Abbotsford/Mission Water & Sewer Commission

City of Abbotsford

District of Mission

Drought Management and Water Conservation Study

Final Report
February 2006

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February 24, 2006

Mr. Jim Duckworth, P.Eng.
Manager, Engineering Services
Abbotsford/Mission Water & Sewer Commission
32315 South Fraser Way
Abbotsford, BC
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Dear Mr. Duckworth:

RE: DROUGHT MANAGEMENT AND WATER CONSERVATION STUDY
Submission of Final Report
Our File 2080.009

We are pleased to provide four copies of the final copy of the above-noted report. This version incorporates the comments on the draft report received from Commission staff.

This report provides a review of the water supply system from a hydrologic perspective. Recommendations on system operation are provided.

This report also provides a review of existing and potential water conservation measures. Water conservation recommendations are provided.

We look forward to further assisting the Commission in implementing the study recommendations.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.

Mike V. Currie, M.Eng., P.Eng.
President

MVC/am
Encl.

Abbotsford/Mission Water & Sewer Commission

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

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EXECUTIVE SUMMARY

This report documents a study of drought management and water conservation for the Abbotsford / Mission Water & Sewer Commission (Commission). The Commission draws the majority of its water from Norrish Creek; other sources include Cannell Lake and several groundwater wells in Abbotsford. During low flow periods, the Commission supplements flow in Norrish Creek by releasing water from Dickson Lake. High demand and extended dry conditions in recent summers have resulted in water shortages.

DROUGHT MANAGEMENT

The Commission is licensed to withdraw a maximum of 141.5 ML/day from Norrish Creek and 9.1 ML/day from Cannell Lake. The water licences also authorize storage of up to 15,900 ML per year at Dickson Lake, and up to 1,849 ML per year at Cannell Lake. In past years, the water licences on Cannell Lake have been overdrawn, therefore, it is recommended that the Commission apply for an additional water licence.

Dickson Lake is the Commission's primary storage reservoir. This report provides updated stage-storage and stage-discharge relationships. A simple water yield model demonstrates that inflow to Dickson Lake during the driest winter on record should be sufficient to completely refill an empty reservoir before the onset of the next summer's drawdown period. Assuming no winter flow releases to Norrish Creek, the probability that winter inflow will be insufficient to completely refill the reservoir prior to June 1st is estimated at less than 1% per year.

Flow release from Dickson Lake is gravity-fed when the lake is high, and pumped once the lake surface drops below 632 m. To date, no more than 50% of the licensed storage at Dickson Lake has been used. The updated stage-discharge relationship suggests that the existing pumps and discharge facilities at Dickson Lake severely limit the rate of withdrawal as the reservoir level drops. Improvements to the pumps and discharge facilities would be appropriate.

Although there is not presently a strong hydrologic need to raise Dickson Lake dam to increase the storage capacity, there are some benefits that make this action worthy of consideration. These include increased ability to meet fish flow requirements and future increases in water demand. As this would be a complex and costly undertaking, a feasibility study is suggested to determine whether it would be cost effective. The possibility of converting the discharge facility to a gravity flow outlet should be considered.

Optimizing source utilization and implementing demand management strategies can improve the reliability of the water supply. The Commission could benefit from an integrated regional source utilization program linking operating plans for the various water sources with the regional Water Shortage Response Plan (WSRP). As an initial step in this direction, this report provides:

- a suggested operating plan for Norrish Creek (Table 4-2);
- a guideline for WSRP stage based on Dickson Lake level (Figure 4-1); and
- identification of appropriate revisions to the WSRP (Table 4-4).

Further to the latter point, it would be appropriate to align the WSRP with that of the GVRD to harmonize public relations efforts.

Climate change may affect the water supply. Of greatest concern is the potential for an earlier freshet, which would prolong the low flow season on Norrish Creek. This report identifies some emergency water supply options for possible future consideration. These options would inevitably be complex and costly.

WATER CONSERVATION

The City of Abbotsford uses about 20 million cubic metres of water per year, or about 480 litres per person per day calculated as an aggregate value based on a service population of 114,000. The estimated residential usage is 297 litres per person per day, which is in line with North American averages. Unmetered usage is estimated to be 6%, which is considered low (i.e., good) by North American standards.

The District of Mission uses about 6.6 million cubic metres of water per year, or about 695 litres per person per day calculated as an aggregate value based on a service population of 26,000. Since the District is not metered, it is not possible to directly calculate the residential usage, although it could be estimated by monitoring a statistically significant number of houses. Similarly, water losses cannot be directly calculated. The given statistics, however, suggest that leakage and losses are much higher in Mission than in Abbotsford, likely over 25%. This could be quantified by further analysis, but an implied conclusion is that accelerated leak detection should be considered.

The Water Master Plan includes no programs for water conservation or demand management. Previous recommendations made to the former Dewdney Alouette Regional District (DARD) have not been implemented. At the same time, the Commission faces rapid population growth that is stressing its water supplies and triggering the need for substantial capital investments – over $85 million in the next 16 years. This report develops a recommended water conservation program consisting of bylaws, audits, rebates, leakage reduction, metering and pricing measures.

If the recommended initiatives were fully implemented, the City of Abbotsford and the District of Mission could reduce their total average-day demands by between 6% and 34%, and between 15% and 48%, respectively.

The need for capital projects (both water supply and wastewater treatment) is triggered by rising water demand. If the peak day demand were reduced, some of those projects (and their associated O&M costs) could be deferred, thereby resulting in savings. Benefits would also arise from the customers' cost savings from reduced consumption.

Financial costs arise from the implementation of the water conservation programs; arguably, environmental costs arise from the extraction of water for human usage.

The City of Abbotsford has universal metering and so charges almost all customers on a volume basis. Residential users and greenhouses are charged $0.56/m^3 regardless of amount consumed. ICI customers are charged on a declining-block scale so that the unit price decreases with consumption. This is done to attract and retain industry.

The District of Mission meters only industrial/commercial/institutional (ICI) and agricultural customers. These are charged on a declining-block scale beginning at $0.42/m^3. Other customers are charged an annual fee of about $208.

Declining-block rates do not promote water conservation, and for this reason a gradual phasing out of these rate structures would be consistent with a comprehensive water conservation plan, and would also be consistent with past recommendations.

The City of Abbotsford reads its approximately 24,000 water meters once per year, and bills customers once per year as part of their annual property tax assessment. To promote water conservation, the water charges should be charged separately in order to make the price signal explicit. It is recommended that billing be done discretely and more frequently.

The District of Mission has considered universal metering with radio-read technology. This program would be progressive, and the District would be only the second jurisdiction in the Lower Mainland (after West Vancouver) to do this. The use of radio technology would allow the District to easily bill monthly. There are many benefits of metering, and the District's initiative is supported.

Note that metering is considered primarily a management tool rather than a conservation tool, and so the implementation cost should not be expected to be immediately offset by reduced demand.

For leak detection, the main challenges are not technical but managerial: collecting, storing and disseminating data in a systematic and planned way that can form the basis for program design. The soil conditions should determine the leakage policy because leaks are easier to detect in glacial tills where the water comes to the surface. Technical leakage detection programs, therefore, should be concentrated in the areas that are underlain by sand and gravel.

Section 1

Introduction

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1. INTRODUCTION

The Abbotsford / Mission Water and Sewer Commission (the Commission) retained Kerr Wood Leidal Associates to complete a drought management and water conservation study for the Central Fraser Valley Water Supply Services area. During recent summers, the area has experienced water shortages due to high demand and extended dry conditions. Although the system successfully coped with these shortages, the Commission wishes to develop a plan that:

- clearly identifies the advantages of water conservation;
- sets out future conservation goals;
- develops a response plan during drought events; and
- assesses the impacts and relative risk of significant drought event.

This will allow more efficient use of the water supply sources in the future.

This project was initiated by the Fraser Valley Regional District. This final report is submitted to the Commission, who now has responsibility for the water system. This report does not incorporate data from summer 2005.

1.1 BACKGROUND

The Central Fraser Valley water system supplies water to most of the District of Mission and the District of Abbotsford. The total population served by the water system is about 142,200 (2001). The 2002 Update of the Water Master Plan (Dayton & Knight, 2003) predicts that the service population will increase to about 234,200 by 2021. This forecast uses a high-growth scenario for the City of Abbotsford and an average growth rate for the District of Mission.

The water supply is from a combination of surface water and groundwater sources:

Surface Water Sources	Norrish Creek / Dickson Lake
	Cannell Lake
Groundwater Sources	Marshall and Townline Wells
	East Abbotsford Wells

Figure 1-1 illustrates the location of the water supply sources and service areas.

Based on data from 1996 to 2001, the average annual water demand is about 446 L/c/d. The peak day water demand is about 754 L/c/d. These values reflect the fact that some water conservation measures are in place. The average ratio of peak day demand to average day demand is 1.62.

For water supply planning purposes, the Water Master Plan recommends an average annual demand of 500 L/c/d with some continued emphasis on water conservation measures. A peak day demand of 900 L/c/d is also recommended. The peak day demand is not considered to be dependent on water conservation measures.

Based on the existing and projected service population, the total water system demand is summarised as follows for planning purposes:

	Present	2021
Average Day Demand	71 ML	117 ML
Peak Day Demand	128 ML	211 ML

The future demand could be further increased if additional users outside Mission and Abbotsford join the water supply system.

Based on the service population, the Central Fraser Valley water system is one of the largest in B.C. The system has grown rapidly as formerly independent systems have been amalgamated. This underscores the need for effective source utilisation.

1.2 STUDY OBJECTIVE

The objective of this study is to develop a drought management and water conservation plan that provides strategies for

- reducing average and peak water usage, thereby reducing water supply demands and sewer flows to the treatment plant;
- assessing the cost saving benefits to customers;
- assessing the cost savings benefits of improved water-use efficiency as a means of offsetting the cost of future upgrades;
- avoiding major water shortages during periods of low rainfall; and
- responding to water shortages when droughts occur.

This is in accordance with the June 2004 Land and Water BC publication *Dealing With Drought - A Handbook for Water Suppliers in British Columbia*.

1.3 WORK PROGRAM

Based on the study objectives, the work program for the project is summarized in Table 1-1. The first column in the table provides cross-references to report sections pertaining to particular work tasks.

Table 1-1: Work Program

Task	Description
0.1 Project Initiation	▪ Obtain data and background information. ▪ Meet with the Commission to: - review scope, schedule and deliverables; - discuss stakeholder involvement, particularly whether the work program should include liaison with DFO; - ensure that the work program provides a good basis for approaching the 2005 low flow season; - discuss the Commission 's intentions with respect to application of the Draft Hydrologic Operating Procedures for Norrish Creek Water System (July 2004); and - discuss the merit of reporting the results of Part A in an updated/final version of KWL's May 2003 Operational Hydrology Plan, and producing a separate report for Part B. ▪ Prepare minutes of the project initiation meeting.
A. DROUGHT MANAGEMENT	
A.1 Update Hydrologic Database (Section 2.3)	▪ Obtain 2003/2004 hydrologic data (hydrometric, water use, precipitation) to supplement KWL's existing database. ▪ Update the following figures from the Operational Hydrology Plan: - Figure 3-1 to add 2003 and 2004 water intake diversion data; and - Figure 3-2 to add 2004 Dickson Lake water level data. ▪ Plot available Cannell Lake water level data. ▪ Update the following appendices from the Operational Hydrology Plan: - Appendix D (Dickson Lake snow course data); - Appendix E (hydrometric data for Station 08MH058); and - Appendix F (hydrometric data for Station 08MH150). ▪ Prepare a long-term (20-year) plot of monthly rainfall for the Mission Westminster Abbey climate station showing mean, minimum recorded, and maximum recorded precipitation amounts for each year. Show available precipitation data from Norrish Creek intake and Dickson Lake for comparison.
A.2 Climate Change Commentary (Section 2.5)	▪ Extract relevant information from previous GVRD climate change work involving KWL. ▪ Also extract relevant information from recent federal/ provincial government publications, such as Responding to Global Climate Change in B.C. and Yukon. ▪ Apply relevant information to this project. ▪ Provide commentary on importance of climate change to the Commission water supply system.

Task	Description
A.3 Water Shortage Response Planning (Section 4)	▪ Define 4 or 5 drought stages based on Dickson Lake level and time of year. ▪ Develop updated drought response matrix based on previous concepts from Section 5 of Operational Hydrology Plan and the Hydrologic Operating Procedures for Norrish Creek Water System. ▪ Consult with the Commission during matrix preparation (by telephone/fax/e-mail).
A.4 Lake Storage Assessment (Section 3)	▪ Obtain current stage-storage curves. Plot water licence diversion limits on curves for comparison with operating curve. ▪ Run existing KWL hydrologic model for Dickson Lake to determine surplus water volume for three dry winter years (1970, 1978, 1987), assuming that the reservoir starts empty in the fall. ▪ Provide hydrologic commentary on water availability for raising Dickson Lake dam. Based on previous work by KWL, there is clearly surplus water available for raising Dickson Lake dam, the issue is whether it is cost-effective and environmentally acceptable.
A.5 Norrish Creek Intake Weir (Section 2.4)	▪ Obtain available discharge measurements and corresponding water level readings at intake weir (from the Commission and Water Survey of Canada). ▪ Plot stage-discharge curve for the intake weir. ▪ Determine intake weir water level corresponding to a flow of 50 cfs.
A.6 Severe Drought Issues (Section 4.4)	▪ Identify options available for emergency water supply: - stand-by power for Dickson Lake; - stand-by power for wells; - temporary water supply sources; and - other relevant options. ▪ Identify options that appear promising.
B WATER CONSERVATION	
B.1 Collect and Review Data	▪ Assume that the Commission will provide required data in digital form. ▪ Minimum data requirements are outlined below.
B.2 Analyze Water Demand Trends by Sector (Section 5)	▪ Disaggregate metered or known water usage by sector: residential, commercial/industrial, etc. ▪ Estimate unmetered usage. ▪ Where possible, estimate non-revenue water/leakage, O&M, etc. ▪ Make reasonable assumptions to create overall water balance. ▪ Calculate relevant statistics such as per-capita usage. ▪ Assess when the peak periods occur.

Task	Description
B.3 Develop Water Conservation Options (Sections 6 and 7)	▪ Develop a 'menu' of programs, including fixture (hardware), regulatory and management measures. ▪ Estimate cost, water savings, participation ratio, and implementation periods for each. ▪ Estimate typical costs to homeowners of water-saving devices and their potential water savings. ▪ Estimate potential savings given that most available fixtures are now low-flow. ▪ Include options for public education programs. ▪ Present results with ranges to reflect confidence limits (low, medium and high range of savings). ▪ Rank programs by water savings and marginal cost for comparison with supply augmentation. ▪ Submit 'short-list' to the Commission for commentary. ▪ Assess and recommend conservation strategies to achieve 10% - 20% reduction. ▪ Address both volume and peak reduction.
B.4 Assess Potential to Defer Capital Costs	▪ Review the CFVWS Water and JAMES Wastewater Master Plans and identify projects that could be deferred or cancelled if water demands were reduced. ▪ Differentiate between projects sensitive to reductions in <u>volume</u> and <u>peak</u> demands. ▪ List cost-effective water conservation programs. ▪ Quantify how much could be spent annually in promoting and implementing water conservation. Level of detail to be commensurate with the data.
B.5 Review Meter Reading Frequency in Abbotsford (Section 9)	▪ Review the current practice of annual meter reading. ▪ Discuss the pros and cons of increasing reading and billing frequency. ▪ Complete cost/benefit analysis. ▪ Estimate costs of moving to quarterly, bi-monthly, monthly, or some combination.
B.6 Review Metering Report for Mission (Section 10)	▪ Review the June 2003 report on metering. Review all costs for a complete metering program including: - meters, registers and associated hardware; - meter boxes, installation, etc.; - restoration of customer properties and services; - reading hardware, vehicles, etc.; - central computer, software; - integration with billing system, or purchase of software; - labour costs for both installation and operation; - future costs for meter testing, calibration, and replacement; and - future costs for battery replacement. ▪ Present costs as 20-year annual cash flow. ▪ Identify/confirm implementation issues. ▪ Write report sections highlighting savings, confirming findings, and suggesting changes.

Task		Description
B.7	Review Water Rates (Section 8)	▪ Review the different types of rate structures in use across North America. Summarize their pros and cons, including effectiveness at promoting water conservation. ▪ Review the existing CFVWS and Municipal water rates against accepted industry (AWWA) practices for rate design. Assess adequacy in terms of fairness and revenue sufficiency. Review will be qualitative; detailed rate-setting is not included. ▪ Comment on both flat and metered rates as required, and both the fixed and variable charges for the latter. ▪ Comment on the CFVWS and Municipal water rates' effectiveness in encouraging water conservation, and suggest improvements that would encourage conservation. ▪ Comment on which sectors should be targeted to minimize peak period water usage.
B.8	Review Bylaws and Codes	▪ Obtain and review current bylaws relating to metering and water conservation. ▪ Assess for completeness and consistency across municipalities, especially regarding metering specifications. ▪ Assess bylaws against the water conservation goals of the Commission and the municipalities. ▪ Summarize recent changes to the BC Building/Plumbing Code that will affect water conservation and municipal bylaws. ▪ Suggest ways to strengthen bylaws to meet conservation goals, complete with enforcement options.
B.9	Assess Leak Detection Programs (Section 11)	▪ Summarize current leakage detection best practices and industry standards. ▪ Summarize the effectiveness of leakage detection programs with different pipe materials and soil conditions. ▪ Assess overall need for leak detection, if any, based on soil conditions and relative newness of systems.
C	**REPORT**	
C.1	Prepare Draft Report	▪ Summarize the study findings and results in a draft report. ▪ Include both drought management and water conservation. ▪ Submit draft report for review.
C.2	Report Presentation and Review	▪ Attend a meeting to receive input and discuss findings. ▪ Perform in-house technical review of draft report. ▪ Present report.
C.3	Prepare Final Report	▪ Update the report to reflect feedback. ▪ Submit final report.

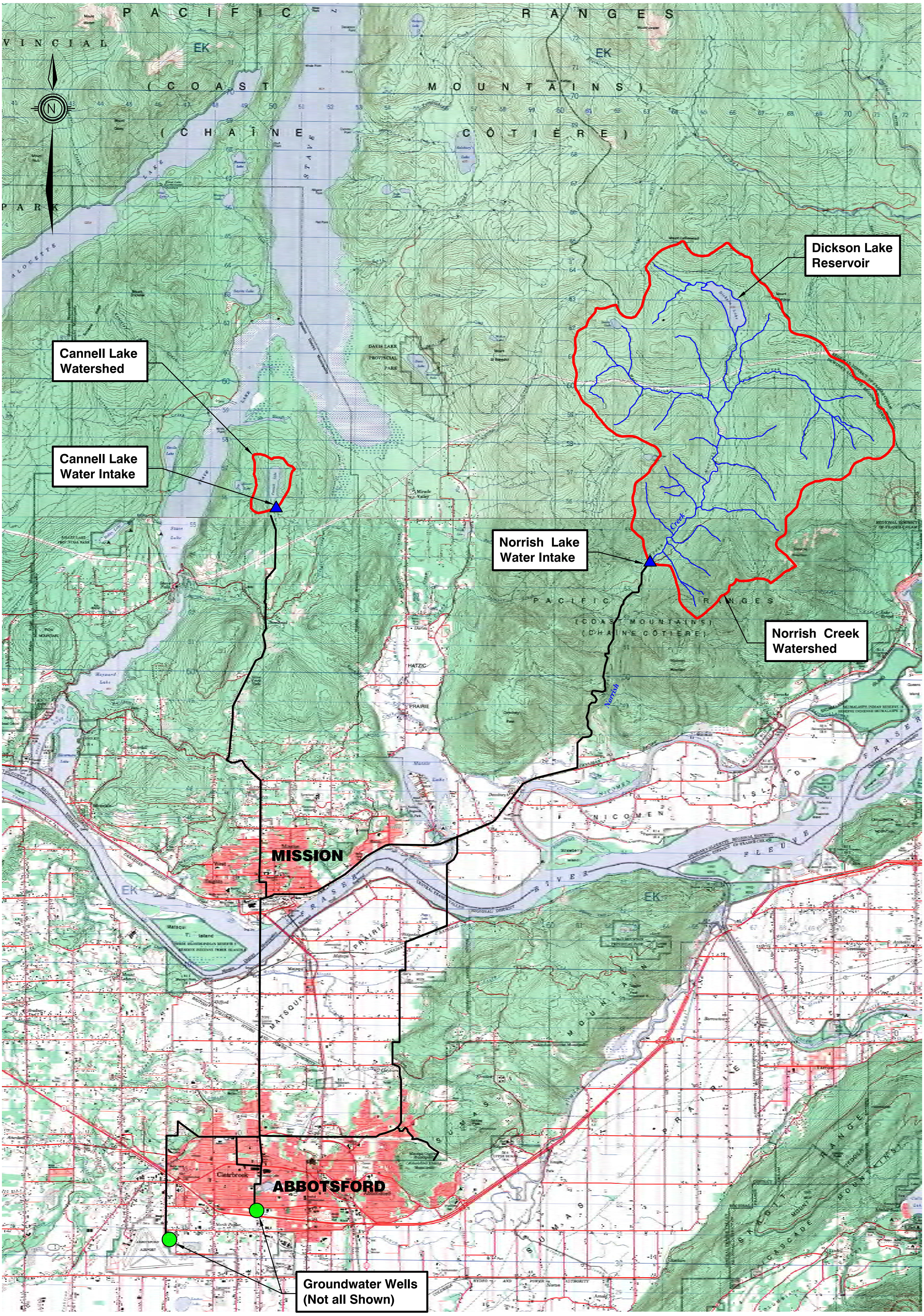
1.4 PROJECT TEAM

The KWL project team includes:

- Mike Currie, M.Eng., P.Eng., Project Manager and Senior Water Resources Engineer;
- Stefan Joyce, P.Eng., Water Resources Engineer;
- David Roche, M.A.Sc., EIT, Water Resources Engineer;
- Allan Bronsro, MCIP, P.Eng., Water Conservation Specialist; and
- Kathryn McCreary, B.A.Sc., Engineer, Meter Policy Planning.

Input from the Commission and its member municipalities was provided by a number of staff members, including the following:

- Rick Bomhof, P.Eng., Project Manager;
- Melvin Mayfield, P.Eng., Capital Projects Manager;
- Claude Hallé, C.Tech., Lead Hand, Water Distribution;
- Derek Casey, Superintendent, Water Supply Services;
- Jim Duckworth, P.Eng., Manager, Engineering Services, City of Abbotsford;
- Carl Berg, District of Mission; and
- Greg Giles, District of Mission.



Baseplan Source: 1:50,000 Department of Energy, Mines and Resources Canada (92G1, 92G8)

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS	Fraser Valley Regional District Drought Management and Water Conservation Study
Project No. 2080-009 / Date January 2005	**Central Fraser Valley Water System**
3000 0 3000 Scale in Metres	**Figure 1-1**

Section 2

Hydrologic Analysis

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2. HYDROLOGIC ANALYSIS

This section provides a hydrologic analysis, with an emphasis on the Norrish Creek system. This section begins with a description of the watersheds, a description of the waterworks infrastructure, and a review of the hydrologic database. This is followed by a brief hydraulic assessment of the Norrish Creek intake weir. The section ends with a commentary on climate change.

