (PHD)

According to the 2004 Water Model Update, peak hour demand is estimated at 12,500 L/min. Although this is significantly higher than the Five Mile pipe line's capacity of 8,000 L/min, peak hour demand is accommodated through the use of storage within the Mountain Station settling pond.

3.6 Summary

Nelson residents can be considered to be quite efficient in their water use. Compared to a number of other BC communities, the peak demands on Nelson's system are relatively low on a per capita basis. Furthermore, MDD is not even twice as high as winter ADD, as shown in Figure 3.3 below. Nonetheless, this profile of Nelson's water demand also indicates that the water system is reaching capacity in peak periods. To offset stress on the system, gains could be made in reducing unaccounted for losses, domestic in-house use, and industrial, commercial, and institutional use.

Figure 3.3 – Summary comparison of winter ADD, ADD, MDD, and PHD (L/min)



4.0 FUTURE DEMAND FORECASTS

4.1 Introduction

Over the past few decades, Nelson has maintained a stable population base while experiencing little growth.[6] This section illustrates the 20 year impact of potential population growth on water demand, and the strain that it may place on supply. Three scenarios are shown:

- An assumed projection of 0.2 percent population growth;
- A low projection of 0.1 percent population growth; and,
- A high projection of 1.0 percent population growth.

In using these scenarios, it is assumed that the rate of growth in water demand will roughly equal the rate of population growth. This presumes that future patterns of development will match current patterns of development.

4.2 Assumed Projection: Growth of 0.2 Percent

A population projection of 0.2 percent annual growth is reasonably consistent with the trends experienced in Nelson over the past few decades. Using this projection, 2025 water demands on the Five Mile source would be as follows:

Table 4.1 - 2025 Demand Projection for Five Mile Source: 0.2% Growth

Demand Scenario	Water Demand (L/min)
Winter Average Day Demand (Winter ADD)	4,484
Average Day Demand (ADD)	5,736
Maximum Day Demand (MDD)	8,343
Peak Hour Demand (PHD)	13,036

In this scenario, winter ADD climbs over 1,600 L/min higher than the 50 year winter low for the Five Mile source, and MDD is approximately 1,100 L/min higher than the 50 year summer low for the Five Mile source. In drought situations, this would place slightly higher strain on the existing water system than in the current situation.

[6] Population figures and projections for the City of Nelson are expanded on in Appendix A.

4.3 Low Projection: Growth of 0.1 Percent

A population projection of 0.1 percent annual growth provides a low growth scenario. Given the small difference between this scenario and the assumed scenario, the demands on the water system would be relatively the same. Using this projection, these 2025 water demands on the Five Mile source would be as follows:

Table 4.2 - 2025 Demand Projection for Five Mile Source: 0.1% Growth

Demand Scenario	Water Demand (L/min)
Winter Average Day Demand (Winter ADD)	4,391
Average Day Demand (ADD)	5,617
Maximum Day Demand (MDD)	8,170
Peak Hour Demand (PHD)	12,765

Although this is a low-growth scenario, winter ADD still exceeds the 50 year winter low for the Five Mile source by over 1,500 L/min, and MDD exceeds the 50 year summer low for the Five Mile source by almost 950 L/min. This reflects the strain that is presently on the system in drought situations.

4.4 High Projection: Growth of 1.0 Percent

A population projection of 1.0 percent annual growth provides a high growth scenario. This scenario could be realized if new development starts to occur in Nelson. As a comparison, many communities in BC are experiencing growth rates that are much higher than this. Additionally, this growth rate is still well below the annual growth rate of 2.9 percent experienced in Nelson in the 1960s. Using this projection of 1.0 percent annual growth, the 2025 water demands on the Five Mile source would be as follows:

Table 4.3 - 2025 Demand Projection for Five Mile Source: 1.0% Growth

Demand Scenario	Water Demand (L/min)
Winter Average Day Demand (Winter ADD)	5,299
Average Day Demand (ADD)	6,778
Maximum Day Demand (MDD)	9,859
Peak Hour Demand (PHD)	15,405

In this higher-growth scenario, winter ADD exceeds the 50 year winter low for the Five Mile source by almost 2,500 L/min, and it exceeds the 5 year winter low by over 500 L/min. In the summer, MDD exceeds the 50 year summer low for the Five Mile source by over 2,600 L/min. These figures demonstrate that if modest growth starts to occur in Nelson, conservation measures alone will not be sufficient, and supply will need to be enhanced. Since population growth often occurs in surges, Nelson's growth may well meet or exceed this higher-growth projection of 1.0 percent at some point within the next twenty years. Should this happen, the need for supply enhancements may become acute.

5.0 POSSIBLE CONSERVATION STRATEGIES

5.1 Overview

Current demand analysis and future demand forecasts reveal that Nelson's water system is running at capacity in peak periods. Further, since MDD compares favourably to the provincial average and is also not even twice as high as winter average day demand, it can be deduced that Nelson is a relatively water-wise community. Regardless, there are still a number of opportunities for demand-side management and conservation.