This information builds on previous hydrology work from a May 2003 draft Operational Hydrology Plan for Water Supply System prepared by KWL for FVRD.

2.1 NORRISH CREEK OVERVIEW

NORRISH CREEK WATERSHED DESCRIPTION

The Norrish Creek watershed is located on the north side of Fraser River approximately 12 km east of Mission. The drainage area of Norrish Creek is published as 117 km^2 to the Norrish Creek near Dewdney hydrometric station on the fan. The portion of the watershed upstream of the water intake is 78 km^2.

The maximum and median elevations of the watershed are 1,340 m and 800 m respectively. The drainage area above the water intake includes three main tributaries: West Norrish Creek (16.8 km^2), East Norrish Creek (18.8 km^2), and Dickson Creek (11.2 km^2). Rose Creek is the principal tributary below the water intake. Dickson Lake is located at an elevation of approximately 655 m, while the water intake is at an elevation of 243 m.

The channel distance between Dickson Lake and the water intake is approximately 10 km at an average channel gradient of 4%. The distance from the water intake to the fan apex is about 6.5 km at an average channel gradient of 3%.

Norrish Creek discharges onto a large alluvial fan below 46 m elevation. Below the fan apex the creek flows for about 3 km before reaching Nicomen Slough, a major side channel of Fraser River that is cut off at its upstream end.

NORRISH CREEK WATERWORKS INFRASTRUCTURE

The water system consists of the Dickson Lake storage reservoir in the upper watershed, and an intake and water treatment plant in the mid reaches of the watershed. During low flow periods, the water supply in Norrish Creek is supplemented by water releases from Dickson Lake.

Dickson Lake

Dickson Lake is a natural lake on which a dam was constructed in 1984 to increase the storage capacity. The west abutment of the rockfill dam is founded into the deposits of an extremely large rock avalanche. There is approximately 20 m of licensed drawdown available in the lake. The upper 6 m is gravity controlled via 600 mm and 1,050 mm diameter pipes with valves. Below this elevation, 3 pumps are used to withdraw water for flow releases. The three pumps are powered by a single generator.

Norrish Creek Water Intake

Water released from Dickson Lake travels for about 10 km before reaching the water intake. The flow in Norrish Creek at the intake comprises natural flow plus flow released from Dickson Lake.

At the intake, water is diverted from the creek through a pipe to a water treatment plant. The water level at the intake is controlled by a concrete weir. The Commission records the intake flow, as well as the residual flow in Norrish Creek.

Water Treatment

The water treatment system at Norrish Creek consists of a sand filtration plant and a membrane treatment plant. The slow sand water filter has a capacity of approximately 90 ML/day (1.04 m^3/s) and is supplemented by the membrane treatment plant (27 ML/day). The membrane plant has been designed to enable the capacity to be doubled to 54 ML/day by the addition of an additional four membrane trains.

Some of the water exiting the slow sand filter is returned to Norrish Creek due to demand fluctuations, and the flow entering the water supply system is recorded.

Water Distribution

The water at the treatment plant is chlorinated and then enters a 7 km pipeline that goes to Bell Road at the valley bottom. At Bell Road, the water is disinfected with ammonia. The volume of water passing through Bell Road is recorded continuously.

WATER LICENCES

The water licences for Norrish Creek and Dickson Lake are summarized in Table 2-1.

Table 2-1: Summary of Norrish Creek / Dickson Lake Water Licences

Licence No.	Purpose	Annual		Maximum Daily	
		(ML/yr)	(ML/day)	(ML/day)	(m^3/s)
CL 63060	Waterworks	9,555	26.2	39.2	0.453
CL 63061	Storage	5,675	15.5		
CL 6449	Waterworks	2,491	6.8	11.4	0.132
CL 102980	Waterworks	19,930	54.6	91.0	1.05
	Storage	10,226	28.0		

In total, the Norrish Creek water licences provide for a maximum storage of 15,900 ML per year and a maximum withdrawal of 141.5 ML per day (1.64 m^3/s) (to convert flows from ML per day to m^3/s, divide by 86.4).

CL 102980 includes a provision that flow must be released from Dickson Lake when the flow over the intake weir drops below 1.42 m^3/s (50 cfs, 122.7 ML/day). Thereafter, the release from Dickson Lake must exceed the intake withdrawal by 0.085 m^3/s (3 cfs, 7.3 ML/day).

2.2 CANNELL LAKE OVERVIEW

WATERSHED DESCRIPTION

Cannell Lake is a 2.1 km^2 watershed located approximately 10 km north of Mission. The lake is a natural water body that was raised by dam construction for water supply purposes. A wood crib dam was originally constructed at the lake outlet in the 1950s and then replaced with an earthfill structure in the 1970s.

The maximum elevation in the watershed is about 650 m. Therefore, snow accumulation is not a significant component of the annual water balance.

WATERWORKS INFRASTRUCTURE

The spillway of the dam is at an approximate elevation of 278.7 m, and the upper four metres of storage is gravity controlled with an intake at approximately 274 m elevation. Below this elevation, water withdrawal is from floating pumps in the middle of the lake. The Commission estimates that maximum drawdown at Cannell Lake is reached at about elevation 268.75 m.

Water is withdrawn from Cannell Lake using two 400 mm pipes, possibly originally intended to act as siphon intakes. However, holes have been cut in the crowns of the two pipes at an approximate elevation of 274 m to permit gravity drawdown. These two 400 mm pipes feed into one 400 mm and one 600 mm-diameter intake pipes at the dam. The intake pipes enter a chlorination plant several hundred metres downstream of the lake outlet. Both intake pipes are chlorinated separately. Ultrasonic flow meters at the chlorination plant measure the water flow.

WATER LICENCES

The water licences for Cannell Lake are summarised in Table 2-2.

Table 2-2: Summary of Cannell Lake Water Licences

Licence No.	Purpose	Quantity
CL 65225	Waterworks	Maximum 1,500,000 gallons (6.8 ML) per day
CL 65226	Storage	850 acre-feet (1048 ML) per annum
CL 65227	Waterworks	Maximum 500,000 gallons (2.3 ML) per day
CL 65228	Storage	650 acre-feet (801 ML) per annum

In total, the Cannell Lake water licences provide for a maximum storage of 1,849 ML per annum and a maximum withdrawal of 9.1 ML per day.

2.3 HYDROLOGIC DATABASE

HYDROLOGICAL MONITORING STATIONS

Hydrological monitoring activities are undertaken by a number of agencies. These monitoring facilities are listed in Table 2-3.

Table 2-3: Hydrological Monitoring Stations

Location	Components	Operator	Comments
Dickson Lake	Snow course	MWLAP (observed by FVRD)	Manual data only
	Rain gauge	FVRD	Unreliable data
Dickson Lake Outlet	Lake level gauge	FVRD	Manual data only
	Flow gauge	FVRD	Data logged
Norrish Creek Intake	Rain gauge	FVRD	
	Hydrometric station	WSC	Standard WSC station
	Water level recorder	FVRD	Data logged
	Water withdrawal	FVRD	Data charted
Norrish Creek Fan	Hydrometric station	WSC	Standard WSC station
Cannell Lake	Lake level gauge	FVRD	Manual data only
	Water withdrawal	FVRD	Data charted

HYDROMETRIC DATA

The flow of Norrish Creek is measured by the Water Survey of Canada (WSC) and the Commission. There is no surface water flow monitoring at Cannell Lake.

WSC Stations

WSC maintains a hydrometric station immediately upstream of the Norrish Creek water intake (Station 08MH150 - Norrish Creek above Rose Creek), which has been in operation since 1984. WSC also maintains a gauge on the Norrish Creek fan (Station 08MH058 - Norrish Creek near Dewdney), which has been in operation since 1960. The available hydrometric data is summarized in Table 2-4.

Table 2-4: WSC Hydrometric Stations on Norrish Creek

Station Name	Station Number	Area (km^2)	Period of Record	Flow Data Available
Norrish Creek above Rose Creek	08MH150	78	1984 – present	13 yr. maximum inst., 17 yr. maximum daily
Norrish Creek near Dewdney	08MH058	117	1960 – present	33 yr. maximum inst., 37 yr. maximum daily

Notes:
- Maximum Instantaneous is the maximum flow at any instant of time in the year of record.
- Maximum Daily is the maximum average flow for one day in the year of record.

Mean annual runoff at both stations is approximately 3,125 mm, which is equivalent to a mean annual flow of 7.8 m^3/s at the water intake and 11.7 m^3/s on the fan. The mean annual floods (average of the annual maximum daily flows) at the upper and lower gauges are estimated at 67 m^3/s and 110 m^3/s respectively.

Daily flow data for the two WSC stations is included in Appendix A. The 2004 discharge data is preliminary and subject to revision. The 2004 data also does not include the whole year: up to June 21 for 08MH058 and July 17 for 08MH150.

FVRD Stations

Flow releases from Dickson Lake used to be recorded manually where the lake outflow passes through a weir box. The outflow was typically recorded once a day. However, a continuous water level recorder was installed at the weir in March 2004. The station consists of a Miltronics meter that is powered by battery and recharged by solar.

The Commission also measures the flow in Norrish Creek that is not diverted to the water treatment plant. The residual flow in Norrish Creek discharges over a weir where the water level is recorded with a data logger (see Section 2.3).

LAKE LEVEL DATA

Dickson Lake

Figure 2-1 shows a plot of the available lake level data at Dickson Lake for the period 1993 to 2004. The lake level is measured manually with a frequency of several days to two weeks. The level is measured more frequently during the drawdown and refill period (June to December). The reservoir is typically full and spilling during the winter and spring.

The elevation of the spillway is 638.34 m with a maximum drawdown elevation of 618.2 m.

Cannell Lake

The recorded lake level at Cannell Lake is available for the period 1995 to 2004 (Figure 2-2). The lake level is recorded manually with a typical frequency of 2 to 3 days. Cannell Lake is typically drawn down below its spillway elevation for a significant portion of the year.

Cannell Lake has a spillway elevation of 278.7 m. Flow release from the lake is gravity controlled to an elevation of approximately 274 m. The lake level has not dropped below this elevation since at least 1995.

PRECIPITATION DATA

There are two climate stations in the Norrish Creek watershed. The Dewdney-Alouette Regional District (predecessor to FVRD) had installed the climate stations near the intake and Dickson Lake in 1984 and 1986 respectively.

The Dickson Lake station has some scattered records, but the data is too unreliable to be used in a hydrologic analysis. Problems were originally encountered with the Norrish Creek intake station also. However, the data has been reasonably reliable since 1991. FVRD does not have full confidence in the gauge (which weighs precipitation) due to the possibility of icing and operator error, but the data appear to be consistent with regional climate stations.

The closest regional climate station to Norrish Creek and Cannell Lake is Mission Westminster Abbey (MWA) at an elevation of 221 m. This station (#1105192) is run by the Meteorological Service of Canada (MSC) and has been active since October 1962. Figure 2-3 is a comparison of average monthly precipitation totals at MWA and Norrish Creek for the period 1991 to 2003.

The precipitation data for Norrish Creek was obtained from the Commission and does not appear to have been quality checked. A comparison of the precipitation records with those at MWA indicates that the Norrish Creek precipitation gauge was down for occasional periods. After a brief review, suspect monthly totals were discarded from the comparative analysis. In general precipitation totals at MWA are 65% to 75% of the total at the Norrish Creek intake, which is expected due to orographic effects. The difference is less pronounced during the summer as convective storms are less influenced by orographic uplift.

A longer-term trend in precipitation is shown in Figure 2-4. This figure plots the average, maximum and minimum monthly precipitation totals at MWA for the period 1962 to 2003.

SNOW COURSE DATA

Snowpack conditions in the Norrish Creek watershed are monitored by the River Forecast Centre (RFC) of the BC Ministry of Environment (MoE). MoE maintains a network of stations across the province that includes automated snow pillows and manual snow courses. Measurements at the snow courses are made at the beginning of the month from January through April and twice monthly in May and June, although not all stations are measured at every sampling period.

Measurements above Norrish Creek are made at the Dickson Lake (#1D16) snow course, which is situated at an elevation of 1,070 m. This station has been in operation since 1991 and the full data set is included in Appendix A. Figure 2-5 shows maximum, mean and minimum snow water equivalent (SWE) for the period 1991 to 2005.

WATER WITHDRAWAL

Water withdrawal from Dickson Lake and Cannell Lake is recorded on a continuous basis by the Commission. Table 2-5 summarizes the average monthly water withdrawal from each system for the period 2000 to 2004.

Table 2-5: Average Monthly Water Withdrawals 2000 to 2004

Month	Norrish Creek (ML/day)	Cannell 600 (ML/day)	Cannell 400 (ML/day)	Total (ML/day)
January	44.09	7.61	4.08	55.78
February	49.23	3.82	4.36	57.41
March	48.84	5.94	3.86	58.65
April	52.72	4.17	3.93	60.82
May	53.88	4.83	4.87	63.57
June	58.28	5.62	4.99	68.90
July	65.91	5.67	5.28	76.86
August	64.52	5.25	5.30	75.07
September	60.74	4.75	4.06	69.55
October	55.82	6.15	4.12	66.09
November	48.08	9.20	4.18	61.45
December	49.15	5.53	4.76	59.45
Average	**54.27**	**5.71**	**4.48**	**64.47**

These recorded water withdrawal flows compare to a total licensed water quantity of 141.5 ML/day at Norrish Creek and 9.1 ML/day at Cannell Lake. Recent water withdrawal at Cannell Lake has therefore exceeded the water licence limit.

Figure 2-6 shows the flow at the Norrish Creek water intake for the summer of 2003. The flow at hydrometric station 08MH150 is shown, along with the water supply withdrawal and the computed net flow over the intake weir.

2.4 NORRISH CREEK INTAKE WEIR

Conditional Water Licence 102980 for Norrish Creek includes a provision that flow must be released from Dickson Lake when the flow over the intake weir drops to 1.42 m^3/s (50 cfs, 122.7 ML/day). Thereafter, the release from Dickson Lake must exceed the intake withdrawal by 0.085 m^3/s (3 cfs, 7.3 ML/day). It is therefore important that a stage-discharge relationship be developed for the intake weir and determine the water level that correlates to a flow of 1.42 m^3/s.

The intake weir is approximately 5 m wide. The right side of the weir is 0.185 m high, while the left side is slightly higher at 0.246 m. The base of the weir is at a slight angle with the left side 0.01 m higher than the right side.

An updated stage-discharge curve was developed by WSC for the intake weir in 2003. Five low discharge measurements were used to create the lower half of the curve (Table 2-6). Three additional spot measurements extended the curve to higher discharges.

The resulting stage-discharge curve for flows less than 6 m^3/s is shown in Figure 2-7. The stage that corresponds to a flow of 1.42 m^3/s (50 cfs) is 0.34 m.

Table 2-6: Stage-Discharge Measurements for Intake Weir at Norrish Creek

Stage (m)	Discharge (m^3/s)	Notes
0	0	
0.098	0.105	
0.166	0.35	
0.206	0.542	Old rating curve diverges
0.48	3.7	Old rating curve crosses
0.512	5.1	
0.726	23.4	November 20, 2002
0.872	34.6	March 31, 2003
0.976	100	December 15, 1999
Note: all elevations are in TERA (data logger) values.		

The largest floods on Norrish Creek cannot be recorded at the weir, as the water level exceeds the capacity of the recording gauge when the flow depth over the weir exceeds about 1.5 m.

2.5 CLIMATE CHANGE COMMENTARY

NATURAL CLIMATE VARIABILITY

The Pacific Ocean exerts a strong climatic signal worldwide. British Columbia is no exception with natural atmospheric-ocean interactions affecting climate on an annual to decadal scale. The principal modes of climatic variability in B.C. are:

- El Niño Southern Oscillation (ENSO); and
- Pacific Decadal Oscillation (PDO).

ENSO is a tropical Pacific phenomenon that influences weather around the world. El Niño, the "warm phase" of ENSO, is associated with warmer sea surface temperature in the eastern parts of the tropical Pacific Ocean. The El Niño phase brings warmer winter temperature and less winter precipitation to B.C. During La Niña events, which are characterized by unusually cool sea surface temperature in the eastern tropical Pacific, the opposite is true. During neutral years, ENSO is in neither a warm nor cool phase and has little influence on global climate. ENSO tends to vary between the two extremes with a cycle of 2 to 7 years, usually staying in the same state for no more than a year or two.

The PDO (a relatively recent discovery) represents an ENSO-like pattern that occurs at longer time scales. The warm phase is associated with anomalously warm waters off the coast of western North America and cold water in the central Pacific. The cold phase is the reverse. These temperature variations influence B.C. as prevailing winds blow from the North Pacific toward the B.C. coast and air temperature is affected by sea temperature. Individual phase duration and strength varies and typically last for 20 to 30 years. Evidence from tree rings indicates that the PDO is not a recent phenomenon. The PDO was in a cool phase from about 1900 to 1925 and from 1945 to 1977. It was in a warm phase from 1925 to 1945 and from 1977 onwards. A change from warm to cool may have occurred in the mid to late 1990s.

For western North America the primary impact of ENSO and PDO is changing storm tracks and hence the spatial distribution of precipitation. The ENSO also modulates the proportion of precipitation falling as rain and snow:

- in El Niño years, the Lower Mainland receives 5% less precipitation than long-term averages ("normal");
- snow is of the order 70% below normal;

- La Niña precipitation is of the order 10% above normal; and
- snow is characteristically 50% above normal.

These effects arise from the influence of El Niño and La Niña on the mean winter temperature, which is approximately +1°C and –1°C respectively compared to normal.

ENSO and PDO are the two most important "drivers" for the climate in the Pacific Northwest, accounting for up to 45% of annual precipitation variance in southwest BC.

HUMAN INFLUENCED CLIMATE VARIABILITY

On top of natural climatic variability, however, there is growing evidence of human induced climate change. Long-term data sets show an increasingly warmer planet over the last century. Much of this increase has been attributed to human activity and the release of greenhouse gases into the atmosphere. The provincial government has become increasingly aware of this issue and the BC Ministry of Water, Land and Air Protection (WLAP) recently completed a study (2002) that evaluated indicators of climate change. Observed trends include:

- coastal BC has warmed at a rate equivalent to 0.5 to 0.6°C per century, or at roughly the same rate as the rest of the world;
- spring temperatures have increased by 0.8°C;
- daytime maximum winter temperatures have increased by 1.9°C;
- the Georgia Depression shows no trend in annual precipitation, although the Coast Mountains show an increase of 2% per decade; and
- no changes were observed in snow-water equivalent.

Climate models project further warming in B.C. at a rate of 1 to 4°C per century. An increase in temperature is important as it affects the amount of snow falling at higher elevations and the timing of peak snowmelt. The United Nations Intergovernmental Panel on Climate Change (IPCC) has concluded that in mountainous regions of North America, particularly at mid-elevations, higher temperatures could lead to a long-term reduction in peak snow-water equivalent, with the snowpack building later in the year and melting sooner. The result is a seasonal shift in runoff, with a larger proportion of total runoff occurring in winter, together with possible reductions in summer flows. While no such trends have been identified as of yet in the Lower Fraser Valley, these trends have been observed in both the Fraser River and Upper Similkameen River (Morrison et al., 2002; Leith and Whitfield, 1998).

RELEVANCE OF CLIMATE CHANGE TO THE COMMISSION

Two aspects of potential climate change are of concern to the Commission:

- higher winter temperatures (less snow and earlier runoff); and
- higher summer temperatures (more evaporation).

Snowpack

An earlier runoff is of concern as spring snowmelt is an important contributor to storage volumes in Dickson Lake and flows at the Norrish Creek intake. Flows typically start to be released from the reservoir between June and July. If spring snowmelt occurs earlier, the "low flow" season will extend for a greater length of time putting additional pressure on the water system.

Since 1993, the Commission has only had to resort to pump storage in 2002 and 2003 (Figure 2-1). In all other years, flow releases were gravity controlled only. Resorting to pump storage increases cost to the Commission.

If the climate change predictions are accurate, the Commission will increasingly have to resort to pumping from reservoirs. Even without climate change, an increasing reliance on pump storage is expected. The water licences at Dickson Lake provide for a maximum withdrawal of 141.5 ML per day. However, withdrawals are presently only between 60 and 65 ML/day in the summer (Table 2-5). Increased demand will therefore put the greatest pressure on the water system, but climate change is expected to exacerbate the situation.

An in-depth analysis of the contribution of snowmelt to the Norrish Creek water supply is beyond the scope of this study. However, it is recommended that the Commission consider this climate change trend in their long-term planning for the reservoir. The potential for increasing reliance on pumped storage tends to support options for increasing the gravity-fed storage volume.

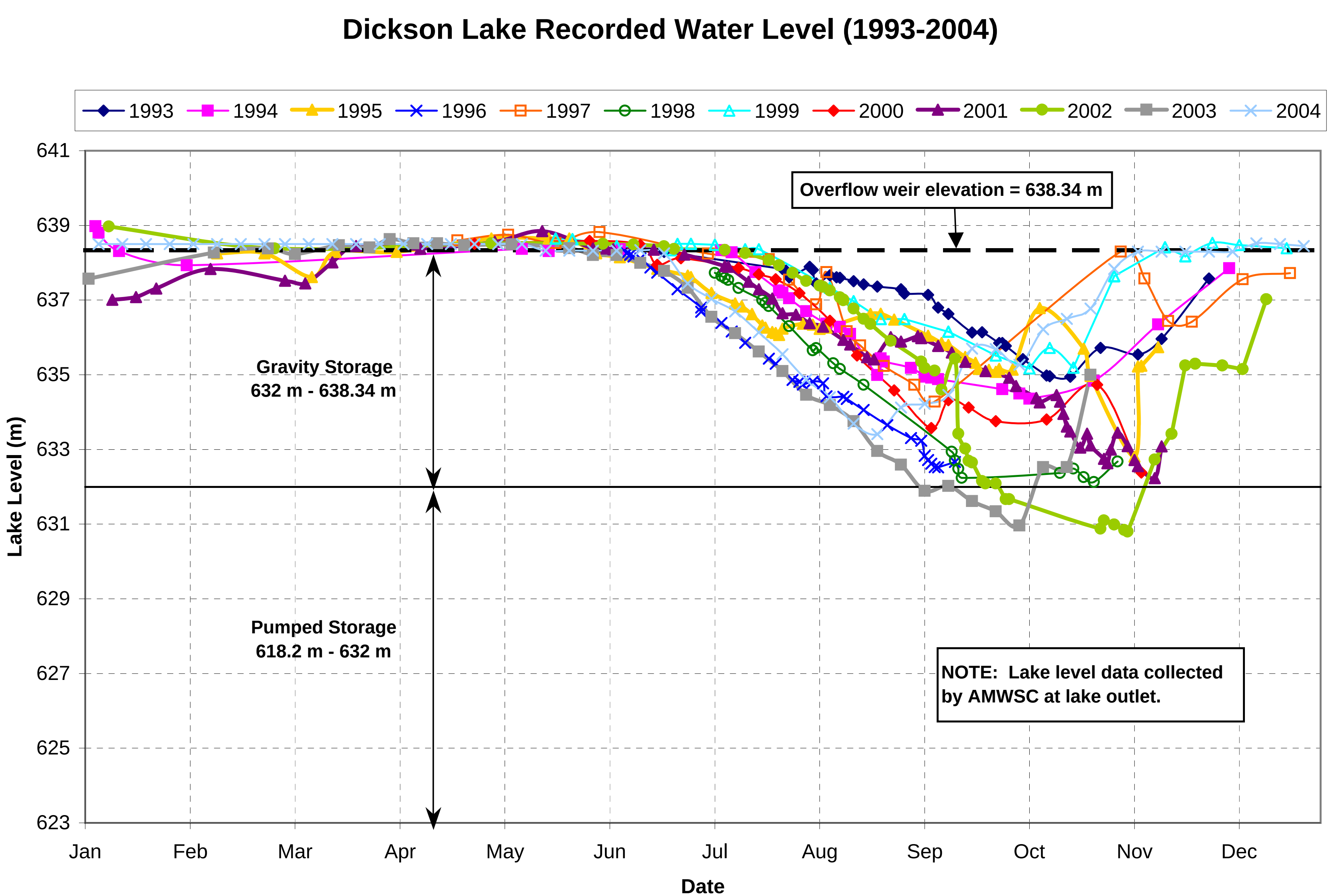
Less snow and an earlier freshet is not of particular concern at Cannell Lake, as snow is not a significant component of the water balance.

Evaporation

Annual evaporation at Dickson Lake is approximately 670 mm, with 80% of that total occurring during the spring and summer. Higher summer temperatures will increase evaporation at both Dickson Lake and Cannell Lake. From a hydrologic perspective, evaporation is a secondary consideration.

Planning for Climate Change

The potential for climate change to impact the Commission's water supply sources provides added incentive to optimize water resource use through effective planning and management. In particular, the uncertainties of climate change increase the importance of hydrologic monitoring as a means of understanding and documenting long term changes.



KERR WOOD LEIDAL ASSOCIATES LTD.
Consulting Engineers
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Figure 2-1

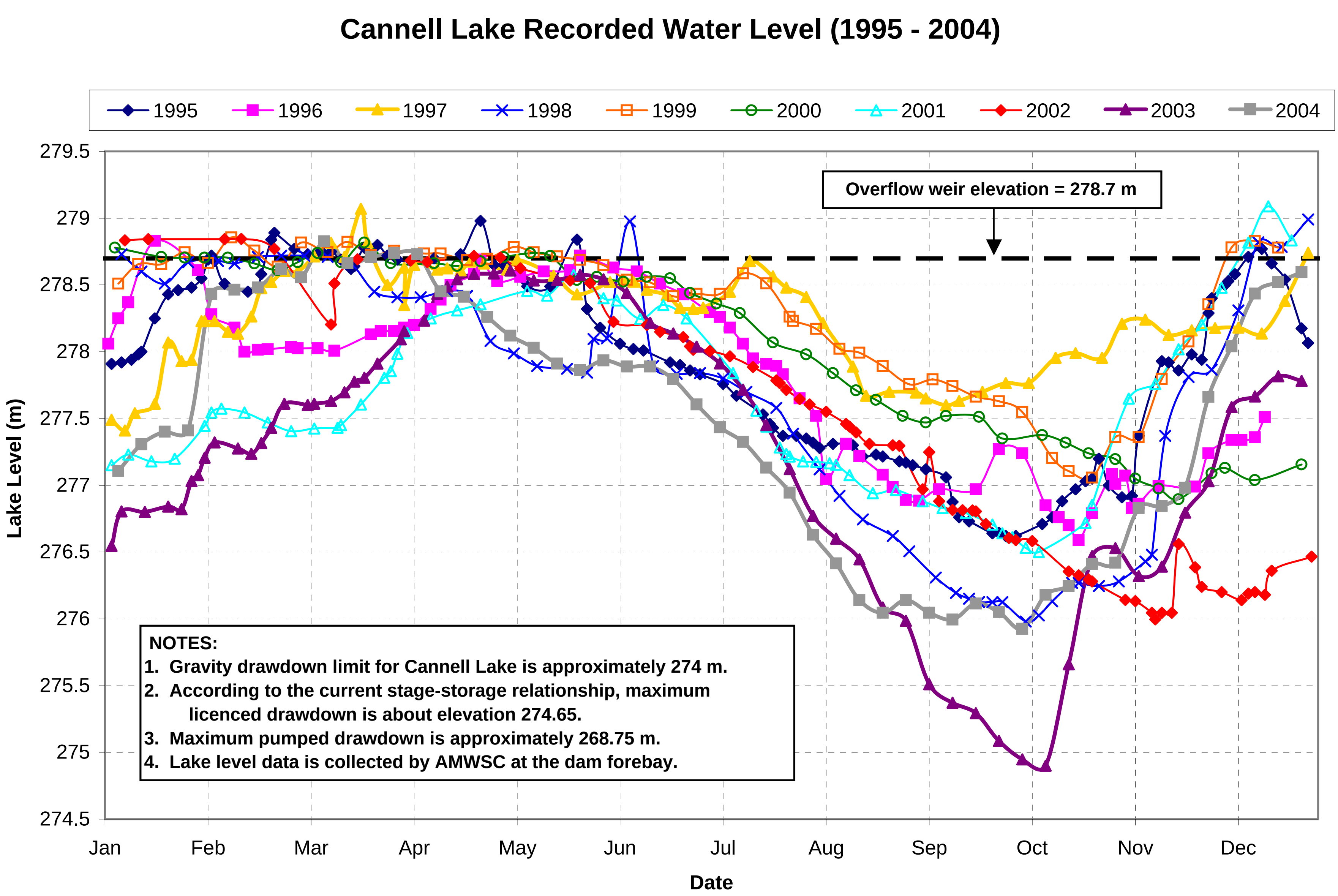

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Figure 2-2

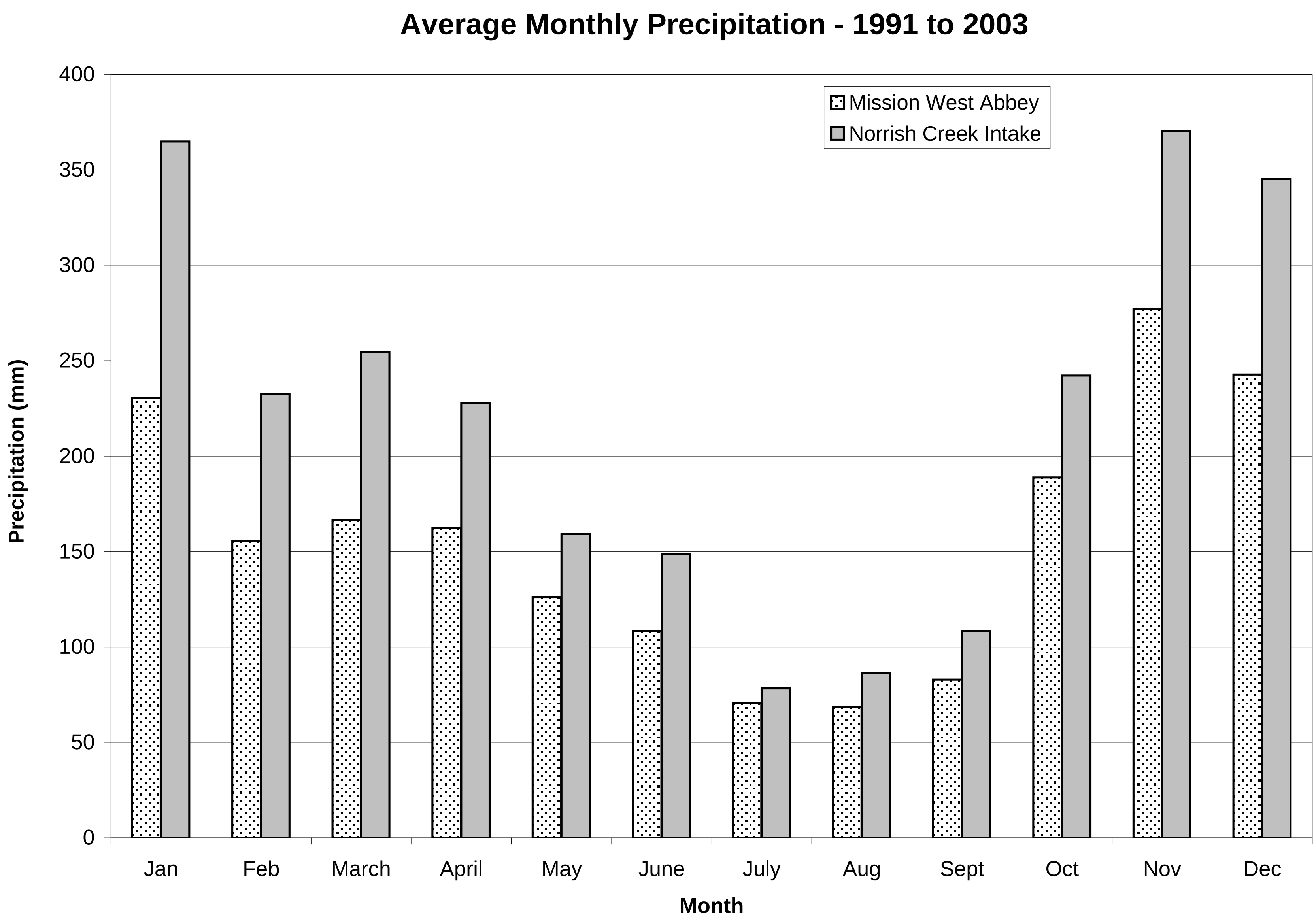

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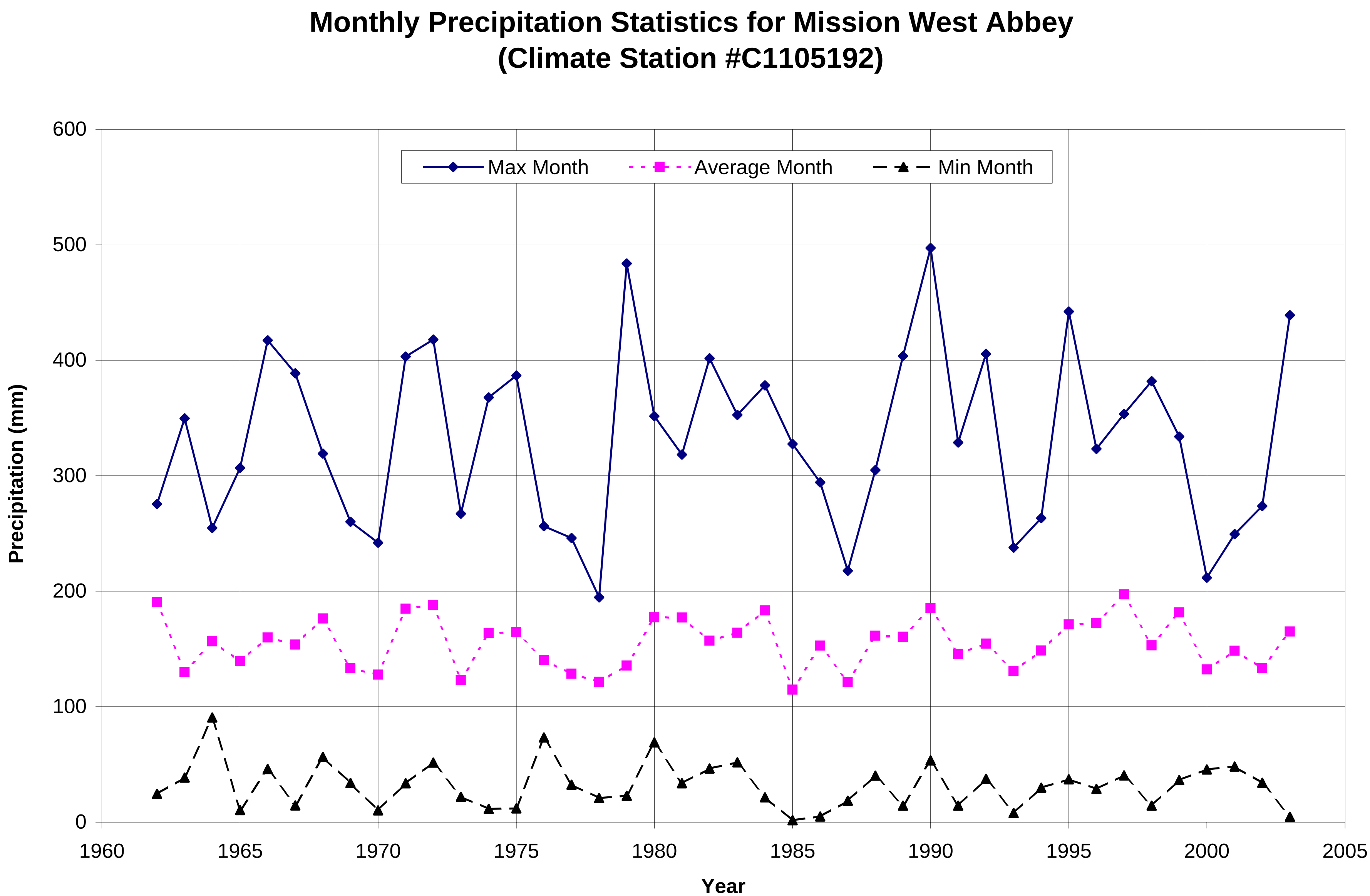
Figure 2-3



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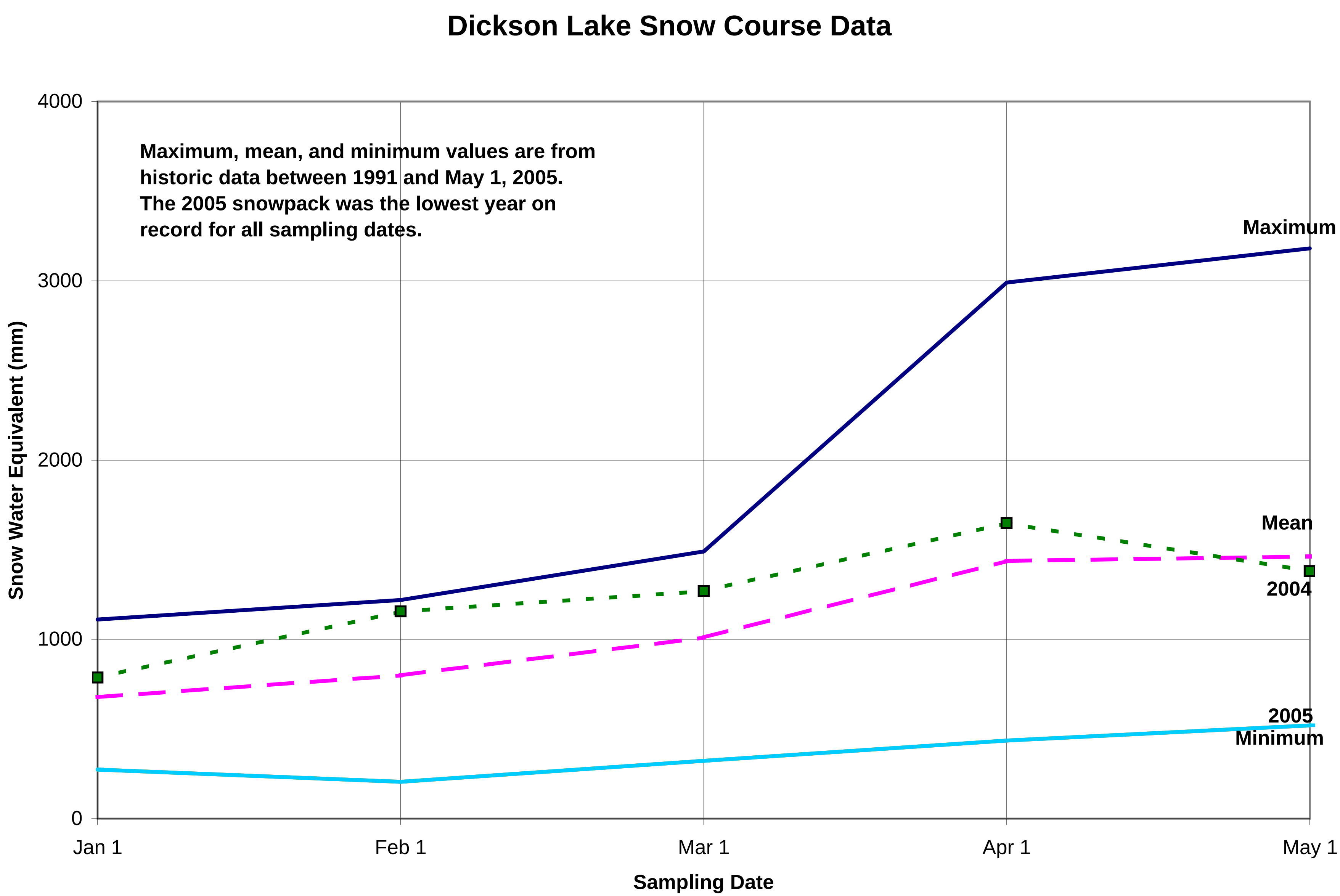
Q:\2000-2099\2080-009\442-Hydrology\Precip\[MWA_precip.xls]Long-Term MWA Precip

Figure 2-4



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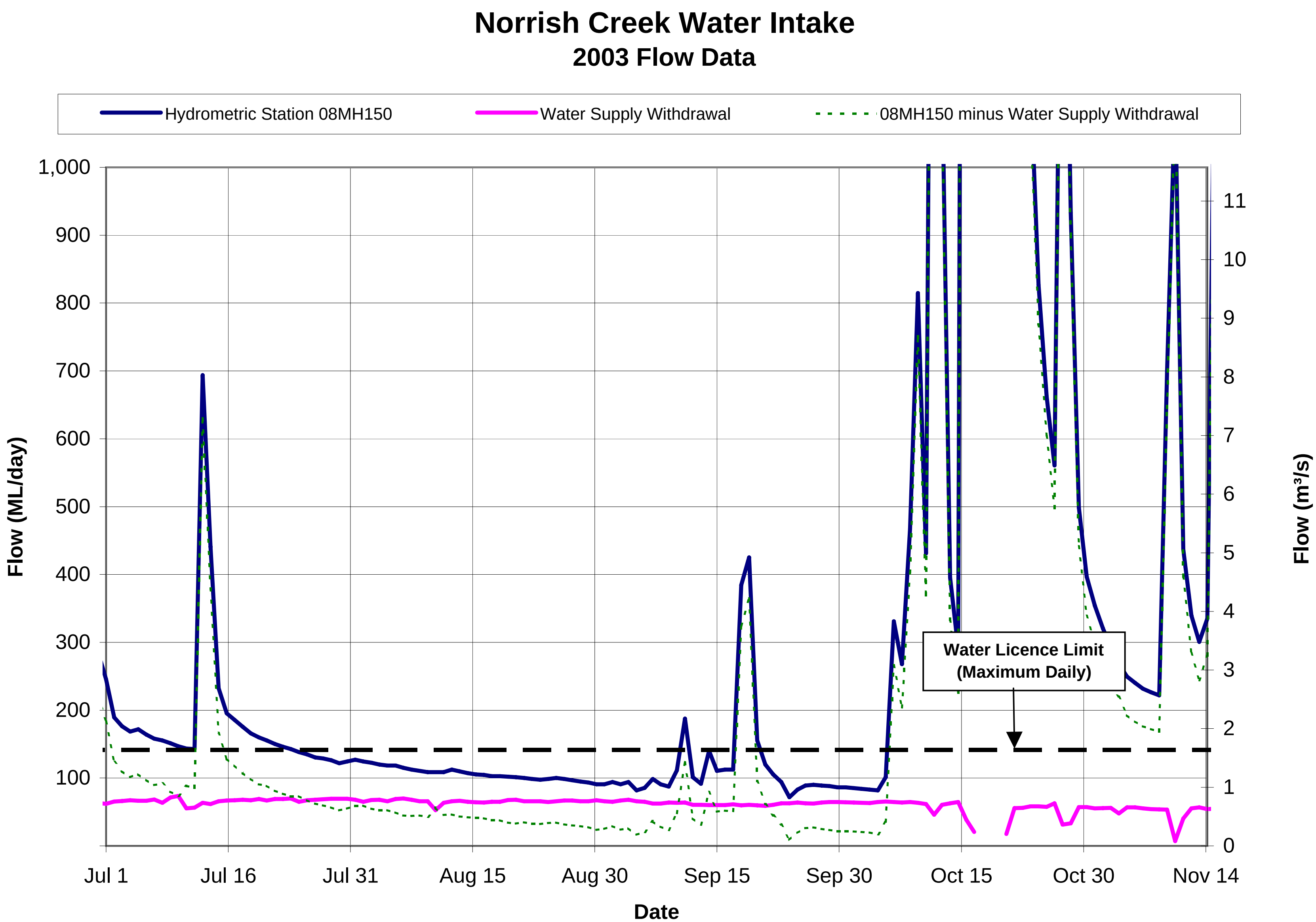
Q:\2000-2099\2080-009\442-Hydrology\Snow\[Snow.xls]Chart

Figure 2-5



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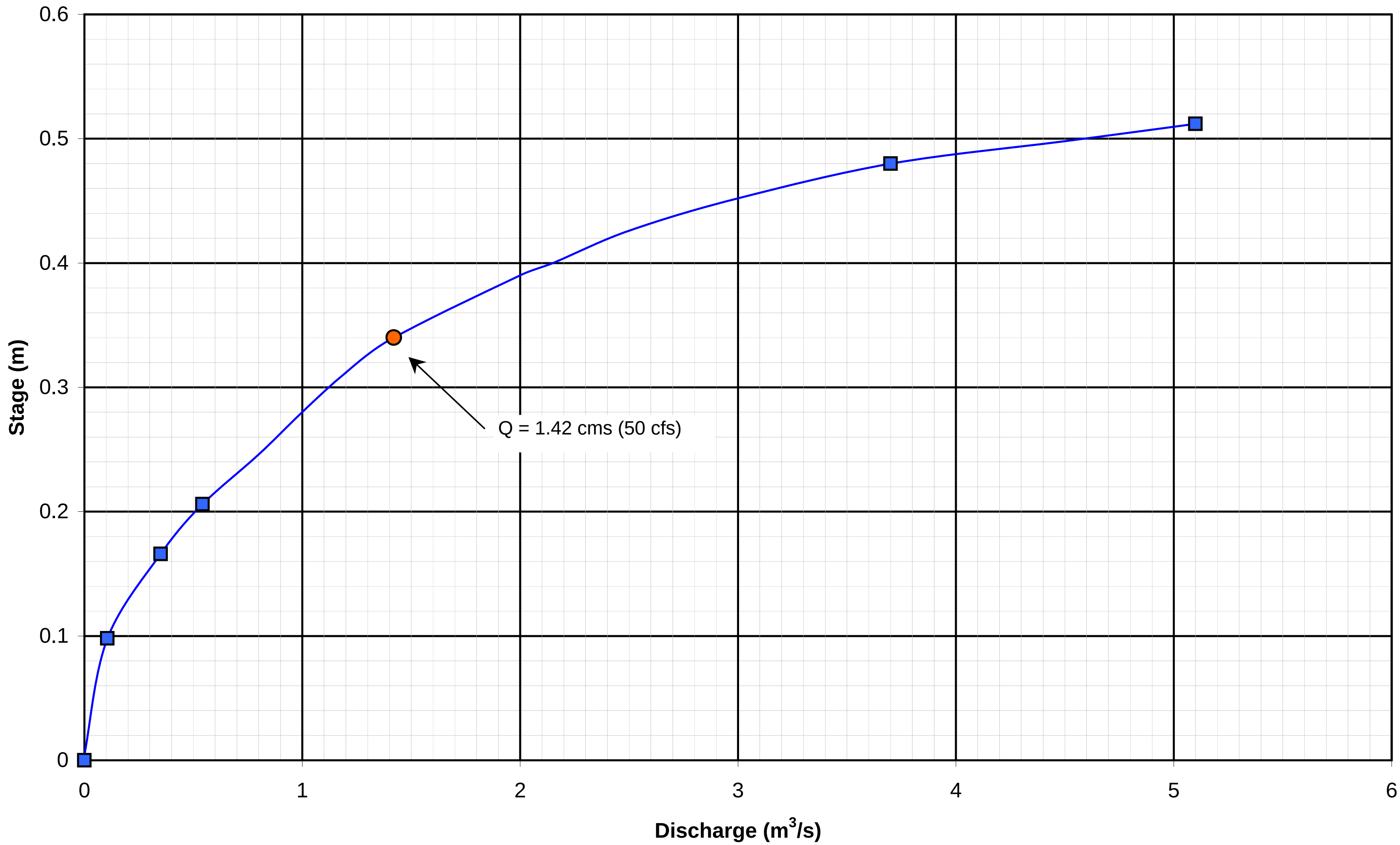
Q:\2000-2099\2080-009\442-Hydrology\Withdrawal\[flow.xls]Chart2003

Figure 2-6

Rating Curve for Norrish Creek Intake Weir



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R:\2000-2099\2080-009\442-Hydrology\IntakeWeir\[Q-stage.xls]Chart

Figure 2-7

Section 3

Lake Storage Assessments

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3. LAKE STORAGE ASSESSMENTS

This section documents a brief storage assessment for Cannell Lake and a detailed storage assessment for Dickson Lake. The lake storage assessments are analyzed in the context of drought management.