Nelson's primary water conservation focus should be on the reduction of unaccounted for losses. These losses represent 22 percent of average day demand, and they are much higher than the losses experienced in most other communities. While Nelson is relatively water-wise in other areas, further opportunities to reduce demand may be pursued in the areas of domestic in-house use, and industrial, commercial, and institutional use. The average Nelson resident appears to already be water-wise in the yard, and opportunities for conservation in the area of domestic irrigation are therefore considered limited.

In all of the aforementioned areas, opportunities for conservation fall under the following categories:

- Regulatory Strategies: includes building and plumbing codes (federal and provincial regulations), and water use restrictions;
- Economic and Financial Strategies: includes full cost pricing and escalating rate structures to reward conservation.
- Operation and Maintenance Strategies: includes leak detection and repair, and water audits; and,
- Educational Strategies: includes social marketing and guides or "how to" manuals;

5.2 Regulatory Strategies

On the hottest of summer days, Nelson's water use almost doubles that of an average winter day. Virtually all of this increase is due to landscape irrigation requirements, in both parks and private properties. As shown in the demand analysis, Nelson's domestic irrigation use on peak days (1,685 L/day for the average household) may not be out of line. However, in emergency situations, this is water use that can be regulated to bring down overall demand requirements. Water use restrictions can be developed and implemented according to the potential severity of water shortages. Appendix C illustrates a potential addition to Nelson's "By-law No. 1500: A Bylaw to Regulate the Waterworks System of the City of Nelson." This potential addition to the by-law sets out four stages of watering restrictions, each requiring an increasingly larger reduction in water use.

To augment any possible watering restrictions, the City of Nelson could encourage voluntary irrigation start times. In the typical community, the water system experiences peak daily summer demand periods in both the early morning and the evening, when most people water their lawns and gardens. By recommending watering times for automatic sprinkler systems, the City may have an opportunity to smooth peak flows into the night hours. For instance, the City could adopt a model like the following schedule for those with automatic sprinkler systems:

Homes ending with numbers:
00-19: start at 11 p.m.
20-39: start at midnight
40-59: start at 1 a.m.
60-79: start at 2 a.m.
80-99: start at 3 a.m.

For obvious reasons, it would be impractical to ask those who manually water their lawns to start sprinkling in the middle of the night. However, by requesting that households with automatic sprinklers irrigate during the overnight low-demand period between 11 p.m. and 4 a.m., the morning and evening peak demand periods could be reduced.

Regulatory strategies can also be used to curb water losses, particularly in the areas of commercial and industrial uses. Nelson's water bylaws prohibit the use of water to waste refrigerant systems and they also contain provisions against wasted water due to imperfect or leaky fixtures. By further enforcing these bylaws, Nelson may achieve progress in reducing overall water losses.

5.3 Economic and Financial Strategies

Economic and financial strategies aim to introduce a greater level of rate equity among users while better accounting for the true cost of distribution of potable water and the collection and treatment of wastewater. One common conservation strategy is the adoption of a universal metering program, combined with escalating rate structures to reward conservation. While Nelson currently has metered water service in some commercial and industrial establishments, a universal metering program would extend meters to all land uses within the City.

In other jurisdictions, the introduction of water meters has helped to reduce overall water use. For example, since Kelowna introduced water meters in 1996, average residential use dropped from 54 cubic meters per month (1.25 L/min) to 42 cubic meters per month (0.97 L/min), a decrease of approximately 25 percent. This includes both domestic in-house use and domestic irrigation use. It is important to recognize that water meters are not a quick-fix solution to demand-management. In the Kelowna experience, consumer behaviour was changed not simply because water meters were installed, but rather because the metering program was complimented with public education strategies and the introduction of consumer incentives to reduce demand. Two such consumer incentives included offering property owners a service that provided their lawns with core aeration and a top dressing of Ogogrow, an organic mulch, and offering property owners water-efficient irrigation timers. These strategies were applied in high-use areas of the City, and the costs of either incentive were shared between the City and property owners. Even if the City of Nelson does not pursue a universal metering program, these consumer incentives may be used to decrease domestic irrigation demand.

Water meters bring with them the opportunity to charge users based on the actual amount of their water usage. In many cases, municipalities will charge a nominal monthly rate for water, plus another rate per cubic meter of consumption. However, another approach involves adopting an escalating rate structure, which would encourage water conservation and better reflect the true cost of water. The following provides an example of an escalating rate structure for single family dwelling units:

- Monthly rate of $7.75, plus:
    - $0.225 per cubic meter for consumption between 0-30 cubic meters
    - $0.335 per cubic meter for additional consumption between 30-125 cubic meters
    - $0.445 per cubic meter for additional consumption above 125 cubic meters.

An escalating rate structure like this is not without drawbacks, as social issues such as ability to pay must be considered carefully. Nonetheless, an escalating rate structure would likely encourage water conservation more so than a flat rate per cubic meter of consumption. Ultimately, a political decision between these rate structures is required, should a universal metering program be considered.