The Norrish Creek work builds on two previous documents prepared for FVRD by KWL:

- Operational Hydrology Plan for Water Supply System. Draft report prepared for FVRD (May 2003).
- Hydrologic Operating Procedures for Norrish Creek Water System. Draft prepared for FVRD (July 2004).

The first document develops a preliminary operational hydrology plan for the Commission during low flow periods. The second document suggests hydrologic operating procedures for the Norrish Creek water system during four stages: spring freshet to low flow period, marginal low flow period, extreme low flow period, and lake refill period.

3.1 CANNELL LAKE STORAGE ASSESSMENT

According to the stage-storage relationship currently used by the Commission, the volume of Cannell Lake between the minimum pumped elevation of 268.75 m and the spillway crest elevation of 278.7 m is about 3,880 ML. The relationship shows that the stage-storage relationship is basically linear between these elevations, although there appears to be a step-change (from 45.7 ML/m to 31.8 ML/m) at about elevation 273.7 m.

Review of materials and data supplied by the Commission gives no indication that the stage-storage relationship has ever been extended above the crest of the spillway (i.e. to estimate surcharging and attenuation during major inflow events).

The source of the current stage-storage relationship for Cannell Lake is not known. It would be appropriate for the curve to be updated, since the assumption of linearly-increasing storage is not generally valid for smaller bodies of water like Cannell Lake.

One typical approach for generating an updated stage-storage discharge is to measure areas within a series of depth contours. The areas of successive contours can be averaged and multiplied by the difference in elevation to obtain a more accurate estimate of volume.

Contour footprint areas for Cannell Lake are available from a plot of lake surface area vs. elevation on a technical drawing supplied by the Commission. The title block for this drawing was not available; thus, the drawing number cannot be identified nor the accuracy of the plot verified. However, using this drawing yields a more realistic (though not necessarily more correct) stage-storage relationship. Storage between pairs of one-metre contours increases 2 to 4% per metre elevation.

Current water licences for Cannell Lake authorize the storage of approximately 1,849 ML per year. According to the current stage-storage relationship, this volume of drawdown corresponds to about elevation 274.65 m. However, calculations based on the unnamed area-elevation relationship suggest that the maximum licensed storage may actually correspond to an elevation less than 274 m.

Water withdrawal during summer 2002 and summer 2003 drew Cannell Lake down to below 275 m. Given that the Commission is approaching their drawdown limit for Cannell Lake, an update to the stage-storage relationship is warranted to determine the elevation of the maximum allowable reservoir drawdown. A better stage-storage relationship would also facilitate optimization of water resources during peak demand periods.

Updating the stage-storage relationship will require reliable survey data. If survey data is not available, a new boat-based, GPS-linked survey of the near-shore areas of the lake at high water followed by a land survey at low water would be appropriate. This would be most cost-effective if performed in conjunction with the similar program suggested for Dickson Lake.

3.2 DICKSON LAKE STORAGE ASSESSMENT

STAGE-STORAGE RELATIONSHIP

The current Dickson Lake stage-storage relationship involves a linear relationship between the full-pool licensed storage of 12,890 acre-feet (approximately 15,900 ML) at elevation 638.34 m and zero licensed storage at an assumed low water elevation of 617 m.

A linear stage-storage relationship implies that the variation in lake area with changing surface elevation is negligible. While this is an acceptable assumption for lakes with large surface areas and a small ratio of drawdown to depth, it is not certain that such an assumption is appropriate for Dickson Lake. Therefore, revision of the current stage-storage relationship appears to be warranted.

Establishing a relationship between lake stage and storage volume for a reservoir is generally accomplished through a combined topographic and bathymetric survey program. In most cases, a bathymetric survey is conducted by boat during high water, with a brief follow-up topographic survey of the littoral and near-shore zones during the low water period. Both are typically necessary to ensure that the full range of lake elevation is adequately represented. The survey data are then used to calculate volume associated with each increment of lake stage.

No topographic survey data for the Dickson Lake area has been located during the course of this study. The only available bathymetric data for Dickson Lake is derived from a series of depth soundings performed on September 12, 1975. The original data for the 1975 survey is not available. However, the survey was reduced to a series of depth contours, which are plotted graphically in a drawing called "Dickson Lake Bottom Contours". The contours have been labelled as depth below the surface, presumably in feet. A footnote indicates that the lake was full with minor wind-induced discharge. No vertical datum or water surface elevation is provided. Further, the drawing has been repeatedly photocopied and is not necessarily to scale.

The "Dickson Lake Bottom Contours" drawing was scanned into electronic format and imported into AutoCAD, then overlaid onto an electronic copy of NTS map sheet 92G / 8E (Edition 1, 1:50,000, dated 1961). The drawing could then be scaled such that the zero contour approximately matched the extents shown on the map sheet. The corrected size of the Dickson Lake drawing compares well with all supporting data.

Footprint areas were calculated for each contour shown in the drawing. Volumes between each pair of contours were obtained by averaging the areas and multiplying by the contour interval.

Storage at Dickson Lake is provided by drawdown rather than by raising the lake elevation. Thus, it is reasonable to assume that the zero depth contour shown on the drawing is at an elevation of approximately 638 m. Storage at the full-pool elevation of 638.34 m is obtained by extrapolating the relationship captured by the 1975 survey.

The resulting relationship between stage and storage, expressed as stage and drawdown volume below full pool, is presented in Figure 3-1. The concave-downward shape of the stage-storage trace is typical of small natural water bodies. Most importantly, the revised relationship indicates that the licensed storage of 12,890 acre-feet (15,900 ML) is reached at elevation 618.2 m. A bathymetric survey would be required to confirm this.

DEVELOPMENT OF WATER YIELD MODEL

There are two key hydrologic questions regarding Dickson Lake:

- Can the reservoir meet and sustain the current and future water demand through the summer/fall low flow period?
- Will the lake fully refill in a dry winter following a complete drawdown?

The first issue is addressed qualitatively at the end of this section, with a detailed lake operating plan developed in Section 4. To address the second issue, KWL produced a water yield model for FVRD in May 2003 as part of the Operational Hydrology Plan. The model was refined and updated for the current project.

The methodology for the water yield model is summarized as follows:

Administrative

- The reservoir is assumed to be at maximum drawdown on November 1. This date was selected based on the approximate timing of the recharge season seen in Figure 2-1.
- The low water level associated with a total licensed storage of 12,890 acre-feet (15,900 ML) is approximately 618.2 m. Stage-storage conversions are based on the relationship shown in Figure 3-1.
- The model estimates the water yield on a daily basis for the period from November 1 through May 31. From Figure 2-1, the drawdown period historically begins around June 1.
- The total drainage area above Dickson Lake is approximately 11.2 km^2, including a lake surface area of approximately 0.95 km^2.

Inflow

- Inflow to Dickson Lake is scaled from daily average unit runoff recorded at WSC stations 08MH058 (Norrish Creek near Dewdney) or 08MH150 (Norrish Creek above Rose Creek) where available.
- The mean elevation of the catchment above the WSC gauging station is lower than the mean elevation of the catchment above Dickson Lake. Therefore, the catchment above Dickson Lake will tend to receive a larger percentage of winter precipitation as snow. The water yield model does not account for this and therefore will have a slight bias toward premature inflow. However, as long as the model includes a significant portion of the freshet, accuracy is not compromised very much; on a seasonal basis, the model is relatively sensitive to short-term variation in the timing of inflow within the refill period.

Precipitation

- Direct precipitation on the lake surface is calculated by scaling up data from the Mission Westminster Abbey precipitation gauge.
- Examination of concurrent precipitation records at MWA and the Norrish Creek intake shows that an adjustment factor of 1.4 is reasonably appropriate for predicting Norrish Creek precipitation from MWA data.
- Reksten (1988) estimates that monthly precipitation at Dickson Lake is 1.15 times that observed at the Norrish Creek Intake.

- In keeping with the above, a factor of 1.61 is adopted for estimating Dickson Lake precipitation from MWA observations. This value compares well with the scaling factor identified by Reksten (1988) for comparing total precipitation from multi-day rainfall events.

- This analysis assumes that all precipitation falls as rain. Since only direct precipitation on the lake surface is considered, this assumption should have negligible impact on the calculations.

Evaporation

- Evaporation from the surface of Dickson Lake is based on 1951 to 1980 30-year normals for monthly lake evaporation collected at the Vancouver UBC Climate Station (#1108487). The data are assumed transferable to the Dickson Lake vicinity because evaporation is only a minor component of the water balance at Dickson Lake.

- Reksten (1988) cites a study by Ferguson (1974) which finds that actual evapotranspiration decreases by 10% for every 350 m increase in elevation. This analysis assumes that lake evaporation undergoes a similar decrease with elevation.

- The difference in elevation between the Vancouver UBC climate station (87 m) and Dickson Lake (638 m) is approximately 550 m. This results in a factor of $(1 - 0.1)^{550/350}$ or approximately 0.85.

Seepage and Discharge

- This analysis assumes there is no controlled outflow to Norrish Creek during the refill period.

- The analysis does not account for any seepage through the dam, nor does it account for potential infiltration or exfiltration to/from the lake.

- The analysis closes the water balance by assuming that any inflow in excess of full pool storage is spilled.

A plot of the 2002/2003 calibration run is shown in Figure 3-2. The result indicates that the model provides a reasonable correlation on reservoir refill characteristics. However, the model still contains a significant degree of uncertainty and is based on limited data. Therefore, the conclusions should be regarded as a rough guide, and a more detailed hydrologic model would be needed to obtain more accurate estimates if the need arises.

3.3 ANALYSIS OF DICKSON LAKE WATER YIELD MODEL RESULTS

MODEL RESULTS

Figures 3-3(a) through 3-3(c) present simulations of reservoir recharge for the three driest winters on record, specifically 2000/01, 1976/77, and 1978/79. Example numerical output for the 2000/01 simulation are included in Appendix C. Each case assumes that the reservoir is fully drawn down to elevation 618.2 m on November 1 and allowed to refill with winter precipitation and natural inflow.

The three years presented here are selected because they have the three lowest precipitation totals for the months of November through May as measured at Mission Westminster Abbey climate station. Only years with complete winter data sets are considered.

Although MWA precipitation records show that 1978/79 was slightly wetter than 1976/77, the 1979 analysis shows that the reservoir does not reach full pool until early May (as compared to mid-April for 1977). This is assumed to be a result of uncertainty in the WSC streamflow record, as gauging station 08MH058 was influenced by ice conditions from late December 1978 through early February 1979, and contains only estimated values throughout the early freshet in March and April 1979. Simulation of the fourth driest winter on record (1969/70) suggests that the 1977 simulation is more correct.

The model results suggest that the inflow to Dickson Lake is sufficient to completely refill the reservoir drawdown for each of the three dry years analyzed. The refill period is typically between six and seven months for these scenarios.

FREQUENCY ANALYSIS

The analysis above indicates that lake inflow in the driest winters on record is sufficient to recharge 100% of the licensed storage, assuming that the refill season begins in November and the drawdown season does not begin until at least mid-May, and that no flow releases to Norrish Creek are required during the refill period.

A preliminary frequency analysis of winter precipitation at MWA yields an estimated return period for the driest winter on record (2000/01) of slightly less than 100 years.

The 2000/01 refill simulation results in a total spill of about 1,000 ML. This represents approximately 6% of the simulated inflow into Dickson Lake between November 1, 2000 and May 31, 2001. When total precipitation recorded at MWA for the same period (851.6 mm) is decreased by 6%, the resulting total winter precipitation (800.5 mm) would have a return period of roughly 200 years.

The frequency analysis suggests winter inflow just sufficient to refill Dickson Lake from empty during a dry winter (November through May) is associated with a return period of about 200 years. In other words, the probability of an "empty" reservoir not refilling is estimated to be roughly 0.5%.

The probability calculated above is conditional on the reservoir beginning to refill from its maximum permitted drawdown on November 1, and the subsequent drawdown season commencing on June 1. If the reservoir has some capacity remaining on November 1, or the next year's drawdown season begins later than June 1, the probability of the reservoir not refilling is reduced. Conversely, if drought conditions delay the start of the recharge season or advance the start of the next drawdown season, the probability of the reservoir not refilling is increased.

Drawdown patterns in both the preceding and subsequent summer seasons are dependent on many factors (e.g. weather, demand, water restrictions, pump capacity, etc.), and quantifying the likelihood of the reservoir being at a given elevation on a given date would require an extensive probabilistic analysis. At present, Dickson Lake has never approached its drawdown limit at any time of year and arguably would be unable to do so given the restricted pump capacity at low reservoir levels. Therefore, the analysis would have to be approached theoretically, since there is no data from which probability distributions can be calculated, and no means of estimating the conditional probabilities of the different system states.

RAISING DICKSON LAKE DAM

The Commission is considering raising Dickson Lake Dam by 6 m. If the live storage volume (i.e., the reservoir operating range) is increased, the probability of the lake not refilling in a dry winter would also be increased. Given that FVRD has never used more than 50% of its current licensed annual storage entitlement, there does not appear to be a strong hydrologic justification for raising the dam. Nevertheless, there could potentially be several other advantages from raising the dam, including:

- greater ability to meet fish flow release requirements during dry summers;
- greater ability to meet water demand in the event of other sources (Cannell Lake, groundwater wells) being temporarily unavailable;
- greater ability to meet increased water demand from short term population growth; and
- less reliance on pumping for lake releases (this will reduce pumping costs and increase system reliability).

Further to the last point, modifications to Dickson Lake Dam should consider the possibility of converting the dam to a gravity discharge facility, with elimination of the pumping system. This may or may not be cost-effective, but should be considered.

Raising the dam would be an expensive proposition. A geotechnical assessment would be required to assess the effects of any changes on the stability of the dam and reservoir slopes, particularly the landslide on the west side of the reservoir. Significant environmental issues would have to be addressed. It would be appropriate to conduct a feasibility study prior to making a decision on whether to proceed with raising the dam.

An assessment of the Dickson Lake spillway prepared by KWL (2005) shows that the spillway is not able to pass the inflow design flood specified in the Dam Safety Guidelines (CDA, 1999). The spillway capacity should be improved, whether or not the dam is raised.

3.4 REVIEW OF DICKSON LAKE OPERATING CURVE

Dayton & Knight Drawing No. 58.64 provides an operating curve for Dickson Lake. The curve begins on May 31 at full pool (reservoir elevation 638.34 m) with 12,890 acre-feet (15,900 ML) of licensed storage remaining. The curve ends on November 15 at the estimated maximum drawdown (reservoir elevation 617 m) with zero licensed storage remaining. The slope of the curve reflects a theoretical lake drawdown rate (discharge). Between the two dates, the curve follows a constant drawdown rate of approximately 94.64 ML/day (1.1 m^3/s). The curve provides a crude tool for water supply assessment in that the water supply can be interpreted as ‘adequate” if the lake level is above the curve at any time, or “inadequate” if the lake level is below the curve.

Aspects of the operating curve that could be improved are discussed below.

- The curve should reflect the most limiting of:

  (a) the capacity of the discharge works at Dickson Lake;
  (b) the required water supply withdrawal at the Norrish Creek intake;
  (c) the water treatment plant capacity; and
  (d) water licence limits and fish flow requirements.

- The curve should reflect the updated stage-storage relationship.

- The curve should be related to the multiple stages of response laid out in the FVRD Water Shortage Response Plan and the 2004 B.C. Government publication *Dealing with Drought*.

- The curve reaches zero storage on November 15 with no buffer. It should be either staged or buffered such that this situation is approached only in extreme circumstances.

As noted above, the curve should respect the discharge capacity of the facilities at Dickson Lake. Dickson Lake currently has three Flygt submersible pumps on a floating platform on Dickson Lake. These pumps provide lake release flow when the lake elevation drops below 632 m. Pump Nos. 1 and 3 are identical 30 hp submersible pumps, while Pump No. 2 is a slightly larger 60 hp model that can pump against a higher total dynamic head. Each pump has a dedicated 450 mm HDPE pipe running to a discharge box at the gravity intake. When the lake surface drops below elevation 632 m, a check valve is closed such that the pumped water cannot backflow into the lake.

Although the nominal combined capacity of the pumps is adequate to meet existing demand in low head situations, flow capacity continuously decreases as the lake level drops. System losses (e.g. pipe friction, elbows, exit losses) also act to further decrease the actual outflow. Finally, anecdotal evidence provided by FVRD suggests that leakage from the discharge box results in a very significant portion of the pumped flow draining back into Dickson Lake.

It is important to conclusively establish the maximum discharge that can be attained from the pump system as the lake is drawn down toward its minimum level. The existing pumps will not be able to provide the 94.64 ML/day flow rate observed from the current operating curve for the month of November if the lake level is low.

Figure 3-4 shows an approximate relationship between lake stage and total pump capacity for the three pumps currently installed at Dickson Lake. This estimate is based on Flygt pump curves provided by the Commission and assumes simple system losses over the 350 m run to the discharge box. It also assumes values for backflow losses based on qualitative descriptions from Commission staff; these losses should be empirically confirmed. Finally, it is assumed that no additional head is required to counteract entrance losses at the intake structure.

Due to the uncertainty associated with the performance of the pump system at Dickson Lake, the values shown in Figure 3-4 should be conservatively viewed as upper limits to the actual values pending further testing and more in-depth analysis.

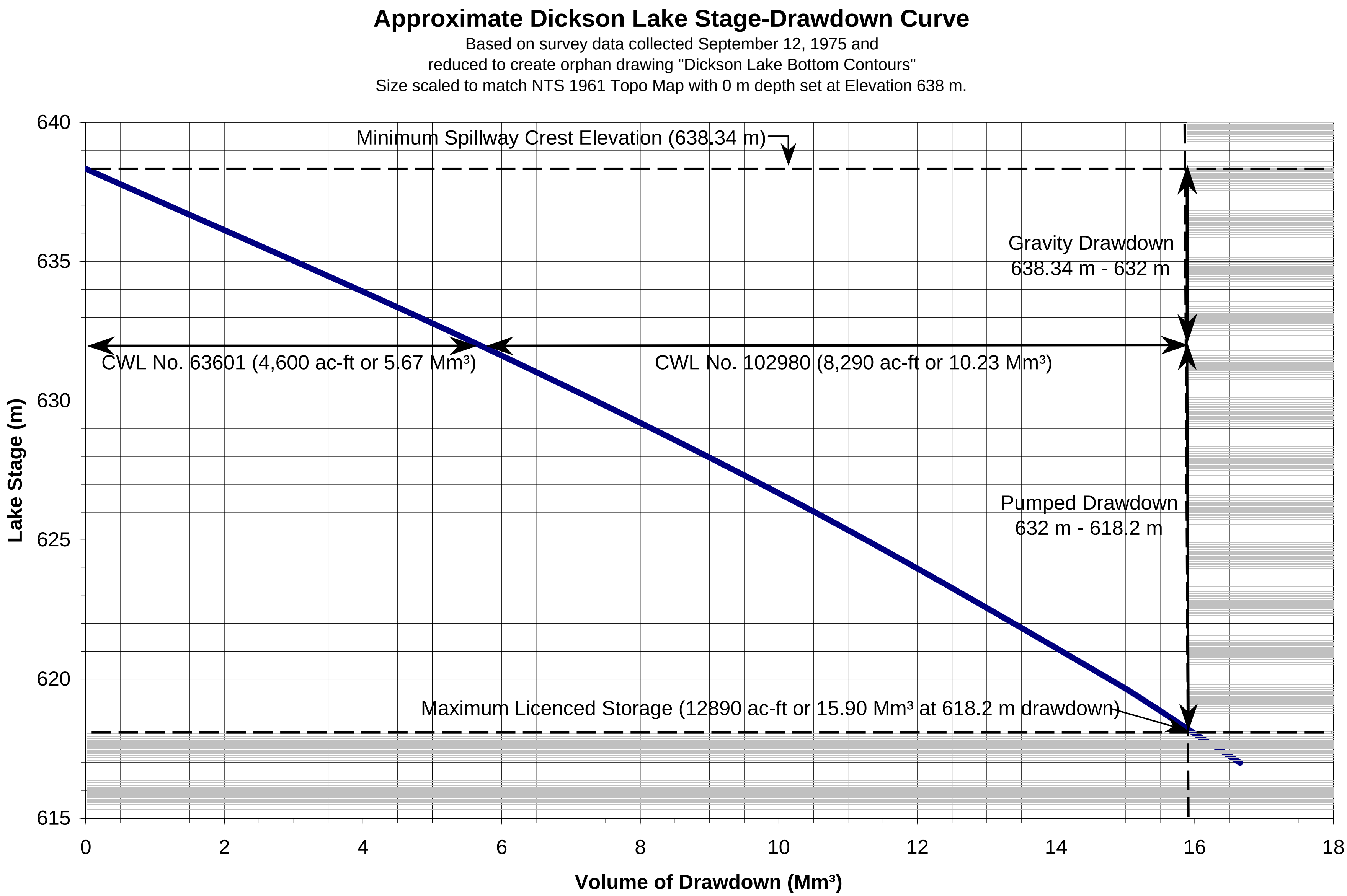
In general, the pump capacity shown in Figure 3-4 is comparable to that calculated by Omni Engineering (2004). Any minor difference falls well within the uncertainty range expected for the analyses, and can be attributed to the different assumptions made in each set of calculations. Most notably, the estimates of pump capacity provided by Omni Engineering have not been reduced to account for backflow at higher discharges.

This analysis supports the conclusions of Omni Engineering (2004) that pumping capacity can be increased to a degree by increasing system efficiency (i.e. by increasing the size of the forcemains and reducing head loss at the intake structure).

The values shown in Figure 3-4 comprise the expected discharge at the Dickson Lake outflow weir. To estimate the allowable corresponding withdrawal at the water intake, these values must be reduced by 3 cfs (85 L/s or 0.085 m^3/s) whenever flow in Norrish Creek is less than 50 cfs (1.42 m^3/s).

The maximum water supply from Norrish Creek that can be achieved at the maximum drawdown elevation of 618.2 m is estimated to be in the range of 12 to 13 ML/day (0.14

to 0.15 m^3/s). The large difference between this analysis and the current operating curve (12 ML/day vs. 94 ML/day) underscores the need for a comprehensive update.



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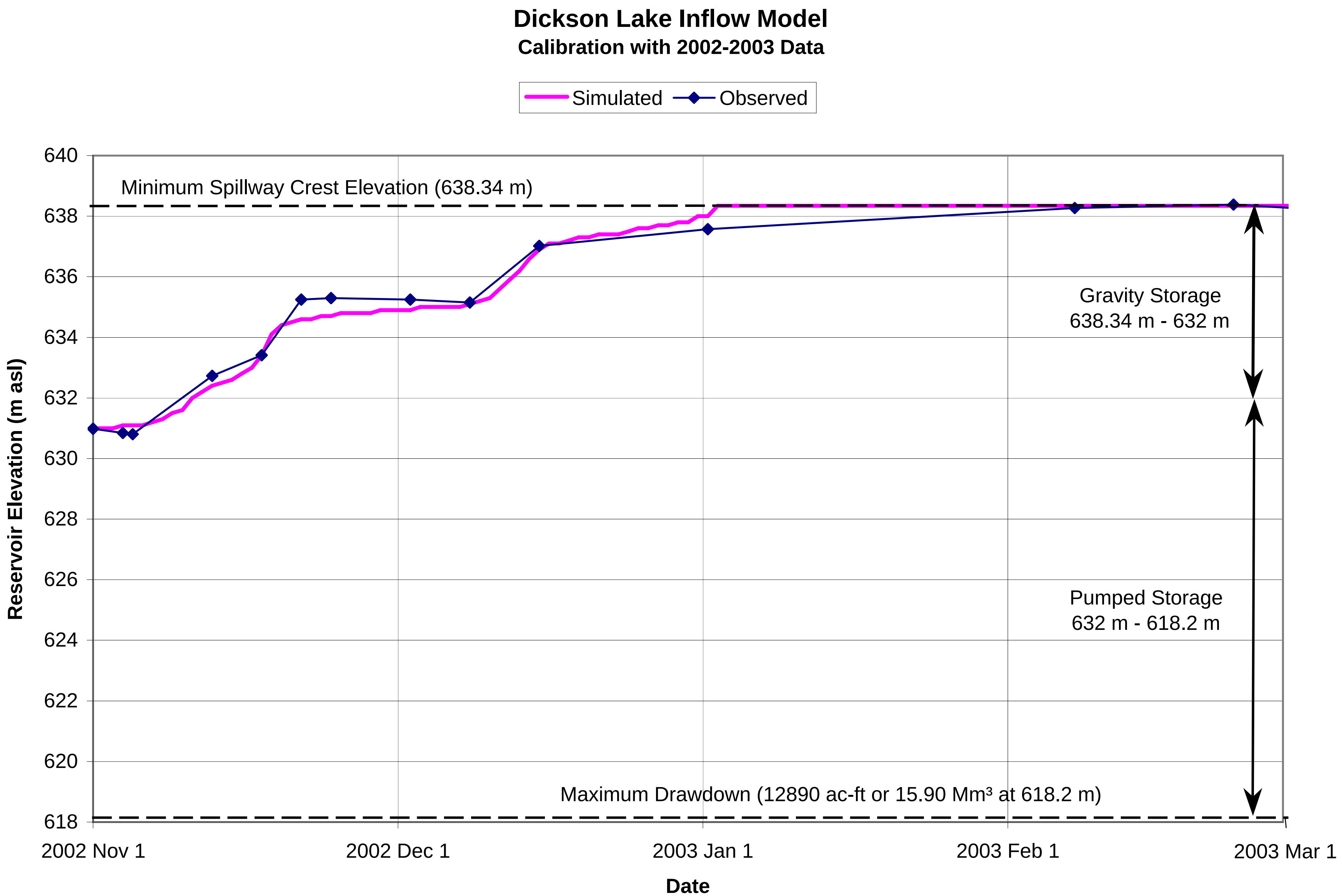
Consulting Engineers

Q:\2000-2099\2080-009\442-Hydrology\Stage-Storage\[DicksonLk_Stage-Storage.xls]DrawdownCurve

Figure 3-1



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Q:\2000-2099\2080-009\442-Hydrology\2080-001model\2080-001masscurveDickson.xlsFigure3-2

Figure 3-2

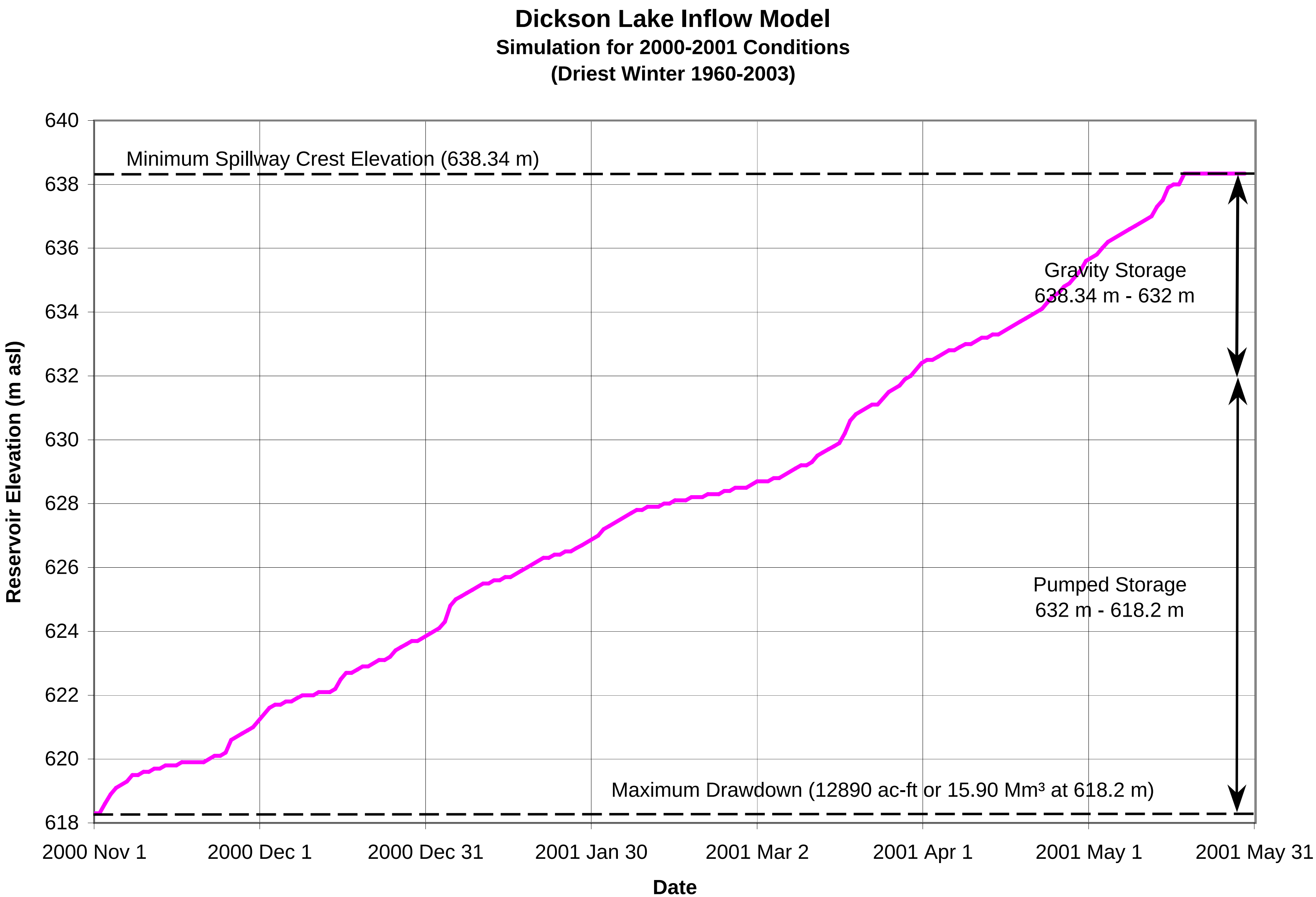

Dickson Lake Inflow Model
Simulation for 2000-2001 Conditions
(Driest Winter 1960-2003)
640
638
636
634
632
630
628
626
624
622
620
618
Reservoir Elevation (m asl)
Minimum Spillway Crest Elevation (638.34 m)
Gravity Storage
638.34 m - 632 m
Pumped Storage
632 m - 618.2 m
Maximum Drawdown (12890 ac-ft or 15.90 Mm³ at 618.2 m)
2000 Nov 1
2000 Dec 1
2000 Dec 31
2001 Jan 30
2001 Mar 2
2001 Apr 1
2001 May 1
2001 May 31
Date

Figure 3-3(a)

Dickson Lake Inflow Modelling
Simulation for 1976-1977 Conditions
(Second Driest Winter 1960-2003)

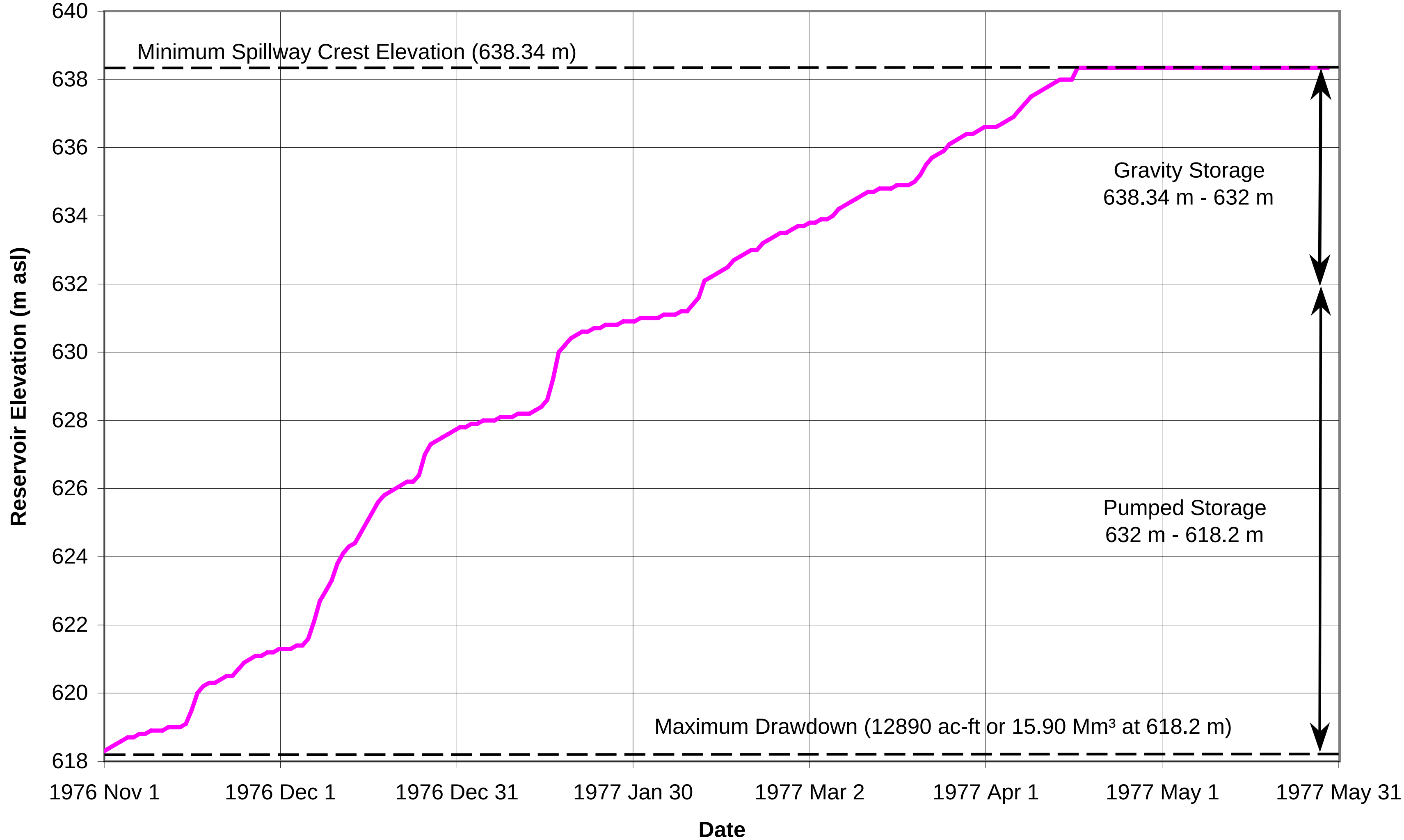


Figure 3-3(b)

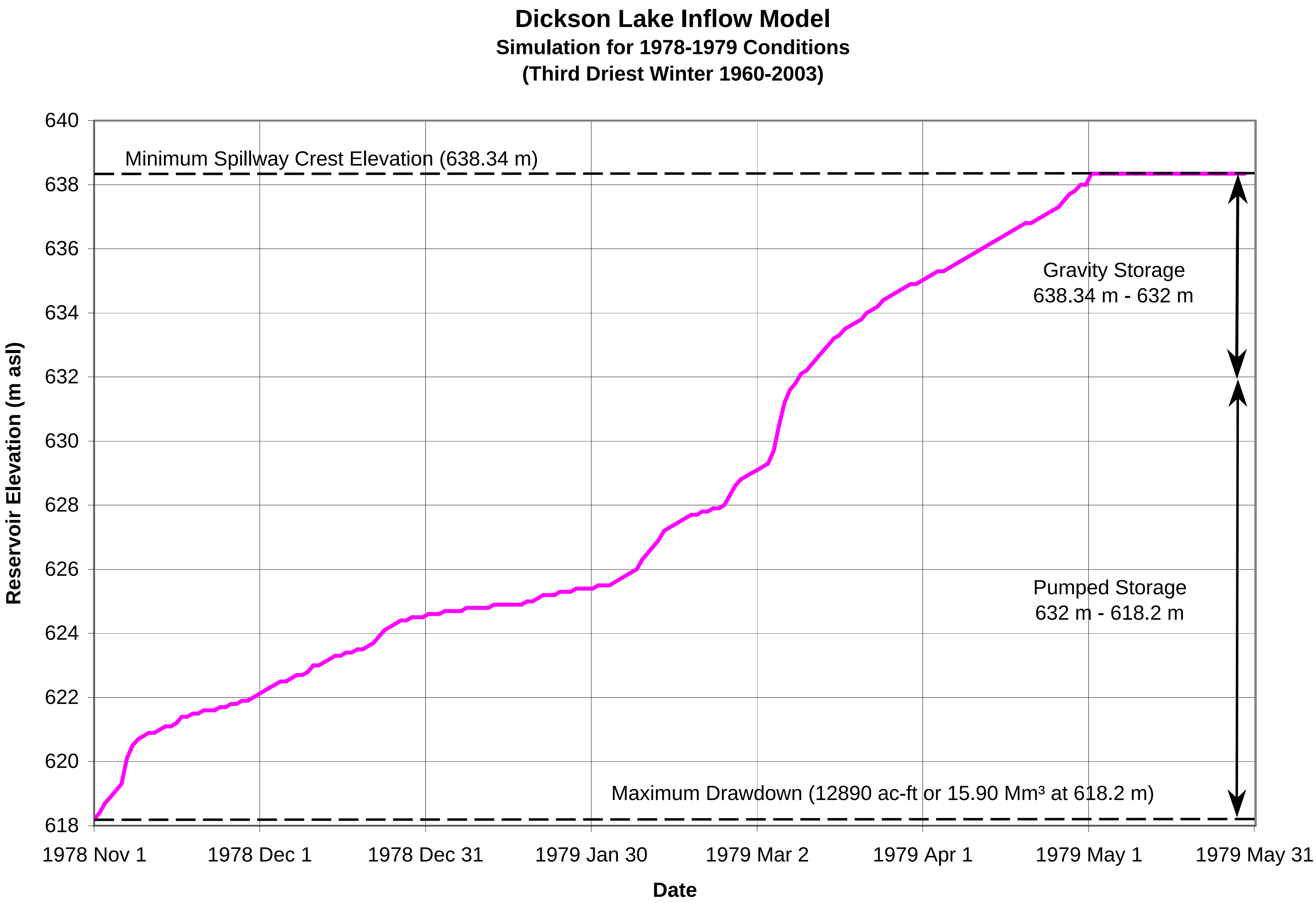
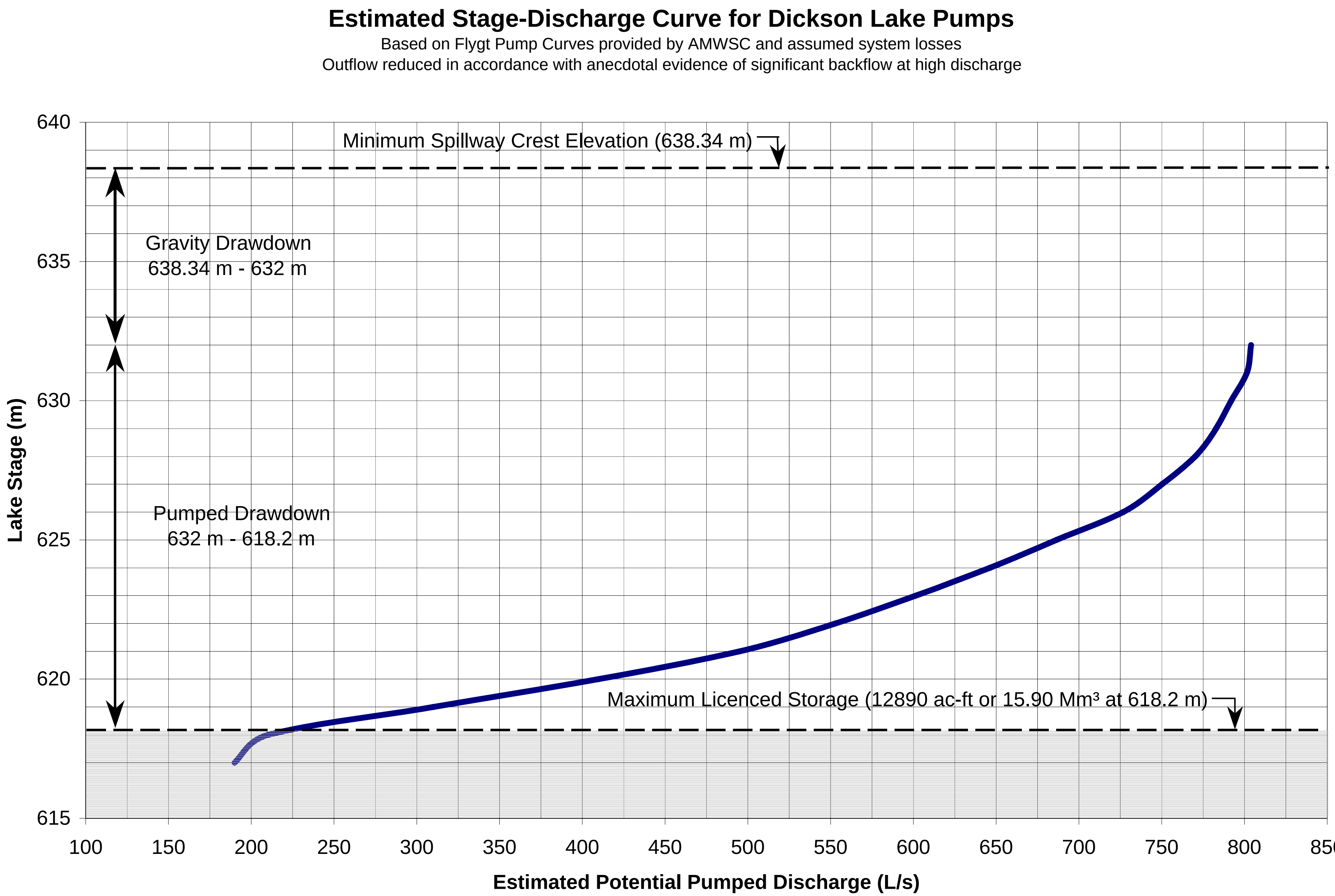

Dickson Lake Inflow Model
Simulation for 1978-1979 Conditions
(Third Driest Winter 1960-2003)
Minimum Spillway Crest Elevation (638.34 m)
Gravity Storage
638.34 m - 632 m
Pumped Storage
632 m - 618.2 m
Maximum Drawdown (12890 ac-ft or 15.90 Mm³ at 618.2 m)
Reservoir Elevation (m asl)
640
638
636
634
632
630
628
626
624
622
620
618
1978 Nov 1
1978 Dec 1
1978 Dec 31
1979 Jan 30
1979 Mar 2
1979 Apr 1
1979 May 1
1979 May 31
Date

Figure 3-3(c)



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Q:\2000-2099\2080-009\442-Hydrology\OperatingPlan\Dickson_System_curves.xlsDischargeCurve

Figure 3-4

Section 4

Water Supply Source Utilization

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4. WATER SUPPLY SOURCE UTILIZATION

The fact that the water supply system has several sources creates both challenges and opportunities for effective resource management. Challenges arise in obtaining and interpreting a real-time snapshot of the regional water supply situation, as well as in identifying the most effective response measure at any particular time. Opportunities arise through effective utilization of the multiple sources.

Three key aspects to an integrated regional source utilization program are as follows:

- a sound hydrologic understanding of each water source;
- operating plans for each water source, detailing recommended actions to optimize use of the water supply; and
- a Water Shortage Response Plan (WSRP) outlining appropriate measures to conserve the water supply during times of low water supply.

This section discusses an approach to integrated source utilization for FVRD.

4.1 NORRISH CREEK SOURCE UTILIZATION

2003 LOW FLOW MANAGEMENT PLAN

A recommended low flow management plan contained in Section 5 of the 2003 Operational Hydrology Plan. The low flow management plan recommended therein is repeated in Table 4-1 for reference.

Table 4-1: Low Flow Management Plan from 2003 Operational Hydrology Plan

Condition or Period	Low Flow Management Provisions
A. Spring Freshet to Low Flow Period (flow at 08MH150 over 3 m^3/s)	▪ No release from Dickson Lake (other than spill over weir if lake level is high). ▪ Water supply withdrawal up to system capacity (90 ML per day). ▪ Increase monitoring frequency as the flow at 08MH150 approaches 3 m^3/s.
B. Marginal Low Flow Period (flow at 08MH150 under 3 m^3/s)	▪ Increase frequency of flow monitoring activities. ▪ Water supply withdrawal up to system capacity. ▪ Gradually release flow from Dickson Lake to maintain a minimum flow of 50 cfs at intake weir. ▪ Ensure that lake level is above operating curve.