In Nelson, it is estimated that water meters would cost in the order of $500 per meter. Assuming approximately 4,000 meters, this would place the installation cost for a universal metering program in the order of $2,000,000. Should Nelson wish to consider a universal metering program, the City should weigh these costs against the potential benefits of a program by completing a metering study prior to project initiation. This study should define the socio-economic benefits and costs of metering, and articulate a plan for implementation of a metering program.

5.4 Operation and Maintenance Strategies

Operation and maintenance strategies are primarily focused on structural or physical improvements to the water system, as well as installation of water efficient devices or processes. As stated previously, Nelson's primary water conservation focus should be on the reduction of unaccounted for losses, which are much higher than the losses experienced in most other communities. Tackling this problem entails improving the efficiency of both the water system and certain commercial and industrial usage, as it is hypothesized that Nelson's water losses are primarily the result of leaks in the system and the use of water to waste refrigerant systems.

A 50 percent reduction in unaccounted for losses would represent an aggressive target for the City of Nelson. Achieving this target would make Nelson's unaccounted for losses represent 12 percent of ADD rather than 22 percent, and it would bring Nelson in line with other communities. In addition, by achieving this target, MDD would drop by about 8 percent, from 8,000 L/min to 7,350 L/min. To achieve this target, the City of Nelson should first undertake an audit to confirm where losses are being experienced. Upon completing this audit, strategies to reduce losses can be developed.

5.5 Educational Strategies

Educational strategies can be adapted to target all sectors, including domestic irrigation use, domestic in-house use, and industrial, commercial, and institutional use. These educational strategies may include social marketing campaigns, guidelines and "how-to" guides, meetings with major water users, and educational programs in local schools. The City of Nelson already does an excellent job of including tidbits of educational material on water conservation in its newsletter to residents. At this stage, it is recommended that the City of Nelson continue with this, and also publish separate educational materials to be distributed to all residents, particularly in the dry summer season. Appendix D of this document contains a list of conservation strategies that the City of Nelson may wish to consider adapting for its public education documents.

6.0 SUMMARY AND RECOMMENDATIONS

Nelson's water system is running at capacity in peak periods, and the summer of 2003 demonstrated that serious conservation measures such as watering restrictions are necessary in high demand periods, to bring water demand in line with available supply. At the same time, it must be recognized that at current levels of demand, Nelson residents are fairly water-wise. Nelson's maximum day demand for water is not even twice as high as winter average day demand, and average day demand per capita is near the provincial average. However, if unaccounted for losses could be reduced, Nelson's per capita average day demand could become lower than the provincial average.

Although the City of Nelson is relatively efficient in its water use, there are a number of priority conservation areas that it should focus on. These include the following:

1. **Target an aggressive 50 percent reduction in unaccounted for losses:**
   As described in section 5.4, Nelson loses significantly more water to leakage and other system losses than the average municipality. If the current losses of 1,200 L/min could be reduced to 600 L/min, MDD would drop from 8,000 L/min to 7,350 L/min, providing a much greater cushion for the water system in high-demand periods. To effectively target this area, the City of Nelson should undertake a detailed audit to confirm the cause of losses and determine the most appropriate strategies for loss-reduction.

2. **Target a 10 percent reduction in domestic in-house use, and industrial, commercial, and institutional use:**
   Through consistent public education strategies, it may be possible to achieve small gains in conserving water in the areas of domestic in-house use, and industrial, commercial, and institutional use. To achieve these gains, the City of Nelson should continue with consistent newsletter updates that provide information to citizens, both on the need to conserve water and on opportunities to reduce water use. In addition, the City should publish separate educational materials to be distributed to all residents and businesses, particularly during peak demand periods.

By achieving these conservation targets, Maximum Day Demand could potentially be reduced by 12 percent overall, dropping from 8,000 L/min to 7,055 L/min. This is illustrated in Table 6.1, below.

Table 6.1 – Potential Impact of Conservation on Maximum Day Demand (L/min)

Current Maximum Day Demand	**8,000**
Unaccounted for Losses: 50% Reduction	-600
Domestic In-House Use: 10% Reduction	-204
Industrial, Commercial, Institutional Use: 10% Reduction	-142
Potential MDD After Conservation	**7,055**

Aside from these priority areas, the City of Nelson should give consideration to other opportunities for conservation. These include the following:

1. **Target potential reductions in domestic irrigation:**
   Domestic irrigation is an area in which Nelson residents are already fairly water-wise compared with a number of other BC communities. However, domestic irrigation causes summer demand for water to rise almost twice as high as average day demand, and this is the area of water use that can be most easily regulated and controlled. Further, as demonstrated by the drought in 2003, watering restrictions may be necessary in Nelson during dry periods. Appendix C sets out a potential water conservation bylaw, illustrating four stages of water restrictions that could be used in the City of Nelson.

   In addition to staged watering restrictions, the City of Nelson may wish to consider offering consumer incentives to help reduce domestic irrigation demand. These could involve providing organic mulch or water-efficient timers to high-use consumers under a cost-sharing arrangement.