Condition or Period	Low Flow Management Provisions
C. Extreme Low Flow Period (flow over intake weir < 50 cfs)	▪ Increase flow release from Dickson Lake to equal at least water supply withdrawal plus 3 cfs. ▪ Monitor flow conditions on a daily basis. ▪ Promptly decrease release from Dickson Lake if flow over intake weir increases above 50 cfs. ▪ Maximize water conservation measures if lake level drops below operating curve.
D. Reservoir Refill Period	▪ No release from Dickson Lake until full. ▪ Water supply withdrawal up to system capacity.

PROPOSED UPDATED OPERATING PLAN

It is suggested that the operating plan for the water supply infrastructure be based on the flow at the Norrish Creek intake, and that the need for water conservation measures be based on the amount of water storage in Dickson Lake (relative to the time of year). The suggested operating plan is shown in Table 4-2. The intent of the operating plan is to promote optimal utilization of the finite storage resource at Dickson Lake.

Source utilization planning for a water supply system should be a dynamic tool. Operating plans must be revisited whenever there is a change to the system constraints (e.g. updates to the stage-storage curve, increases in pump or treatment plant capacity, or changes to the relevant water licences). They should also be updated periodically to ensure that they reflect current best management practices and up-to-date demand forecasts.

4.2 UTILIZATION OF OTHER WATER SOURCES

An effective integrated source utilization strategy for the Commission will eventually require development of operating curves and plans for Cannell Lake and the groundwater wells. Operating curves and plans for all three sources could collectively become an effective tool for load balancing amongst the as well as for identifying and implementing the appropriate WSRP Response Stage.

For example, if the Dickson Lake operating curve were to show storage at Dickson Lake approaching the boundary between WSRP stages during a dry summer, then the Commission could begin utilizing proportionately greater supply from the other two sources. When the operating curves for Dickson Lake, Cannell Lake, and the groundwater wells all indicate that the next response stage is imminent, that stage would be activated and the Commission could re-allocate system supply based on other considerations.

Over the long term, this approach would promote optimal use of all three water sources, as well as the most effective use of the WSRP.

Table 4-2: Suggested Operating Plan for the Norrish Creek Water Supply System

Flow Criteria	Dickson Lake				Norrish Creek			
	Releases	Flow Ramping	Monitoring	Data Collection	Withdrawals	Flow Ramping	Monitoring	Data Collection
08MH150 > 3 m³/s AND Flow Over Norrish Creek Intake Weir > 1.42 m³/s	▪ No controlled release ▪ Reservoir either recharging or full and spilling	▪ None	▪ Weekly visit to Dickson Lake (May – October) ▪ Test generator and pumps at Dickson Lake once per month ▪ Periodic visit to Dickson Lake (November – April) ▪ Check lake level and climate data recording equipment	▪ Continuous automatic lake level and climate data recording ▪ Weekly manual measurement of lake level plotted AMWSC office	▪ Withdrawal as needed up to licenced amount or system capacity	▪ None	▪ Daily visual inspection of Norrish Creek intake Monday - Friday	▪ Record daily withdrawal at intake and outflow from clearwell ▪ Plot daily water level at the intake weir on chart in AMWSC office
08MH150 < 3 m³/s AND Flow Over Norrish Creek Intake Weir ≥ 1.42 m³/s	▪ Release flow from Dickson Lake as required to maintain a minimum flow of 1.42 m³/s at the intake weir ▪ Stop Dickson Lake release if WTP is shut down	▪ If release is to be increased or decreased by > 0.3 m³/s, flow should be ramped evenly over ½ hour ▪ Release can be stopped up to 3.5 hours before WTP shutdown ▪ Release (if necessary) must resume at least 5 hours prior to start-up of WTP	▪ Daily visit to Dickson Lake (Monday to Friday), including visual inspection of generator and pumps ▪ Test generator and pumps at Dickson Lake at least once per month ▪ Check lake level and climate data recording equipment	▪ Continuous automatic lake level and climate data recording ▪ Daily manual measurement of lake level plotted at the AMWSC office	▪ Withdrawal as needed up to licenced amount or system capacity	▪ If withdrawal is to be increased or decreased by > 0.3 m³/s, flow should be ramped evenly over ½ hour ▪ If withdrawal is to be increased by > 0.6 m³/s, flow should be ramped up evenly over 1 hour ▪ Flow records should indicate that necessary discharge from Dickson Lake has reached the intake weir before increasing withdrawal	▪ Daily visual inspection of Norrish Creek intake (Monday – Friday) ▪ Test the low-flow alarm once per week	▪ Record daily withdrawal at intake and outflow from clearwell ▪ Plot daily water level at the intake weir on chart in AMWSC office
08MH150 < 3 m³/s AND Flow Over Norrish Creek Intake Weir < 1.42 m³/s	▪ Release flow from Dickson Lake as required to equal water supply withdrawal plus 0.085 m³/s ▪ Daily flow rate based on average flow over intake weir for previous 24-hour period	▪ If release is to be increased or decreased by > 25%, flow should be ramped evenly over ½ hour ▪ Reduction in release at Dickson Lake can preceed reduction in flow at the WTP by up to 3.5 hours ▪ Release at Dickson Lake must be increased at least 5 hours prior to increasing withdrawal at the WTP	▪ Daily visit to Dickson Lake including visual check of generator and pumps (Monday – Sunday) ▪ Test generator and pumps at Dickson Lake every two weeks when not in use ▪ Check lake level and climate data recording equipment	▪ Continuous automatic lake level and climate data recording ▪ Check daily manual measurements of lake level for general consistency against average daily recorded values ▪ Plot daily average recorded lake level measurements on Operating Curve at the AMWSC office	▪ Withdraw release from Dickson Lake less 0.085 m³/s, up to licenced amount or system capacity ▪ Increase water use from other water sources	▪ If withdrawal is to be increased or decreased by > 25%, flows should be ramped evenly over ½ hour ▪ If withdrawal is to be increased by > 0.6 m³/s, flow should be ramped up evenly over 1 hour ▪ Flow records should indicate that necessary discharge from Dickson Lake has reached the intake weir before increasing withdrawal	▪ Hourly visual inspection of Norrish Creek intake (Monday – Sunday) ▪ Test the low-flow alarm once per week	▪ Record hourly withdrawal at intake and outflow from clearwell ▪ Plot hourly water level at the intake weir on chart in AMWSC office

Q:\2000-2099\2080-009\300-Report\2005-07Final\Table4-2.doc

4.3 WATER SHORTAGE RESPONSE PLAN

As part of the current work, KWL updated the 1994 Water Shortage Response Plan.

1994 WATER SHORTAGE RESPONSE PLAN

Following the dry summer of 1992, several jurisdictions in British Columbia developed plans for reducing water demand during future droughts. The Central Fraser Valley Water Commission implemented the Water Shortage Response Plan outlined in Table 4-3 in 1994.

Table 4-3: Summary of 1994 Water Shortage Response Plan

Restriction Level	Details
Conservation Advisory	**Stage I** ▪ Public information
Twice-Weekly Sprinkling	**Stage II** ▪ 2 days per week (1 weekday, 1 weekend) ▪ 16 hours per week total
	▪ Municipalities requested to reduce sprinkling.
Once-Weekly Sprinkling	**Stage III** ▪ 1 day per week (weekday) ▪ 8 hours per week total ▪ Hosing of outdoor surfaces prohibited ▪ Spring-loaded shutoff on all hoses
	▪ Municipalities requested to reduce sprinkling.
Total Sprinkling Ban	**Stage IV** ▪ Lawn sprinkling prohibited ▪ Hosing of outdoor surfaces prohibited ▪ Spring-loaded shutoff on all hoses ▪ Garden watering by hand-held hose or containers only
	▪ Municipalities requested to reduce sprinkling ▪ Non-recirculating ornamental fountains turned off ▪ Wading pools filled only when required ▪ Curtail street-flushing ▪ Curtail washing of municipal vehicles ▪ Speedy leak-detection and repair ▪ Allow municipal lawns and boulevards to dry out if permanent loss will not occur
Note: This table presents a summary for illustrative purposes only.	

COMPARISON WITH GVRD WATER SHORTAGE RESPONSE PLAN

FVRD's 1994 WSRP is similar to one developed by GVRD in 1993. Experience in GVRD in 2003 (another dry summer) showed that WSRP restrictions are effective in reducing with consumption. As a result, GVRD reviewed, revised, and strengthened its WSRP in 2004 to make it a more effective water management tool.

The Commission should consider streamlining and integrating its WSRP with that of GVRD in order to take advantage of its substantial technical foundation. This would provide mutual reinforcement for both WSRPs, placing water conservation in the face of shortages in a more regional context.

It is expected that general water use patterns will be sufficiently similar between the two jurisdictions to allow a WSRP based on the GVRD plan to act as an effective interim document. Notwithstanding, these comments, there are unique conditions in both systems that require further consideration

GUIDELINE FOR WRSP STAGE DESIGNATION

Section 3.4 identified several areas where the current operating curve for Dickson Lake could be improved in the context of an integrated source utilization strategy. In this respect, Figure 4-1 provides a guideline for WSRP stage designation based on Dickson Lake level. The figure incorporates variable demand based on time of year and WSRP restrictions.

Figure 4-2 is a replica of Figure 4-1, with historical Dickson Lake levels shown. Of interest, Dickson Lake drops only partway into the “Precautionary” Stage (Stage II) for limited periods during a few years.

Figure 4-1 can be used by the Commission to help define WSRP stage based on Dickson Lake level and time of year. However, these guidelines should be used with discretion by qualified personnel as a decision support tool rather than a definitive indicator. In some cases, detailed hydrologic and operational analyses may result in a recommended WSRP stage that differs from that obtained by applying Figure 4-1. Some key points concerning Figure 4-1 are noted below:

- Stage 1 is mandatory from June 1 to September 30. This is based on harmonizing with the GVRD’s WSRP. As there is no hydrologic benefit to WSRP measures when reservoirs are overflowing, the Commission could consider implementing Stage 1 only when the reservoirs cease to overflow. However, this may complicate public relations.

- There is provision for Stage 1 to be implemented on May 1 in the event that Dickson Lake is not full. There is also provision for Stage 1 to be extended through October if Dickson Lake is near the gravity drawdown limit (El. 632 m).

- Stage 2 is invoked during the summer when Dickson Lake is, or is projected to get, below the gravity drawdown limit (El. 632 m). This is due to cost and reliance on mechanical components during periods of lake pumping.

- Suggested criteria for Stages 3 and 4 in summer are also provided.

- A condition of critical low lake level is identified for summer months when Dickson Lake is projected to possibly fall below the level at which the existing pumps can meet estimated demand under Stage #4 WSRP restrictions. This is noted as "Summer Critical", and may warrant detailed hydrologic analysis, stringent WSRP restrictions and additional pumping infrastructure at Dickson Lake.

- Periods of no WSRP restrictions are identified for November 1 to June 1. These are based on Dickson Lake being above the gravity drawdown limit, and projected to be full by June 1.

- A condition of cautionary low lake level is identified for winter months, noted as "Winter Operational Caution". In such a situation, it might become necessary to invoke pumped winter releases at Dickson Lake if Norrish Creek experiences extreme low flow conditions (freeze-up or winter drought). Hydrologic review would be warranted and WSRP restrictions may be considered.

- A more extreme condition of cautionary low lake level is identified for winter months, noted as "Winter Hydrologic Caution". In such a situation, a detailed hydrologic analysis should be performed to assess the capability of Dickson Lake to refill by June 1, in view of prevailing hydrologic and operational considerations.

The guideline presented in Figure 4-1 is based on current water supply infrastructure and should be updated in future years based on system upgrades and experience gained by the Commission. This will become more critical as Dickson Lake is increasingly drawn down to meet peak demand. It would be appropriate to incorporate Cannell Lake level and other indicators in the future.

The Commission will need to develop a formal policy for designating WSRP stages.

SUGGESTED REVISIONS TO THE COMMISSION WATER SHORTAGE RESPONSE PLAN

Suggested revisions to the Commission's WSRP are outlined in Table 4-4. These reflect water management issues in the Fraser Valley and an attempt to align the Commission's WSRP with the 2004 GVRD WSRP.

Re-specifying the numbers of the WSRP Stages to match those of the revised GVRD WSRP would be a simple task. Stage 1 of the 1994 WSRP would be eliminated or considered as Stage 0, and each of the other stages would basically be lowered by one. A new Stage 4 would be added, representing a set of very severe water use restrictions that would only be used in the case of rare and severe droughts or critical water supply situations.

The 1994 WSRP states that Stage II sprinkling restrictions will begin each year on the last weekend in May and remain in place until the supply situation permits their removal.

The Commission has taken some steps to advance the start date of sprinking restrictions to May 1.

Stage I of the GVRD WSRP imposes similar sprinkling restrictions; however, the restrictions commence on June 1 of each year and remain in effect until September 30. This period may be extended by direction of the GVWD commissioner. Since sprinkling restrictions for the two stages are virtually identical, minor administrative changes could match dates to those of the GVRD, creating the possibility of shared public awareness and publicity campaigns at the start of each season.

Based on historic lake level data from Dickson Lake, June 1 represents an appropriate date of commencement for Stage I. The lake is virtually always full on June 1.

Restrictions such as those designated in a WSRP require enforcement if they are to be effective. Enforcement is particularly critical to the successful operation of any integrated source utilization strategy, since operating curves for water supply sources are usually developed based on demand forecasts that include the reduction measures of the WSRP.

Since the minimum WSRP stage would be dictated by the regional water supply, the Commission could consider enforcement as optional at times between June 1 and September 30 when all operating curves indicate that storage is above the appropriate threshold. The Commission's WSRP should not apply to the use of collected rainwater, grey water, or other forms of recycled water.

The WSRP would have to be refined over time as the Commission gains experience and knowledge working with the integrated source utilization program.

Table 4-4: Suggested Revised Water Shortage Response Plan

WSRP Stage	Details
Stage 1 "Normal" (in effect from June 1-Sept. 30)	▪ Sprinkling restricted to twice per week as per Stage II of 1994 WSRP. This applies to all customers, including residential, industrial, commercial, institutional, and municipal sites. ▪ Permits are required for watering newly-planted lawns outside of permitted times. ▪ No restrictions on watering flowers, vegetables, planters, shrubs, trees, commercial flower and vegetable gardens, or commercial turf farms. ▪ Spring-loaded shutoff valves must be installed on all hoses. ▪ Municipalities to avoid street and system flushing, except where required for safety or public health. ▪ Municipalities request that golf course operators cut water use on fairways as much as possible.

WSRP Stage	Details
Stage 2 "Precautionary"	▪ Sprinkling restricted to once per week as per Stage III of 1994 WSRP, for all customers. ▪ Hosing and pressure-washing of outdoor surfaces prohibited unless required for safety, public health, or to apply surface treatments (e.g., painting, sealing, etc.). ▪ All fountains and water features must be shut down. ▪ Only water play parks with user-activated switches will be operated. ▪ Golf course fairways may be watered once per week; greens and tee areas may be watered normally. ▪ Schoolyards, sports fields, and sand-based playing fields may be watered at minimum levels required to maintain a useable condition.
Stage 3 "Dry"	▪ All lawn sprinkling using municipally-supplied water prohibited. ▪ No permits issued or renewed for newly-planted lawns. ▪ Flowers, vegetables, planters, shrubs, and trees may be watered using drip irrigation or a hand-held spring-loaded shut-off nozzle. No restrictions on watering commercial flower and vegetable gardens or commercial turf farms. ▪ Filling of swimming pools, hot tubs, and garden ponds prohibited. ▪ Watering of golf course tees, greens, school yards, and sports fields limited to minimum amounts necessary to maintain usability. Golf course fairway watering prohibited. ▪ Outdoor washing of vehicles prohibited except as required for safety (e.g. windows, lights, and licence plates). ▪ Municipalities promptly investigate and repair reported water leaks. ▪ Industry strongly encouraged to maximize water conservation. ▪ Begin daily publication of actual consumption versus target consumption in local newspapers.
Stage 4 "Very Dry"	▪ All outdoor watering, hosing, and washing (except vehicle windows, lights, and licences) prohibited for all customers unless ordered by a regulatory authority such as the Health Inspector. ▪ Indoor commercial car washes asked to suspend operations. ▪ Municipalities shut down non-spring-loaded public faucets and close outdoor pools. ▪ Industry asked to implement voluntary reductions in demand. ▪ Intensify public campaign on reducing everyday water use.

4.4 SEVERE DROUGHT ISSUES

This section provides commentary on options available to the Commission in severe drought situations. It is not intended to comment on other emergency situations such as loss of distribution capability. However, the Commission should ensure that emergency stand-by power is available at both Cannell and Dickson Lakes to maintain the integrity of the pumped water supply during a drought.

LIMITATIONS IN DICKSON LAKE PUMP CAPACITY

In the event of a severe water shortage, Dickson Lake is expected to provide most of the water supply. However, as Dickson Lake approaches its minimum licensed elevation, the pump capacity declines to less than 230 L/s (20 ML/day). After subtracting the required 85 L/s (7.3 ML/day) fisheries allowance, this would allow a withdrawal at the intake of about 12 ML/day. This compares to a treatment plant capacity of 117 ML/day, including 90 ML/day for the slow sand filtration system and 27 ML/day for the membrane filtration plant. The licensed withdrawal allowed at the intake is approximately 141.5 ML/day.

Based on these comparisons, it is obvious that the capacity of the pumps at low lake elevations will impose strong limitations on the water supply available from Dickson Lake. Table 4-5 provides minimum elevations at which the existing Dickson pumps can be expected to meet the estimated daily demand on October 31 under each stage of the Water Shortage Response Plan.

Table 4-5: Minimum Operating Elevations for Dickson Lake

WSRP Stage	Estimated Flow (Oct. 31, ML/day)	Minimum Elevation to supply Estimated Flow (m)*
No Restrictions (WTP capacity)	117	632 (gravity supply only)
Stage 1 (“Normal”)	59	627.6
Stage 2 (“Precautionary”)	53	625.2
Stage 3 (“Dry”)	50	624.6
Stage 4 (“Very Dry”)	47	623.7
Summer Critical (“Extremely Dry”)	N/A	618.2 (maximum licensed drawdown)

* These values do not include the storage buffer used in the Figure 4-1.

CANNELL LAKE

Storage at Cannell Lake is much less than at Dickson Lake. Drawdown in summer 2003 approached the currently-assumed maximum licensed drawdown of about 274.6 m. It is possible that a more severe drought would result in Cannell Lake dropping below the licensed minimum elevation. The Commission may wish to pursue water licences for additional storage at Cannell Lake to secure this water supply under moderately severe drought conditions.

TEMPORARY PUMPING AT DICKSON LAKE AND/OR CANNELL LAKE

The Commission has expressed a desire to explore options for emergency water supply in a severe drought, assuming that the current supply cannot meet demand. In such an extreme case, the most cost-effective and efficient option would be to use temporary pumps to draw Dickson and Cannell Lakes down beyond their maximum licensed drawdown elevations. This would be subject to approval from the Regional Water Manager and other regulatory authorities.

Based on Table 4-5, additional pump capacity will be required at Dickson Lake well before the licensed storage is fully utilized. This makes the use of temporary pumps at Dickson Lake very cost-effective, since additional capacity would already need to be in place when the lake reaches its maximum drawdown. Individual pumps can be procured on a precautionary basis as forecasts of dropping reservoir levels indicate they might be necessary.

This option results in relatively normal operation of the water system under high-stress conditions, providing potable water at the tap by utilizing the existing treatment plant and distribution system. For pricing purposes, a worst-case scenario was defined using equipment rented from Canadian Dewatering. The scenario assumes a demand of about 63 ML/day at the Norrish Creek treatment plant, which requires an estimated pump capacity of 1,200 L/s at Dickson Lake (including allowances for fisheries releases and backflow to the lake). The static head was assumed to be 30 m, corresponding to a lake elevation of about 608 m. The Canadian Dewatering cost estimate of about $12,000 per week includes the following equipment:

- 4 x 100 hp 10” pumps with a nominal capacity of 5000 USgpm (317 L/s);
- 2 x 200 hp generators with double-walled fuel tanks;
- 4 x 100’ of submersible electrical cable; and
- 4 x fish screens for pump intakes (4’ x 4’ x 6’).

The cost estimate assumes that all four pumps could feed into the 18” HDPE pipes currently attached to the two existing 30 hp pumps, since these pumps (Nos. 1 and 3), exceed their shut-off head when the reservoir declines below 619 m. The estimate does not include ancillary expenses such as construction of a new floating platform for the temporary pumps or fuel for the generators.

Discounts are available for longer-term rentals. Since the equipment would be phased in as the reservoir elevation declines, actual costs would depend on the duration of use for each piece of equipment.

The cost estimate above assumes that Dickson Lake would be required to supply 75% of the estimated total Stage 4 water demand for the month of July. The cost would increase proportionally if additional supply is required. If water supply from Dickson Lake were to be augmented by drawing Cannell Lake down below its maximum licensed drawdown elevation (about 274.6 m), it would be necessary to implement a second temporary pumping system. However, Cannell Lake is a much smaller reservoir than Dickson Lake and would be less able to support sustained demand during a deep drawdown situation.

OTHER TEMPORARY WATER SUPPLY SOURCES

If deep drawdown of Dickson Lake and Cannell Lake is unacceptable, or if the volumes attainable are forecast to be insufficient, other options could be explored. All of the options discussed below have very significant financial, technical, and logistical challenges. Further exploration of these options would require scenario-based engineering analysis and extensive consultation with potential suppliers.

Although the Fraser River is the closest water source to the demand centres, it would be difficult to use as a source of potable water due to the high turbidity level. A large-scale ultra-filtration system, if available, would be prohibitively expensive to obtain and install on a short-term, temporary basis. This option is not explored further.

Water from Stave Lake is of much higher quality and could be treated using "package" treatment plants if necessary. Any use of Stave Lake water would require permission from BC Hydro as well as from the Regional Water Manager. Several options exist for delivering water from the Stave Lake system.

Options for securing emergency water supply from Stave Lake itself would require installing rented high-head turbine pumps near the Stave Falls Generating Station, taking advantage of the proximity of the Lower Mainland power grid. Water could be pumped up along Dewdney Trunk Road to meet the gravity mains from Cannell Lake where they cross Cardinal Street. The pumps in Stave Lake would have to raise the water about 120 m over a distance of about 4 km to this point.

At Cardinal Street, the water could be pumped up to Cannell Lake (another 80 m vertical) using either a 4 km long temporary pipe, or using one of the two existing mains (providing the two mains can be fully isolated between Cardinal Street and Cannell Lake). This would again utilize the existing treatment and distribution system to provide the service population with potable water at the tap, and would allow effective storage to attenuate peak demand rates.

Most of the cost associated with any Stave Lake to Cannell Lake pumping option is linked to the high pumping head. In total, the pumps at Stave Lake would need to raise the water about 200 vertical metres. Based on a required flow rate of 63 ML/day (730 L/s), representing 75% of estimated Stage 4 demand, Canadian Dewatering provided an order-of-magnitude cost estimate of between $2,000,000 and $3,000,000. The cost would be proportionally reduced for the substantially lower demand that would likely be associated with such a severe drought.