2. **Implement a universal metering program:**
   Water meters come at a relatively high capital cost compared to other conservation strategies, but combined with an appropriate rate structure and other measures such as public education and consumer incentives, they have been shown to have a significant impact on water demand. Should the City of Nelson consider a move towards universal metering, it should complete a metering study that define the socio-economic benefits and costs of metering, and articulates a plan for implementation of a metering program.

Notwithstanding all of the aforementioned opportunities for conservation, the City of Nelson may require water system upgrades and capacity enhancements. Chapter Four of this report illustrates that the existing water system would be unable to sustain consistent population growth of 1.0 percent per annum, given current patterns of water demand. Although this is much higher than Nelson's current growth rate, sudden growth at 1.0 percent per annum or higher could quickly trigger the need for enhanced capacity. While there are a number of tools for conservation to reduce water demand, Nelson is already a relatively water-wise community and the potential for demand-side savings is limited. Thus, if the population starts to grow at even a modest rate, the City should anticipate a need for future water system capacity enhancements.

APPENDIX A:

Irrigation of Park Lands in Peak Periods

Information on parkland irrigation in the summer months was provided by the City of Nelson. All of the following parks draw from the Five Mile system:

- Cemetery – 75 USGPM sprinklers x 4 sprinklers on at one time x 180 minutes total sprinkling time = 54,000 US gallons per day
- Lions Park – 16 USGPM sprinklers x 5 on at one time x 120 minutes total sprinkling time = 9,600 US gallons per day
- Gyro Park - 16 USGPM sprinklers x 3 on at one time x 120 minutes total sprinkling time = 5,760 US gallons per day
- Queen Elizabeth Park - 16 USGPM sprinklers x 3 on at one time x 180 minutes total sprinkling time = 8,640 US gallons per day
- Lakeside Park - 16 USGPM sprinklers x 4 on at one time x 180 minutes total sprinkling time = 11,520 US gallons per day
- Cottonwood Park and others - 16 USGPM sprinklers x 2 on at one time x 120 minutes total sprinkling time = 3,840 US gallons per day

Total parkland irrigation requirements in the summer months:
93,360 US gallons per day = 353,405 litres per day = 245 L/min

APPENDIX B:

Data for Nelson Population Projections

Nelson Population by Year: 1976-2004

Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Nelson Population	9,572	9,689	9,673	9,360	9,589	9,513	9,481	9,596	9,194	8,823	8,612	8,564	8,596	8,745

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
8,902	8,983	9,380	9,550	9,699	9,819	9,948	9,883	9,655	9,609	9,555	9,703	9,637	9,765	9,784

Source: BC Stats

Nelson Population by Decade: 1921-2001

Year	1921	1931	1941	1951	1961	1971	1981	1991	2001
Nelson Population	5,230	5,992	5,912	6,772	7,074	9,400	9,513	8,983	9,703

Source: BC Stats

As shown above, Nelson's population experienced dramatic growth from the 1940s to the late 1960s, and the population has since stabilized. Nelson's 1971 population was 9,400, and Nelson's 2004 population stands at 9,784, an increase of just 384 people over 33 years.

Nelson's annual growth rate for various periods is presented below:

- 1994 to 2004: growth of 0.09 percent per annum (from 9,699 to 9,784)
- 1984 to 2004: growth of 0.31 percent per annum (from 9,194 to 9,784)
- 1976 to 2004: growth of 0.09 percent per annum (from 9,572 to 9,784)
- 1921 to 2004: growth of 0.78 percent per annum (from 5,230 to 9,784)

From 1961 to 1971, in a decade of significant growth, Nelson experienced growth of 2.88 percent per annum (from 7,074 to 9,400).

Given Nelson's pattern of stable population with little growth since the early 1970s, it is reasonable to assume a growth rate of 0.2 percent over the next 10 to 20 years, for planning purposes. In this study, a low growth scenario of 0.1 percent and a high growth scenario of 1.0 percent were also used for comparative purposes.

City of Nelson Population Projections

Growth Rate	2005	2010	2015	2020	2025
0.1%	9,794	9,843	9,892	9,942	9,992
0.2%	9,804	9,902	10,001	10,102	10,203
1.0%	9,882	10,386	10,916	11,473	12,058

Given that the Five Mile Creek serves an area with a 2004 population of 8,630, as identified in the 2004 Water Model Update, population projections have been applied to this number too, as shown below.

Population Projections for the area supplied by Five Mile Creek

Growth Rate	2005	2010	2015	2020	2025
0.1%	8,639	8,682	8,725	8,769	8,813
0.2%	8,647	8,734	8,822	8,910	9,000
1.0%	8,716	9,161	9,628	10,119	10,636

APPENDIX C:

Potential Water Conservation Bylaw

The following illustrates an example of staged watering restrictions that the City of Nelson could use to replace and expand on Section 17 (h) of the current Bylaw No. 1500: A Bylaw to Regulate the Waterworks System of the City of Nelson. Alternatively, the City of Nelson could write these staged watering restrictions into a separate water conservation bylaw.[7]

OUTDOOR WATER USE RESTRICTION STAGES

1. Stage 1 – Every Second Day Lawn Watering

(1) During Stage 1,

(a) no person shall use a sprinkler or irrigation system to water a lawn growing on a property with

(i) an even numbered address, except on even numbered days of the month between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.; and,

(ii) an odd numbered address, except on odd numbered days of the month between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.