Alternatively, it may be desirable to investigate the costs of installing a temporary disinfection system at Cardinal Street, and pumping the water from Stave Lake directly into the system at this point. This would reduce the total pumping head by over 80 m, and the upstream transmission distance by 4 km. Either of these options are assumed to provide sufficient head for the distribution system.

Further consideration could also be given to obtaining water from BC Hydro's Hayward Lake reservoir. Water would need to be piped about 12 km along Hayward Street and Lougheed Highway, and could tie in to the existing distribution main near the Mission Bridge. This option would only require pumping to feed and pressurize the pipeline; therefore, pumping costs are expected to be at least an order of magnitude less than pumping water from Stave Lake. This option would also not affect BC Hydro generation at Stave Falls; however, co-ordination with BC Hydro would be necessary as Hayward Reservoir is bracketed by generation facilities.

For the Hayward Lake reservoir option, the tie-in to the distribution system would require engineering design and additional pump facilities (either at Lougheed Highway or Hayward Lake) to ensure adequate distribution pressures. This option would also require a temporary disinfection system, likely either chlorination at the pump platform, or UV disinfection and residual chlorination just before entering system. If further study were to conclude that the system tie-in and temporary disinfection could be easily implemented, this would be the recommended option for securing water supply in an emergency situation.

A further option involves obtaining water from the Harrison River. The water would have to be piped approximately 16 km along the Lougheed Highway or the CPR right-of-way to meet the existing Bell Road main from Norrish Creek near Dewdney. Water from the Harrison River could be of lower quality than water from Stave Lake or Hayward Lake in drought conditions. However, if a supply is available and does not require filtration, this option would be superior to pumping from Stave Lake, and comparable to pumping from Hayward Lake. If further study concludes that water quantity and quality are sufficient, and that a system tie-in and temporary disinfection can be easily implemented, this option would likely prove superior to the Stave Lake option on the basis of cost.

FILTRATION REQUIREMENTS

All of the options above assume that filtration would not be required for water. If filtration is required, some options are:

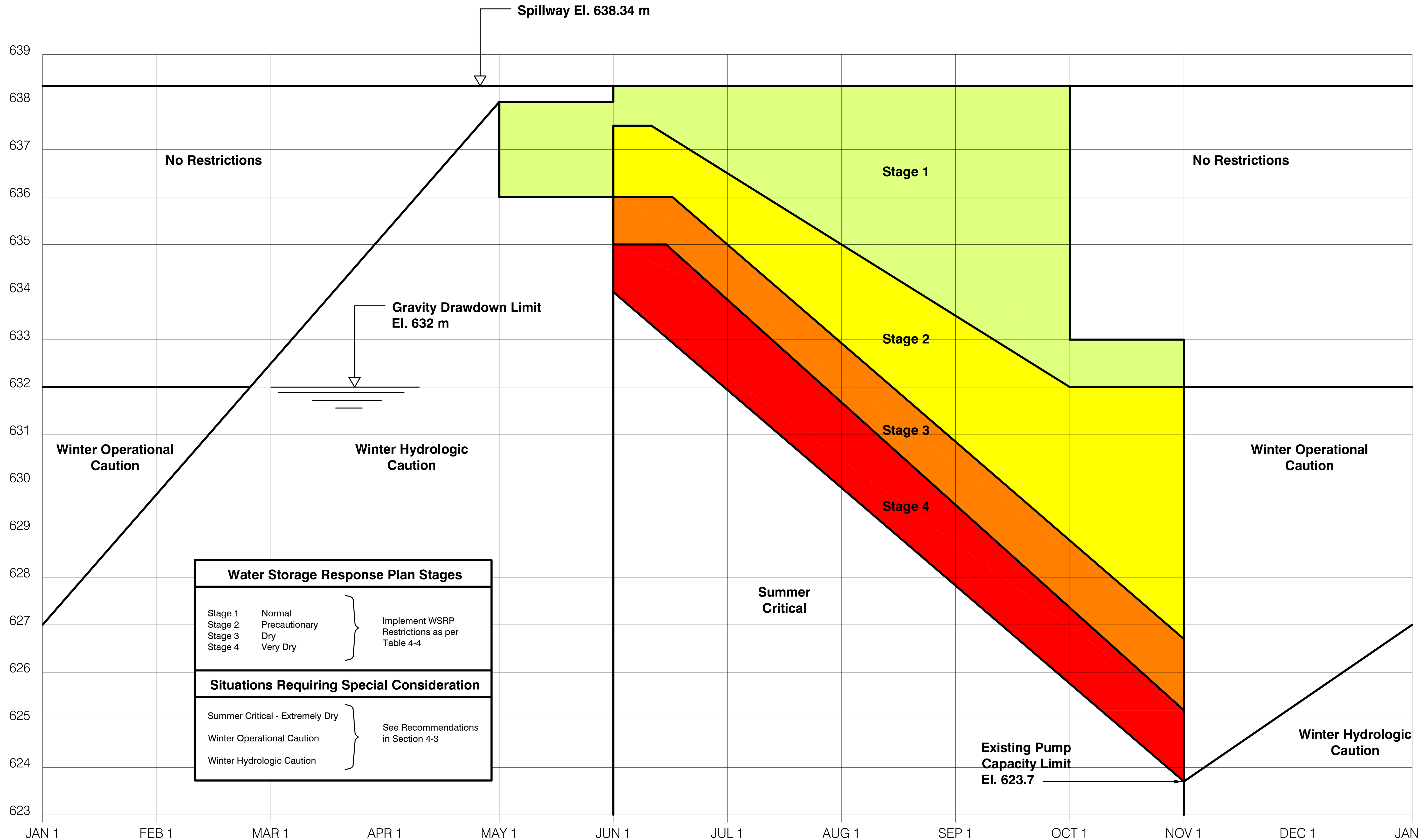
- install a large-scale filtration plant near Mission on a temporary basis;
- pre-emptively install permanent filtration at the Cannell Lake treatment plant and pump water from Stave Lake; or
- implement a small-scale "package" filtration plant to provide bottled water, and feed unfiltered water into the distribution system using one of the above options.

It may be possible to procure a temporary, large-scale filtration plant to filter water from Hayward Lake or the Harrison River. However, there would be very significant challenges. The availability of a system with sufficient capacity on short notice and for short-term use is highly questionable under normal circumstances. Availability would undoubtedly be reduced by increased demand in a severe drought situation. In light of these challenges, other filtration options should be explored.

There is currently no filtration capability at the Cannell Lake water treatment plant. If a filtration system were installed, it would require substantial excess capacity before it could supply regional demand under emergency conditions. The low-probability, short-term nature of the scenario under consideration would likely result in a disproportionately high cost/benefit ratio for a filtration system with emergency supply capacity.

If water from Stave Lake, Hayward Lake, or the Harrison River would require filtration, smaller-scale "package" plants could be used to provide bottled water while unfiltered (but possibly disinfected) water is pumped into the distribution system for non-potable use. BI PureWater provided a cost estimate of $65,000 for a gas-powered "package" water treatment system capable of treating 50 US gallons per minute at a turbidity between about 5 and 10 NTU. According to BI PureWater, these systems are generally not available for rent, and require three to six weeks lead time for purchase.

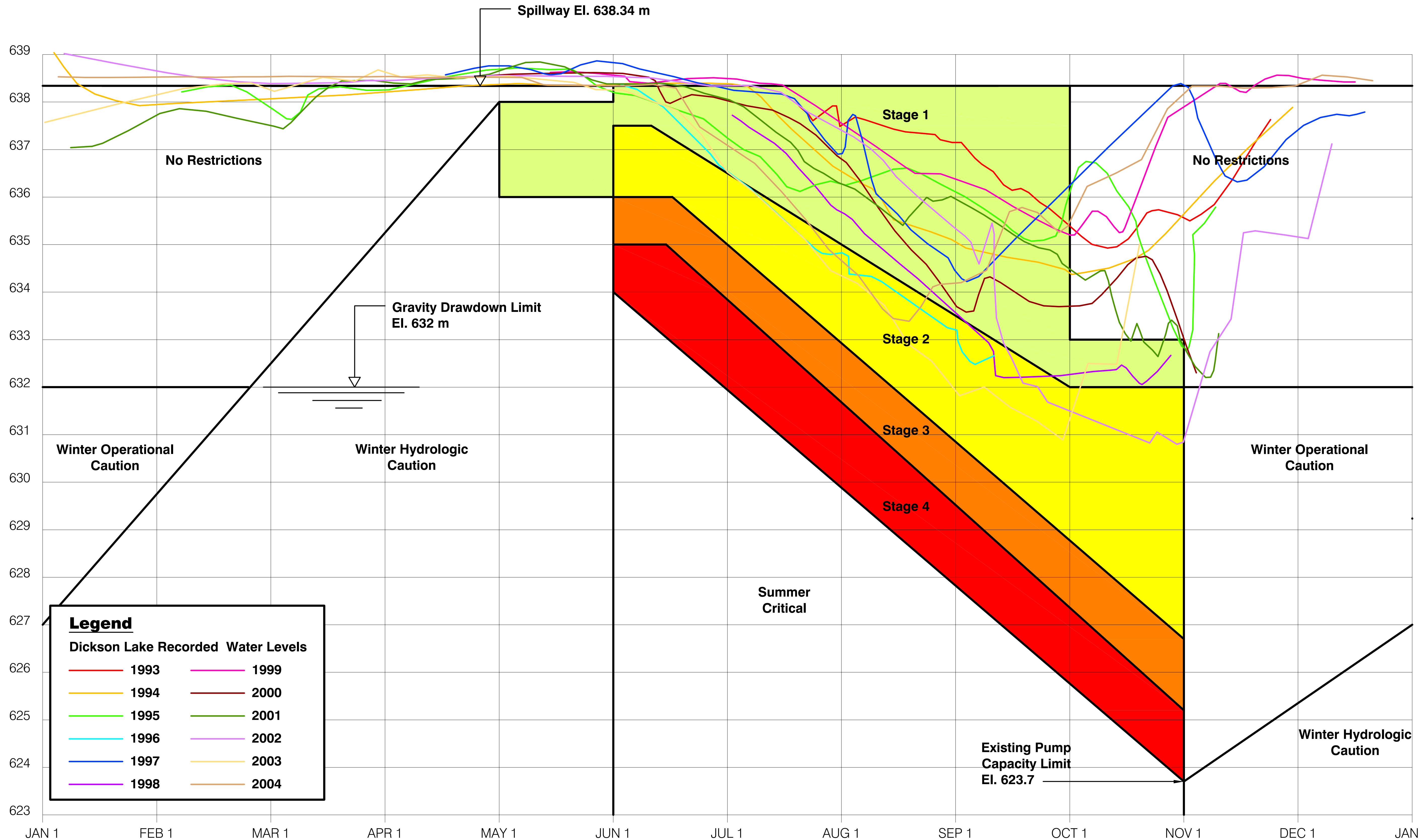
More than one emergency water treatment plant would be required to service a population of 142,200, as each plant would provide only about 1.9 L of potable water per capita per day. If untreated water was supplied to the system, the emergency water treatment plants could be located at any location on the distribution system that could supply the required 50 USgpm.



**Guideline for WSRP Designation
Based on Dickson Lake Level**

Figure 4-1

KERR WOOD LEIDAL associates limited CONSULTING ENGINEERS



Guideline for WSRP with Historic Dickson Lake Levels

Figure 4-2

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Section 5

Water Demand Trends

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5. WATER DEMAND TRENDS

5.1 INTRODUCTION

This section briefly reviews water demand trends for use in subsequent sections of the report. More detailed analyses can be found in the Central Fraser Valley Water Commission *Water Master Plan*, most recently updated in May 2003.

5.2 CITY OF ABBOTSFORD

SERVICE CONNECTIONS

Table 5-1 shows the number of dwelling units in the City of Abbotsford.

Table 5-1: Dwelling Units in the City of Abbotsford

Connection Type	2000	2001	2002	2003	2004
Single detached house	22,921	23,229	23,736	24,238	24,654
Apartment / detached duplex	324	326	326	331	331
Suite	3,088	3,198	3,308	3,410	3,539
Townhouse	5,899	5,899	6,011	6,095	6,115
Apartment	10,966	10,966	10,966	11,127	11,187
Mobile home	560	560	560	530	530
Totals	**43,758**	**44,178**	**44,907**	**45,731**	**46,356**
Census population	118,187	120,500	122,641	123,462	126,634
Average household size	2.70	2.73	2.73	2.70	2.73
Source: Housing data from City of Abbotsford Planning Department. Population data from BC Statistics.					

The number of service connections is summarized in Table 5-2.

Table 5-2: Service Connections in the City of Abbotsford

Type of Connection	Estimated Number
Residential	21,660
Industrial/Commercial/Institutional/Agricultural	2,500
Total	24,160

The numbers in Table 5-2 indicate a possible discrepancy in the City's records, since the number of residential meters is reported to be less than the number of single-family houses. However, this will not affect the conclusions of this overview report.

OVERALL WATER DEMAND

Aggregated water usage statistics for the City of Abbotsford are summarized for 2003 and 2004 in Table 5-3. Total water usage was derived from various sources as listed in the Source/Assumptions column. Note that ICI is the abbreviation for Industrial/Commercial/Institutional.

Table 5-3: Breakdown of Water Usage in the City of Abbotsford

Water Usage	2003	2004	Average	Source/Assumptions
Total Usage	19,875,020	20,503,851	20,189,435	2003 & 2004 CFVWSS spreadsheet from FVRD
Metered Usage	18,646,683	N/A		City of Abbotsford ArcView Zoning Queries
Outdoor	4,206,574	4,695,717	4,451,146	(water usage) – (average February month 2003 & 2004)*12
Metered ICI	4,521,906			City of Abbotsford ArcView Zoning Queries
- indoor ICI	3,564,839			Assume same indoor/outdoor split as overall metered
- outdoor ICI	957,067			
Metered Agricultural	3,312,210			City of Abbotsford ArcView Zoning Queries
Metered Residential	10,812,567			City of Abbotsford ArcView Zoning Queries
- indoor residential	8,433,802			Assume same indoor/outdoor split as overall metered
- outdoor residential	2,378,765			
Unmetered usage	1,228,337			(water usage) – (metered usage)
- as percent	6%			
Service Population	110,962	114,134	112,548	Excludes 10,000 in the Clearbrook Water District and 2,500 in other areas that have other water supply.
Per capita residential usage (litres/person/day)	297			
- Per capita indoor residential	208			Assume same indoor/outdoor split as overall metered

Note: Numbers are cubic metres per year unless noted otherwise.
ICI refers to Industrial/Commercial/Institutional.

PEAK-DAY DEMAND

The 2003 & 2004 CFVWSS spreadsheet that was provided for this study indicates peak days as shown in Table 5-4.

Table 5-4: Peak-Day Demands in the City of Abbotsford

Year	Date	Total Usage for Day (m^3)
2003	Monday, July 28	91,110
2004	Sunday, August 14	100,420

Of interest, the peak day in 2003 was on a non-sprinkling day.

OTHER USAGE

The 'unmetered' usage is calculated to be 6%, which is considered low by industry standards. Unaccounted-for water usage of 10% is often considered acceptable (although no code or standard sets that target) and many jurisdictions have much higher percentages, or simply do not measure it.

5.3 DISTRICT OF MISSION

SERVICE CONNECTIONS

Table 5-5 shows the overall number of dwelling units in the District of Mission.

Table 5-5: Housing Statistics for the District of Mission

Connection Type	2000	2001	2002	2003	2004
Single detached house	7,856	7,935	8,054	8,215	8,420
Semi-detached	208	210	213	217	223
Townhouse	460	465	472	481	493
Apartment / detached duplex	921	930	944	963	987
Apartment	1,054	1,065	1,081	1,103	1,130
Mobile home	79	80	81	83	85
Other single attached homes	25	25	25	26	27
Totals	**10,603**	**10,710**	**10,871**	**11,088**	**11,365**
Census population	32,403	32,638	32,865	33,297	33,970
Average household size	3.06	3.05	3.02	3.00	3.00
Source: District of Mission website and B.C. Stats.					

Table 5-6 summarizes the current number of service connections on the municipal water system.

Table 5-6: Service Connections in the District of Mission

Type of Connection	Estimated Number
Single-Family Residential Units	8,471
Multi-Family Residential Units, including townhouses, mobile homes and duplex/fourplexes	1,847
Industrial/Commercial/Institutional	264
Total	10,582

OVERALL WATER DEMAND

Aggregated water usage statistics for the District of Mission are summarized for 2003 and 2004 in Table 5-7. Total water usage was derived from various sources as listed in the Source/Assumptions column.

Table 5-7: Breakdown of Water Usage in the District of Mission

Water Usage	2003	2004	Average	Source/Assumptions
Total Usage	6,334,948	6,897,500	6,616,224	2003 & 2004 CFVWSS spreadsheet from FVRD
Metered Usage	1,440,000	1,520,000	1,480,000	Provided by District of Mission
Outdoor	1,324,823	1,881,985	1,603,404	Water usage - (average February month 2003 & 2004)*12
ICI/Agricultural	1,440,000	1,520,000	1,480,000	Provided by District of Mission
- ICI/agricultural indoor	1,091,024	1,151,637	1,121,330	Assume same indoor/outdoor split as overall metered
- ICI/agricultural outdoor	348,976	368,363	358,670	
Unaccounted-for Water	1,580,000	1,720,000	1,650,000	UFW is unknown. Values are back-calculated assuming per-capita residential usage is approximately 30% higher than in Abbotsford.
Residential	3,314,948	3,657,500	3,486,224	(total) – (ICI + UFW)
- indoor residential	2,511,589	2,771,126	2,641,358	Assume same indoor/outdoor split as overall metered
- outdoor residential	803,359	886,374	844,866	
Service Population	24,147	26,249		Approximately 3,000 homes are on their own well supply
Per Capita Water Usage (L/c/d)	376	382	379	
- Per Capita Indoor Residential (L/c/d)	285	289	287	Assume same indoor/outdoor split as overall metered
Note: Numbers are cubic metres per year unless noted otherwise.				

Assuming that unmetered usage comprises residential usage, leakage and other unaccounted-for water usage, the given statistics suggest that leakage/UFW is much higher in Mission than in Abbotsford, likely over 25%[1]. This could be quantified by further analysis, but an implied conclusion is that accelerated leak detection should be considered.

PEAK-DAY DEMAND

The 2003 & 2004 CFVWSS spreadsheet that was provided for this study indicates peak days as shown in Table 5-8.

Table 5-8: Peak-Day Demands in the District of Mission

Year	Date	Total Usage for Day (m^3)
2003	Thursday, August 21	31,350
2004	Wednesday, August 18	33,400

[1] As indicated in Table 5-7, this is if residual water usage is 30% higher than in Abbotsford; if this were not the case, the calculated HYFW would be even higher.

Section 6

Water Conservation Options

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6. WATER CONSERVATION OPTIONS

6.1 INTRODUCTION

This section reviews the current situation with respect to water conservation in the study area, develops a 'menu' of water conservation or demand management programs, and recommends possible strategies to achieve a 10% to 20% reduction in water usage.

Water demand management is any incentive or measure designed to reduce the volume of water being withdrawn, but without reducing consumer satisfaction or output. The 2003 Water Master Plan (Section 4) discusses demand management in general terms, and lists a number of potential water conservation initiatives that could be considered:

Residential

- Retrofit kits
- Low-flush toilet rebates
- Low-flow fixture bylaw
- Irrigation audits
- Rain barrel program
- Landscaping/xeriscaping

Commercial/Institutional

- Process water audits
- Landscape water audits
- Landscape bylaws

Other

- Leak reduction
- Education
- Metering

The Water Master Plan, however, does not include goals for water conservation or budgets for water conservation programs.

6.2 OVERVIEW OF DEMAND MANAGEMENT

Water demand management is any incentive or measure designed to reduce the volume of water being withdrawn - but without reducing consumer satisfaction or output. In this regard, clarifying the distinction between conservation *incentives* and *measures* is critical:

- incentives are used to increase customer awareness about the importance or value of reducing waste; and
- measures are the efficiency devices or practices that actually reduce demand.

Demand management is becoming increasingly important in B.C., because of increasing demands on water resources, increasing costs for water and wastewater treatment, and increasing environmental awareness.[2]

CONSERVATION INCENTIVES

In order to motivate customers to take specific actions to conserve water, conservation *incentives* must be established for every 'hardware' or behaviour-oriented measure. There are three types of conservation incentives: regulatory, financial, and educational, as shown in Table 6-1. One or several incentives must be integrated with each measure in order to gain customer participation in the conservation program.

Table 6-1: Examples of Conservation Incentives

Class of Incentive	Representative Examples
Educational	Bill-inserts, literature, school and public events, conferences, newsletters, workshops, training, paid TV and radio advertisements
Financial	Metering combined with conservation-pricing rate structures, rebates, credits, conservation incentive or surcharge fees, cost-sharing, loans
Regulatory	Efficiency laws and codes for plumbing fixtures and appliances, outdoor water waste bylaws, irrigation scheduling (odd-even, time of day, etc.), builder water-demand offset requirements, utility unaccounted-for-water standards.
Table 6-1 and Table 6-2 are adapted from Vickers, Amy, "What Makes a True Conservation Measure?" Opflow, American Water Works Association, Vol. 22, No. 6 (June 1996).	

Educational incentives by themselves may exert only short-term influence on customer behaviour because they are easily forgotten. They must continue for a long time, and be coupled to hardware/technology programs.

Conversely, *financial* and *regulatory* incentives can be more effective because they often involve adverse consequences if they are not heeded. For example, excessive-sprinkling bylaws can be strong inducements to reduce outdoor water waste. Similarly, metering and volume-based pricing, when properly designed, can reduce overall water usage.

[2] Parts of this section are adapted from Kerr Wood Leidal Associates Ltd. and Amy Vickers & Associates, Inc., 2001, *Development of Estimates for Water Conservation Potential Costs in the GVRD*), for the Greater Vancouver Regional District, February 2001.

CONSERVATION MEASURES

Once customers have been motivated to conserve water through the establishment of incentives, it is the adopted conservation *measures* that actually save water. The measures are the 'things' that directly reduce long-term water use. There are two general types of water-conservation measures, as shown for the major customer groups in Table 6-2, namely hardware/technology measures, and behaviour/management measures.

Table 6-2: Examples of Conservation Measures

Class of Customer	Representative Examples	
	Hardware/Technology	Behaviour/Management
Water Utility	Leakage detection and repair, hydrant capping, pressure reduction	Maintain and replace production and customer meters, service and adjust equipment and valves
Residential	Low-volume toilets, showerheads and faucets, efficient washing machines, dishwashers, leak repair, water audits	Wash full loads only; shut off unused faucets and hoses
Commercial, Industrial, Institutional	Recirculating cooling towers, process water reuse, efficient fixtures and appliances, waterless urinals, leak repair, water audits	Shut off unused valves, service and adjust equipment and valves, wash full loads only, meter large usages
Landscape	Native and drought-tolerant turf and plant species, drip irrigation, cisterns, hand watering, control valves, matched sprinkler heads, automatic shut-off hoses	Ground-sloping, irrigation scheduling (frequency and time of day)

Conservation hardware and technology measures can be very effective because they usually need to be installed only once, and do not require ongoing efforts to maintain efficient water use. In contrast, training people to change their household and yard irrigation practices can result in water savings, but typically requires ongoing public-relations efforts.