(b) a person may

(i) water trees, shrubs, flowers and vegetables on any day with a sprinkler during the prescribed hours for Stage 1 lawn watering and on any day at any time if watering is done by hand-held container or a hose equipped with a shut-off nozzle;

(ii) use micro-irrigation or drip-irrigation systems to water trees, shrubs, flowers and vegetables at any time on any day; and,

(iii) wash a vehicle with water using a hand held container or hose equipped with a shut-off nozzle and at commercial car washes.

2. Stage 2 – Two Days Per Week Lawn Watering

(1) During Stage 2,

(a) no person shall use a sprinkler or irrigation system to water a lawn growing on a property with

[7] See, for example, the Capital Regional District's Bylaw No. 3061 – "Water Conservation Bylaw" or the District of Peachland's Bylaw No. 1688 – "A Bylaw to Prescribe Water Use Restrictions"

(i) an even numbered address, except on Wednesdays and Saturdays between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.; and,

(ii) an odd numbered address, except on Thursdays and Sundays between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.

(b) a person may

(iv) water trees, shrubs, flowers and vegetables on any day with a sprinkler during the prescribed hours for Stage 2 lawn watering and on any day at any time if watering is done by hand-held container or a hose equipped with a shut-off nozzle;

(v) use micro-irrigation or drip-irrigation systems to water trees, shrubs, flowers and vegetables at any time on any day; and,

(vi) wash a vehicle with water using a hand held container or hose equipped with a shut-off nozzle and at commercial car washes.

3. Stage 3 – One Day Per Week Lawn Watering

(1) During Stage 3,

(a) no person shall use a sprinkler or irrigation system to water a lawn growing on a property with

(i) an even numbered address, except on Wednesdays between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.; and,

(ii) an odd numbered address, except on Thursdays between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m.

(b) no person shall use water to wash sidewalks, driveways or parking lots, exterior windows or exterior building surfaces, except as necessary for applying a product such as paint, preservative and stucco, preparing a surface prior to paving or repointing bricks, or if required by law to comply with health or safety regulations.

(c) a person may

(i) water trees, shrubs, flowers and vegetables on any day with a sprinkler during the prescribed hours for Stage 3 lawn watering and on any day at any time if watering is done by hand-held container or a hose equipped with a shut-off nozzle;

(ii) use micro-irrigation or drip-irrigation systems to water trees, shrubs, flowers and vegetables at any time on any day; and,

(iii) wash a vehicle with water using a hand held container or hose equipped with a shut-off nozzle and at commercial car washes.

4. Stage 4 – No Lawn Watering

(1) During Stage 4,

(a) no person shall

(i) water a lawn or boulevard;

(ii) fill a swimming pool, hot tub or garden pond;

(iii) fill or operate a decorative fountain or pond; or,

(iv) wash a vehicle with water

(v) use water to wash sidewalks, driveways or parking lots, exterior windows or exterior building surfaces, except as necessary for applying a product such as paint, preservative and stucco, preparing a surface prior to paving or repointing bricks, or if required by law to comply with health or safety regulations.

(b) a person may

(i) water trees, shrubs, flowers and vegetables on any day between the hours of 4:00 a.m. to 10:00 a.m. and 7:00 p.m. to 10:00 p.m. if watering is done by hand-held container or a hose equipped with a shut-off nozzle;

(ii) use micro-irrigation or drip-irrigation systems to water trees, shrubs, flowers and vegetables on any day between the hours of 4:00 a.m. to 10:00 a.m. and 7:00 p.m. to 10:00 p.m.;

(iii) wash a vehicle with water using a hand held container or hose equipped with a shut-off nozzle and at commercial car washes.

PERMITS

1. A person who has installed a new lawn, either newly seeded or new sod, may apply to the City of Nelson for a permit, which will allow the new lawn to be sprinkled outside of watering days, but within restricted hours. This permit shall be conspicuously displayed at the premises for which it was issued.
2. New sod may be sprinkled for 21 days after installation, and newly seeded lawn may be watered until growth is established or for 49 days after installation, whichever is less, provided a permit pursuant to Section 1 has been issued for the premises at which the new lawn has been installed.
3. Permits will not be issued or be valid during Stage 3 or 4 restrictions.

EXEMPTIONS AND SPECIAL CASES

1. Exempted Users

The provisions of the watering restrictions shall not apply to persons who own, operate or carry on the following operations or activities that rely on the steady supply and use of water:
(a) nurseries;
(b) farms;
(c) orchards.

2. Newly Planted Trees and Shrubs

A person may during:
(a) Stage 1, 2, or 3 watering restrictions, water new trees and shrubs during installation and for the following 24 hours, and after that 24 hour period, watering must comply with the Stage 1, 2, or 3 watering restrictions as applicable;
(b) Stage 4 watering restrictions, water new trees and shrubs between the hours of 4:00 a.m. to 9:00 a.m. and 7:00 p.m. to 10:00 p.m. only by hand-held container or hose equipped with a shut-off nozzle during installation and for the following 24 hours, and after that 24 hour period, watering must comply with the Stage 4 watering restrictions as applicable.

3. Public Authorities

Public authorities may during:
(a) Stage 1, water lawns, boulevards and playing fields on any day at any time;
(b) Stages 2 and 3, water lawns, boulevards and playing fields at any time, but no more often than every second day.

APPENDIX D:

Water Conservation Tips to Promote through Public Education

Outdoor Water Conservation Tips:

In the yard:

- Add organic material to lawns. If water soil conditions are poor, water either runs right through the soil or sits on top of it. The solution to both of these problems is to aerate the lawn at least once per year and to frequently top dress it with organic material. By aerating, one ensures that nutrients, oxygen, and water can penetrate the soil. Leaving organic materials like grass clippings on the lawn can also help build up the soil and encourage healthy grass growth. In the long run, both of these measures will help to conserve water and result in healthier grass.
- Leave grass clippings on lawns. This saves time, money, and effort. Clippings will break down into fertilizer, and because they cover the lawn, they reduce evaporation and the need to water.
- Add organic mulch to gardens. Mulch acts as a protective cover for plants, and it keeps soil cool and moist, while also discouraging weed growth. Overall, mulch will also result in a reduced requirement for watering.
- Follow xeriscape principles. Xeriscaping is water conservation through creative landscaping. Aside from the use of organic materials and mulches, it involves landscaping with slow-growing, drought tolerant plants to conserve water and reduce yard trimmings. Xeriscaping saves water, it requires less maintenance, it is environmentally appropriate, it provides attractive and functional landscaping that uses a variety of flowers, colours, and interesting plants, and it uses plants adapted to the local area.
- Inspect and upgrade inefficient automatic sprinkler systems. As automatic sprinkler systems age, they become less efficient. As water pressures change over time, sprinkler heads may not provide total coverage, and one may over-water to compensate for this. Over-watering can also occur if irrigation systems are not properly installed, or if they are poorly designed. Water can be conserved by ensuring that sprinkler systems are inspected on a regular basis, to ensure that water is going where it is supposed to be going and that sprinkler heads are not leaking. Often, water can also be conserved by upgrading older systems to newer ones.
- Install drip irrigation wherever possible or use a root irrigator for deep watering. Sprinklers are water inefficient, and root irrigators bring water down to the roots, where the plants need it.
- Avoid watering during the hottest times of the day. Watering in the hot sun should be avoided, as up to 50 percent of the water can be lost to evaporation. As well, scald or burn damage can occur when hot sunlight hits water droplets that cling to leaves. The tiny droplets imitate powerful, miniature magnifying glasses. The best times to water are in the early morning or evening.
- Do not over-water. To stay healthy, most lawns need about 2.5 centimetres of water a week. This approximates one hour of sprinkling, including rainfall, which can easily be applied on just one day of sprinkling per week. To determine if your grass needs watering, step on it. If it springs back when you lift your foot there is no need to water. When you do water, give the

lawn a thorough soaking. This produces a deep root system and stronger grass. Daily watering results in shallow roots and weaker grass.

- Water trees slowly, deeply, and infrequently to encourage deep rooting.
- When watering your garden, use a watering can or spring-loaded nozzle to save 10 to 35 litres a minute.
- Keep your lawn mower blades sharp, to avoid ripping grass and leaving it open to heat stress or disease.
- Over-seed, introducing a mix of drought tolerant grasses to existing turf. This should be done while fertilizing, aerating, or top-dressing.
- Let grass grow to a height of about 2.5 to 3 inches, as taller grass shades new growth and reduces evaporation.
- Collect rain water in a barrel and use it to water your garden.

In the driveway:

- When possible, use a broom to clean the driveway instead of a hose. A running hose wastes over 20 litres of water per minute.
- When washing vehicles, use a bucket and sponge. Use a hose with a shut-off nozzle to wet the vehicle down and rinse it.

Indoor Water Conservation Tips:

In the bathroom:

- Turn off the tap when you brush your teeth, shave, or wash your face. This could save 7 to 12 litres of water a minute.
- Take shorter showers. This could save 6 to 19 litres of water a minute.
- Install a water-saving showerhead. This could save up to 3,000 litres a month.
- Install a new low-volume toilet that uses only 6 litres per flush. Toilets account for as much as 40 percent of indoor water use, and older toilets use up to 30 litres per flush. Installing a low-volume toilet could save over 1,500 litres a month.
- Don't use your toilet as a wastebasket.
- Toilets are notorious for hidden leaks, and they can waste hundreds of litres of water a day. Check worn parts to see which ones need replacing, and use food colouring in the water tank to see if water is leaking. If food colouring appears in the bowl without flushing, there is a leak.

In the kitchen and laundry room:

- Keep a bottle of water in the refrigerator and use ice instead of running the tap until the water is cold.
- When cleaning fruits and vegetables, never leave the tap running continuously. A tap uses 7 to 12 litres of water for each minute it runs. Instead, wash fruits and vegetables in a partially filled sink or pan, and use the leftover water to water house plants or your garden.
- When cooking vegetables, use only enough water to cover them and use a tight fitting lid. Steaming uses even less water and conserves more nutrients.
- Run dishwashers with only full loads, or do dishes by hand and don't leave the water running for rinsing.
- Run your washing machine only when you have a full load, or be sure to adjust the load size.
- When buying a new washing machine or dishwasher, consider a model which uses less water and is more energy efficient.
- A dripping tap can waste as much as 300 litres per week. To help stop drips, change tap washers.

Other general tips:

- Check your appliances and plumbing fixtures for leaks. By fixing leaky taps and plumbing joints, you can save up to 75 litres per day for every leak stopped.
- Install flow restrictors and aerators in faucets.

APPENDIX D

Water Licenses

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
F005283	82.F.054.2.1 E (PD27522)	Anderson Creek	Irrigation	1.5	AF	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19120304	0
F012222	82.F.054.2.1 D (PD27520)	Anderson Creek	Domestic	500	GD	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19300127	0
F013397	82.F.054.2.1 D (PD27520)	Anderson Creek	Domestic	500	GD	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19450820	0
F013486	82.F.054.2.1 G (PD27524)	Anderson Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF	NEL - NELSON	Current	N/A	18980112	0
"	82.F.054.2.1 H (PD27525)	Anderson Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF	NEL - NELSON	Current	N/A	18980112	0
F008854	5301A XX (PD28247)	Bird Creek	Waterworks Local Auth	4380000	GY	T	N	NELSON CITY OF	NEL - SLOCAN JUNCTION	Current	N/A	19310105	0
"	82.F.054.2.1 J (PD27526)	Fell Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF	NEL - NELSON	Current	N/A	18980112	0
C008562	82F/11b A (PD27761)	Five Mile Creek	Waterworks Local Auth	5.9E+08	GY	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19250131	0
C100548	82F/11b A (PD27761)	Five Mile Creek	Waterworks Local Auth	3.93E+08	GY	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19900309	19950515
C038253	82.F.044.3.4.W CC (PD27355)	Kootenay Lake	Land Improve	0	TF	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19710730	0
C116233	82.F.054.2.1.1 Y (PD76003)	Kootenay Lake	Watering	17.5	AF	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	20010523	20020114
C037867	5301A L (PD28234)	Kootenay River (Lower)	Power-General	714	CS	T	N	NELSON CITY OF	NEL - SLOCAN JUNCTION	Current	N/A	19710720	0
F014255	5301A L (PD28234)	Kootenay River (Lower)	Power-General	1428	CS	T	N	NELSON CITY OF	NEL - SLOCAN JUNCTION	Current	N/A	19050306	0
Z112021	5301A L (PD28234)	Kootenay River (Lower)	Power-General	750	CS	T	N	NELSON CITY OF	NEL - SLOCAN JUNCTION	Active Appl.	Victoria Application	19960731	0
C021894	82.F.044.4.1 RR (PD27432)	Selous Creek	Waterworks Local Auth	3.65E+08	GY	T	N	NELSON CITY OF	NEL - NELSON	Current	N/A	19530228	0

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C120401	82.F.054.2.1 F (PD27523)	Anderson Creek	Watering	2.5	AF	T	N	INTERIOR HEALTH AUTHORITY 101-2355 ACLAND ROAD KELOWNA BC V1X7X9	NEL - NELSON	Current	N/A	19070514	20060608
F005283	82.F.054.2.1 E (PD27522)	Anderson Creek	Irrigation	1.5	AF	T	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19120304	0
F012222	82.F.054.2.1 D (PD27520)	Anderson Creek	Domestic	500	GD	T	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19300127	0
F013397	82.F.054.2.1 D (PD27520)	Anderson Creek	Domestic	500	GD	T	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19450820	0
F013486	82.F.054.2.1 G (PD27524)	Anderson Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	18980112	0
"	82.F.054.2.1 H (PD27525)	Anderson Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	18980112	0

Licence No	WR Map/ Point Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
F013486	82.F.054.2.1 J (PD27526)	Fell Creek	Waterworks Local Auth	5.48E+08	GY	M	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	18980112	0

Licence No	WR Map/ Point Code	Stream Name	Purpose	Quantity	Units	Qty Flag	Rediv Flag	Licensee	Water District/Pr	Licence Status	Process Status	Priority Date	Issue Date
C021894	82.F.044.4.1 RR (PD27432)	Selous Creek	Waterworks Local Auth	3.65E+08	GY	T	N	NELSON CITY OF NELSON HYDRO SUITE 101-310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19530228	0
F009633	82.F.044.4.1 QQ (PD27431)	Selous Creek	Incidental - Domestic	500	GD	T	N	SCHESNUK KATHERINE EXECUTRIX BOX 13 NELSON BC V1L5P7	NEL - NELSON	Current	N/A	19300607	0
"	"	Selous Creek	Irrigation	2.61	AF	T	N	SCHESNUK KATHERINE EXECUTRIX BOX 13 NELSON BC V1L5P7	NEL - NELSON	Current	N/A	19300607	0

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C008562	82F/11b A (PD27761)	Five Mile Creek	Waterworks Local Auth	5.9E+08	GY	T	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19250131	0
C100548	82F/11b A (PD27761)	Five Mile Creek	Waterworks Local Auth	3.93E+08	GY	T	N	NELSON CITY OF NELSON HYDRO SUITE 101- 310 WARD ST NELSON BC V1L5S4	NEL - NELSON	Current	N/A	19900309	19950515
C104849	93.A.011 JJ (PD40067)	Five Mile Creek	Irrigation	72	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19000915	20050104
"	"	Five Mile Creek	Storage	36	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19000915	20050104
"	93.A.011 Y3 (PD66064)	Five Mile Creek	Irrigation	72	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19000915	20050104
"	"	Five Mile Creek	Storage	36	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19000915	20050104

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
C107548	93P/NE(10-h) E5 (PD68732)	Five Mile Creek	Dust Control	2000	GD	D	N	TRANSPORTATION & HIGHWAYS MINISTRY OF 300 10003 110TH AVE FORT ST JOHN BC V1J6M7	PEA - DAWSON CREEK	Current	N/A	19930325	19940602
"	93P/NE(10-h) F5 (PD68733)	Five Mile Creek	Dust Control	2000	GD	D	N	TRANSPORTATION & HIGHWAYS MINISTRY OF 300 10003 110TH AVE FORT ST JOHN BC V1J6M7	PEA - DAWSON CREEK	Current	N/A	19930325	19940602
"	93P/NE(10-h) G5 (PD68735)	Five Mile Creek	Dust Control	2000	GD	D	N	TRANSPORTATION & HIGHWAYS MINISTRY OF 300 10003 110TH AVE FORT ST JOHN BC V1J6M7	PEA - DAWSON CREEK	Current	N/A	19930325	19940602
C120073	93.A.011 HH (PD40066)	Five Mile Creek	Storage	116	AF	T	N	CALL BASIL E & CAROL J PO BOX 14 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19640811	20050105
C121359	93.A.011 PP (PD40072)	Five Mile Creek	Irrigation	102	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19650628	20060606
"	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	102	AF	M	N	153 MILE RANCH LTD	CAR - SAN JOSE	Current	N/A	19650628	20060606

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
								BOX 577 150 MILE HOUSE BC V0K2G0					
C121360	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	143	AF	T	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	19650628	20060606
C121361	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	40	AF	T	N	153 MILE CONTRACTING LTD PO BOX 1074 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19650628	20060606
C121364	93.A.011 MM (PD40070)	Five Mile Creek	Storage	102	AF	T	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19650628	20060606
C121365	93.A.011 MM (PD40070)	Five Mile Creek	Storage	143	AF	T	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	19650628	20060606
C121366	93.A.011 MM (PD40070)	Five Mile Creek	Storage	40	AF	T	N	153 MILE CONTRACTING LTD PO BOX 1074 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19650628	20060606
C121619	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	114	AF	T	N	153 MILE RANCH LTD	CAR - SAN JOSE	Current	N/A	19061009	20060609

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
								BOX 577 150 MILE HOUSE BC V0K2G0					
C121620	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	36	AF	T	N	153 MILE CONTRACTING LTD PO BOX 1074 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19061009	20060609
C121621	93.A.011 PP (PD40072)	Five Mile Creek	Irrigation	34.1	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19120527	20060713
"	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	34.1	AF	M	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19120527	20060713
C121622	93.A.011 QQ (PD40073)	Five Mile Creek	Irrigation	10.7	AF	T	N	153 MILE CONTRACTING LTD PO BOX 1074 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19120527	20060713
C121623	93.A.011 MM (PD40070)	Five Mile Creek	Storage	120	AF	T	N	153 MILE RANCH LTD BOX 577 150 MILE HOUSE BC V0K2G0	CAR - SAN JOSE	Current	N/A	19120527	20060713
F010003	93.A.011 RR (PD40074)	Five Mile Creek	Domestic	2000	GD	M	N	WILLIAMS LAKE INDIAN BAND	CAR - SAN JOSE	Current	N/A	19080602	0

Licence No	WR Map/	Stream Name	Purpose	Quantity	Units	Qty	Rediv	Licensee	Water District/Precinct	Licence Status	Process Status	Priority Date	Issue Date
								2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7					
"	"	Five Mile Creek	Irrigation	90	AF	M	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	19080602	0
"	93.A.011 SS (PD40075)	Five Mile Creek	Domestic	2000	GD	M	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	19080602	0
"	"	Five Mile Creek	Irrigation	90	AF	M	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	19080602	0
F010278	93.A.011 LL (PD40069)	Five Mile Creek	Storage	100	AF	M	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	18700609	0
"	93.A.011 NN (PD40071)	Five Mile Creek	Storage	100	AF	M	N	WILLIAMS LAKE INDIAN BAND 2672 INDIAN DRIVE WILLIAMS LAKE BC V2G2V7	CAR - SAN JOSE	Current	N/A	18700609	0