The following sections summarize the current situation in FVRD, document some relevant experiences with water conservation in other jurisdictions, and discuss the potential for various water conservation initiatives to reduce water use in FVRD.

6.3 EXISTING WATER CONSERVATION INITIATIVES

For this report KWL reviewed the following documents with respect to metering and water conservation:

- 2003 Update of Water Master Plan, May 2003 (Abbotsford and Mission);
- Consolidated Waterworks Rates and Regulations Bylaw, 2001 (Abbotsford);

- Water Bylaw No. 2196-1990 (Mission);
- Water Rates Bylaw No. 2197-1990 (Mission);
- 1994 Water Shortage Response Plan, January 1994; and
- Overview of Water Conservation / Demand Management, July 1994 (Dewdney-Alouette Regional District).

GENERAL COMMENTS

The older (1994) report prepared for the then Dewdney-Alouette Regional District recommended five actions:

1. that an inter-jurisdictional **water conservation committee** be set up;
2. that the Districts of Mission and Matsqui (the latter now part of the City of Abbotsford) review their water rate structures with a view to moving to **inclining-block rates**;
3. that Mission implement **universal metering**;
4. that Matsqui (Abbotsford) **increase the frequency of meter reading** from one to four times per year; and
5. that the largest commercial, industrial and agricultural users be identified and **water audits** conducted for possible savings in water demand.

To the best of KWL's knowledge, these recommendations have not been implemented, nor does the latest Water Master Plan include any specific programs for water conservation or demand management.

Rate structures are discussed in Section 8 of this report. Meter reading frequency for Abbotsford is discussed in Section 9. Metering for Mission is discussed in Section 10. This section of the report considers water conservation from a program perspective. It comments on metering and rates, but also includes a number of other measures that would be part of any water conservation plan that sets specific goals for demand reduction.

WATER RATES

Both the District of Mission and the City of Abbotsford use declining-block water rates for metered customers. In the City all customers are metered, while in the District only industrial, commercial and institutional (ICI) customers are metered (residential customers are billed on a flat rate).

The City of Abbotsford bills its customers by volume, which can encourage conservation. The declining-block rate for ICI customers, however, reduces the incentive for the sector to conserve water. Moreover, billing is done just once per year, with the property tax notices, which does not send a clear price signal that would encourage consumers to change their water use behaviour.

The District of Mission bills its metered customers quarterly, which is more likely to encourage conservation. As noted, however, only a minority of customers are metered, and the declining-block rate structure discourages conservation.

METERING

The North American water industry views metering primarily as a management tool that facilitates system optimization and equitable customer billing. In this regard, the long-standing policy of the American Water Works Association (a parent of the B.C. Water and Waste Association) is as follows:

> The American Water Works Association (AWWA) recommends that every water utility meter all water taken into its system and all water distributed from its system at its customer's point of service. AWWA also recommends that utilities conduct regular water audits to ensure accountability. Customers reselling utility water – such as apartment complexes, wholesalers, agencies, associations, or businesses – should be guided by principles that encourage accurate metering, consumer protection, and financial equity.
>
> Metering and water auditing provide an effective means of managing water system operations and essential data for system performance studies, facility planning, and the evaluation of conservation measures. Water audits evaluate the effectiveness of metering and meter reading systems, as well as billing, accounting, and loss control programs. Metering consumption of all water services provides a basis for assessing users equitably and encourages the efficient use of water.
>
> An effective metering program relies upon periodic performance testing, repair, and maintenance of all meters. Accurate metering and water auditing ensure an equitable recovery of revenue based on level of service and wise use of available water resources.
>
> Source: www.awwa.org/About/OandC/officialdocs/AWWASTAT.cfm

The policy of the Canadian Water and Wastewater Association uses similar language:

> It is the position of the Canadian Water and Wastewater Association that:
>
> - all water utilities be encouraged to implement universal metering programs;
> - the full costs of water and wastewater systems should be recovered through properly structured user charges;
> - the costs of source water protection programs (such as watershed and aquifer recharge area management programs) should be included in the recoverable costs;
> - rate-setting should make use of a long-term planning horizon to take into account reasonable future planning and costs based on realistic capital plans;
> - municipalities should aim to achieve the desired degree of water servicing at the least cost;
> - customers should pay for water servicing in proportion to their usage of the system; and
> - metering is an essential step in controlling water and wastewater treatment demands and applying volumetric user charges, and thus municipalities should implement universal metering.
>
> Source: www.cwwa.ca/policy

The City of Abbotsford is one of the Lower Mainland jurisdictions that requires every water service to be metered. Others include the District of Chilliwack, the City of Langley, and the City of White Rock (served by a private water utility). The District of West Vancouver initiated a universal metering program in 2004 using radio-read technology.

The District of Mission meters only industrial, commercial and institutional (ICI) customers.

WATER SHORTAGE RESPONSE PLAN

The WSRP is discussed in Section 4.3.

6.4 POTENTIAL WATER CONSERVATION PROGRAMS

The Commission wishes to consider the potential costs and benefits of implementing water conservation programs, with the goal of reducing demand by 10 to 20%. Developing a comprehensive water conservation plan can be a major undertaking in itself, as described in AWWA's forthcoming Manual M52, Wat*er Conservation Programs – A Planning Manual*. Such a plan would identify the most appropriate conservation measures based on consideration of existing customer water-use characteristics and efficiencies, as well as the experience of other utilities with similar programs. For comprehensiveness, every major type of water-using activity and equipment should be considered for evaluation of potential water savings in each customer group to which they could apply. In addition, the long-term reliability of potential water savings and customer acceptance of potential measures should be evaluated.

This report provides an overview-level assessment of programs, participation ratios, savings and costs, in order to indicate potential directions for the Commission. Each program is based on a conservation measure, combined with one or more regulatory, financial, and/or educational incentives. A range of potential water savings was estimated for each program based on results obtained from similar programs implemented by other water utilities. Capital and operating costs were also estimated for each program.[3]

1. HOME WATER AUDIT & RETROFIT

Description: This measure would target residential water users and offer to provide a free indoor water audit. The auditor would check the water usage by toilets, showerheads and faucets, and install retrofit devices such as toilet displacement bags or diverters, low-

[3] The program descriptions in this section are partly based on the report "Estimates for Water Conservation Potential Costs in the GVRD", completed by Kerr Wood Leidal Associates Ltd. and Amy Vickers Associates, Inc., February 2001.

volume showerheads, and faucet aerators. Toilet leaks would be repaired, and other household leaks would be identified (hose connections, faucets, and other).

This measure could save approximately 15-45 L/c/d in homes that have leakage repair work completed and retrofit devices installed.

References: Home Water Audit.[4]

2. LOW-VOLUME TOILET AND WATERLESS URINAL REBATE

Description: This measure involves the installation of toilets that use a maximum of 6 litres per flush (LPF) to replace existing high-volume (13.5-20 LPF) fixtures. This measure also includes the installation of waterless urinals in non-residential settings such as offices, schools and businesses. Estimated water savings average about 7.5 LPF for toilets and about 4 LPF for urinals.

Toilets that use 6 LPF or less are now standard in many parts of the world (see below). Waterless urinals are also becoming more common in Europe and North America, including BC. They are nearly identical to flush urinals except that they use a vegetable oil seal trap at the drain. KWL has been using dual-flush toilets and waterless urinals in its Burnaby head office since April 2004.

This measure assumes that a financial incentive, typically $100-250, would be offered to customers (both residential and non-residential) who replace their existing fixtures with low-volume replacements. This measure would accelerate water savings from low-volume fixtures over a short-term period (about 10 years), but these same water savings would be achieved automatically over a long-term (about 20 years) period.

The success of rebate programs is highly dependent on how well they are designed (amount of rebate, customer perception of need to conserve, ease of program participation) and marketed to consumers. New York City's toilet rebate program has resulted in over 1 million 6-LPF toilet installations and has contributed to that city's 20% demand reductions since the early 1990s (along with more aggressive leak reduction and universal metering). Other systems have not had such significant results. As an example, the City of Victoria has had an ongoing toilet rebate program since 1993. That program reportedly has experienced low participation rates because of the relatively small rebate available ($50-$100) and the low residential water rates.

Documented Examples: Waterless urinals are used increasingly in Germany and other locations and several U.S. and Canadian utilities such as Seattle and Victoria have sponsored demonstration and rebate programs to encourage their use.

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[4] Cover, Trish Johnson, and Rose, Tammy, "Water Audits and Water use Analysis in The Regional Municipality of Ottawa-Carleton," *Proceedings of the Annual Conference of the American Water Works Association*, Toronto, Ont, June 1996.

References: Low-Volume Toilet and Waterless Urinal Rebate.[5, 6, 7, 8, 9]

3. CLOTHES WASHER REBATE

Description: This measure involves the installation of high-efficiency (including horizontal-axis) clothes washing machines that use about 90-125 litres per load, as compared to the 150-190 litres that conventional washers require. Estimated average water savings range from 25-35% (about 37-52 litres per day per household or 14-20 L/c/d) of prior water use for conventional clothes washers.

Rebates of $250-600 for residential customers and $300-700 for non-residential customers would be offered as incentive to purchase and install the more efficient washers.

Documented Examples: Austin, TX; Bern, Switzerland.

References: Clothes-washer Rebate.[10, 11, 12]

4. LOW-FLOW TOILET BYLAWS (6 LPF TOILETS)

Description: This measure would update the water bylaws in the service area to require that all newly installed toilets use no more than 6 LPF. The current code allows 13.5 LPF, and therefore changing the plumbing code to require water-efficient toilets would save at least 7.5 LPF. Since the average number of flushes per person per day is 5 in the typical home, at least 35 L/c/d could be saved.

Note that changes to the plumbing code to address water-use efficiency are currently under study. However, the use of toilets that use no more than 6 LPF is likely to become widespread since they are required by law in the USA.

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[5] Berry, Trent, MRM, Compass Resource Management Group, The Role of Demand-Side Management in Managing Greater Victoria's Water Supply: Needs Assessment and Evaluation, September 24, 1996.

[6] Behling, Patrick J., and Bartilucci, Nicholas J., "Potential Impact of Water-Efficient Plumbing Fixtures on Office Water Consumption," Journal AWWA, October 1992.

[7] Evaluation of New York City's Toilet Rebate Program: Customer Satisfaction Survey Final Report, prepared by Westat, Inc. (Rockville, MD) for the New York City Department of Environmental Protection, December 16, 1996.

[8] California Urban Water Conservation Council, The CII ULFT Savings Study: Final Report, prepared by Hagler Bailly Services, Inc., (San Francisco, Calif.), August 5, 1997.

[9] Chesnutt, Thomas W., McSpadden, Casey N., and Bamezai, Anil, Ultra Low Flush Toilet Programs: Evaluation of Program Outcomes and Water Savings, prepared for the Metropolitan Water District of Southern Califnornia, Los Angeles, November 1994.

[10] Edgemon, S.D., Gregg, T.T., and Baechler, M.C., *ENERGY STAR® Partnerships Clothes Washer Volume Purchase: Partnering with the City of Austin,* presented at the Annual Conference of the American Water Works Association, Dallas, Texas, June 23, 1998.

[11] Tomlinson, J.J., and Rizy, D.T., *Bern Clothes Washer Study Final Report*, prepared by the Energy Division, Oak Ridge National Laboratory, for the U.S. Department of Energy, Report No. ORNL/M-6382, March 1998, p. ix.

[12] "Spin city: ratings of washing machines and clothes dryers," *Consumer Reports*, July 1998, vol. 64, No. 7.

Documented Examples: Plumbing codes and national standards that specify 6 LPF toilets are now required in the U.S., Scandinavia, Japan, the Far East, and elsewhere. Savings in the above-noted range have been documented in Seattle and many other jurisdictions.

References: Plumbing Code Revision.[13, 14]

5. LANDSCAPE & IRRIGATION AUDIT & RETROFIT

Description: This measure would target large users of outdoor water. A trained irrigation auditor would evaluate the water use efficiency of customer irrigation systems for correctable problems such as broken sprinkler heads, leaks, poorly designed zones, irrigation scheduling, and irrigation controller programming errors. The landscape would also be evaluated for opportunities to reduce or replace turf areas with drought-tolerant turf and native groundcovers.

The auditor would install rain-sensor devices on automatic irrigation systems to turn off sprinkling systems during and after rain events. Customers with manual hoses would also be provided with and educated about automatic shut-off nozzles. Information to be provided to the customer would include guidance about efficient irrigation systems (e.g., cisterns and drip for shrubs and gardens), the use of native and adaptive low-water turf and plant species, minimizing turf area, advice on regular (weekly or monthly) controller programming, and site-specific advice on the frequency and duration of irrigation runs.

Estimated water savings average 5-20% of outdoor water use for all customers (both residential and ICI) that implement measures suggested by the auditor.

Documented Examples: Johnson County, KS; Seattle, WA.

References: Irrigation Audit.[15, 16, 17]

6. RAIN BARREL REBATE

Description: This measure involves the installation of rainwater collection barrels and cisterns for non-potable water use purposes such as landscape irrigation and vehicle

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[13] Vickers, Amy, "Legislation/Regulation: Implementing The Energy Policy Act," *Journal American Water Works Association,* Vol. 88, No. 1 (January 1996): 18-20, 112.

[14] "In search of a better toilet," *Consumer Reports*, May 1998: 44-46.

[15] Vickers, Amy, and Scott, Nancy. "Residential Landscape Irrigation Characteristics and Conservation Program Needs in Johnson County, KS," *Proceedings of Conserv96,* American Water Works Association, Orlando, Florida, January 4-8, 1996.

[16] Brauen, S., and Stahnke, G., *Principles of Turfgrass Management: Water Use and the Healthy Lawn*, produced by the Seattle Water Department, the Everett Public Works Department, and the Tacoma City Water, undated.

[17] Vickers, Amy, "Handbook of Water Use and Conservation", WaterPlow Press, Amherst, MA, 2001.

washing. Estimated average water savings in outdoor use for this measure are 5-10%. This measure would provide rebates to customers who install permanent rainwater cisterns. The rebate or bill credit would be about $50 for residential properties and $150-300 for non-residential users.

In addition to saving water for landscape irrigation, rain barrels and cistern systems can help with stormwater retention by spreading out the release of rainfall to stormwater management systems. To this end, they should be connected to household roof-leaders.

Documented Examples: Cisterns and rain catchment systems are being used increasingly. Vancouver, Toronto and Edmonton, for example, have rain barrel programs, and many catchment systems have been installed in Texas and other southwest states in recent years.

References: Cistern Rebate.[18, 19]

7. EFFICIENT IRRIGATION REBATE

Description: This measure would target high outdoor water usage by upgrading existing or installing new irrigation systems to be more water-efficient. Measures include the installation of drip systems, hose-leak repair, and replacement of broken spray heads. Estimated water savings average 20-50% of outdoor water use.

This measure would offer rebates to customers who make improvements to their irrigation systems in accordance with efficiency standards. Rebates up to $500 would be offered to eligible residential customers and up to $1,000 for non-residential customers. This measure would also offer rebates to customers who make efficiency improvements to their manual irrigation systems.

Documented Examples: Austin, TX; Albuquerque, NM.

References: Efficient Irrigation Rebate.[20]

8. EFFICIENT LANDSCAPE REBATE

Description: This measure would facilitate the upgrading and installation of existing turf and landscape plants to be more water-efficient, such as by the replacement of irrigated turf with low-water-use groundcovers and/or decorative material. The goals would be to

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[18] *Texas Guide To Rainwater Harvesting*, Texas Water Development Board, in cooperation with the Center for Maximum Potential Building Systems, Austin, Texas, 1997.

[19] Grice, S. L., *The City of Toronto Trial Rain Barrel Installation Programme*, presented at the American Water Works Association Annual Conference, Toronto, Ont., June 1996.

[20] Fuller, F., Gregg, T., and Curry, J., “Austin’s Xeriscape It! Replaces Thirsty Landscapes,” *Opflow*, American Water Works Association, December 1995.

minimize irrigated turf and plant areas and to encourage the installation of native and water-efficient plant replacements.

Estimated water savings from improved landscape watering efficiencies could average 15-40% of outdoor water use for program participants. Rebates would be offered to customers who make improvements to their irrigation systems in accordance with efficiency standards. Rebates up to $350 would be offered to eligible residential customers, and up to $750 for non-residential customers.

These goals must be achieved without increasing net impervious area. Note that this measure potentially could conflict with other objectives such as air quality, environment, fisheries, and water quality.

Documented Examples: Austin, TX; Albuquerque, NM.

References: Efficient Landscape Rebate.[21]

9. ICI AUDITS

Description: This measure was recommended in the 1994 DARD plan. It would target the top 25% of ICI and agricultural customers and offer to provide on-site water audits. The water savings from this measure could be 10-50% of indoor ICI water use for customers that adopt recommended measures.

An audit involves the evaluation of onsite water use efficiency, particularly that related to water process systems, cooling equipment, maintenance practices, leakage, and other water-using activities. The auditor typically develops a 'water balance' for the facility that estimates all of the end uses of water at the site. Each end use is scrutinized for opportunities to increase efficiency. Specific measures to reduce water use will be identified, such as the installation of recirculating cooling systems, reuse of rinse water for non-potable use activities, leakage reduction, the installation of water-efficient fixtures and appliances, and other appropriate measures.

It should be noted that, particularly for ICI customers, it could be possible to implement a contractor-based audit program along the lines of the B.C. Hydro PowerSmart program in order to reduce program costs.

Documented Examples: Island Farms Dairies, Victoria, B.C.; Centres for Disease Control, Vancouver, B.C.; Pacific Coast Terminals Co. Ltd., Port Moody, B.C.

References: ICI Audits.[22]

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[21] Fuller, F., Gregg, T., and Curry, J., "Austin's Xeriscape It! Replaces Thirsty Landscapes," *Opflow*, American Water Works Association, December 1995.

10. WATER WASTE BYLAWS

Description: This measure would establish bylaws to prohibit or reduce wasteful indoor and (primarily) outdoor water use. The following is a list of components that could be included:

- Prohibit irrigation sprinkler runoff to sidewalks, curbs, and streets.
- Require automatic rain shutoff valves on all automatic irrigation systems with controllers.
- Require all manual hand-held hoses to have automatic shutoff valves.
- Specify limits to irrigated areas; require native plants and ground covers for all non-turf areas, but without increasing net impervious area.
- Require all renovated and new properties to meet water efficiency standards for landscaping.
- Require all renovated and new properties to meet water efficiency standards for irrigation.
- Limit irrigation sprinkler run times and the number of days per week that sprinkling is allowed.
- Require car-washes to use recirculating water only for all but the final rinse (self-service car-wash operations may be exempt).
- Require newly installed water-cooled cooling systems, x-ray and photo-processing machines, icemakers, and dental office vacuum pumps to use recirculated non-contact cooling water.
- Limit the slopes of irrigated areas, and require terracing for steep slopes.

It is emphasized that all of the foregoing components have been proven in other jurisdictions. Not all may be applicable to the study area, but there may be additional ones that are. Note that turfed areas should have a minimum of 100-150 mm of topsoil in order to meet permeable-area requirements related to stormwater quantity.

Documented Examples: The City of Seattle has implemented a water waste ordinance that incorporated some of the listed elements.

References: Water Waste Ordinance.[23, 24, 25]

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[22] Sweeten, J.G., and Chaput, B., *Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector*, presented at the Annual Conference of the American Water Works Association, Atlanta, GA, June 1997.

[23] The Bruce Company, *Final Draft: Local Ordinances For Water Efficiency,* prepared for the U.S. Environmental Protection Agency, Office of Policy Analysis, EPA Contract #68-W2-0018, Subcontract #EPA 353-2, Work Assignment 24, March 31, 1993.

[24] City of Austin, Texas, City Code Article II. Emergency and Peak Day Water Use Management (81' Code, § 4-4-21) (Ord. 860703-K; Am. Ord. 970604-A), 1997.

[25] Vickers, Amy, "Handbook of Water Use and Conservation", WaterPlow Press, Amherst, MA, 2001.

11. UNACCOUNTED-FOR WATER REDUCTION

Description: This measure would promote increased water use efficiency within water system infrastructure with the goal of reducing water lost to leakage and unmeasured usage. Accelerated leak-detection activities would be instituted to establish annual system surveys, and all leaks would be repaired within 30 days.

Statistics provided by the City of Abbotsford indicate that unmetered water usage is 6% of overall usage, which is considered relatively low. No figures are available from the District of Mission; a value of 15% has been used for evaluation purposes.

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

Unaccounted-for water exists in every system; this 'lost water' represents an untapped source of under-utilized water supply and revenues that are being wasted. For water systems with above-normal (15%) UFW, fixing leaks and minimizing unmeasured water use can typically boost available water supplies and revenues, sometimes significantly.

Documented Examples: Boston, MA; New York City; Singapore; Resort Municipal of Whistler.

References: Unaccounted-for Water Reduction.[26, 27, 28, 29]

[26] Smith, James B. and Vickers, Amy, "Unaccounted-For Water: Costs and Benefits of Water Loss and Revenue Recovery in Four Vermont Municipal Water Systems," *Proceedings of Conserv 99*, American Water Works Association, Monterey, California, January 31- February 3, 1999.

[27] U.S. Environmental Protection Agency, *Water Conservation Plan Guidelines*, Office of Water, Washington, D.C., Document No. EPA-832-D-98-001, August 1998.

[28] AWWA Leak Detection and Water Accountability Committee, "Committee Report: Water Accountability," *Journal AWWA*, Vol.88, No. 7 (July 1996): 108-111.

[29] Yepes, Guillermo, *Reduction of Unaccounted for Water – the Job Can Be Done!* World Bank Best Practices Series, Water and Sanitation Division, The World Bank, Washington DC, 1995.

12. PUBLIC EDUCATION

Description: Informing and educating the public are key steps to raising awareness about the need for conservation and, ultimately, getting people, businesses, and governments to install practical measures that will result in permanent water savings.

Public education 'tools' include:

- easy-to-understand water bills that show recent and historical customer consumption patterns;
- conservation program literature (mailed separately from the water bills);
- local workshops designed for specific water users who are targeted for program participation;
- citizen advisory committees; and
- news media (newspapers, magazines, television, radio).

To realize long-term savings, public education materials and strategies should always be geared toward motivating water users to participate in specific conservation programs (e.g., home water audits, clothes-washer rebates, ICI audits, adherence to conservation ordinances, etc.) or adopt specific water-use practices. The benefits of educational measures *alone* are likely to be short-lived.

References: Public Education.[30, 31]

13. UNIVERSAL METERING AND VOLUME-BASED PRICING

Universal metering is primarily a management tool that facilitates system optimization and equitable revenue-generation. Combined with appropriate rate structures, metering can also be a conservation tool to establish pricing incentives to conserve water, provided the proper price signals are communicated to the customers.

Many studies point out that water consumption is higher in unmetered than metered communities. This fact is not generally indicative of wasteful usage by unmetered customers (except as noted below) but rather better overall management by metered communities. A recent GVRD study of water usage in unmetered houses in showed usage within the ranges typically seen for metered homes. The indoor water usage of 265 L/person/day (750 L/household/day) is similar to that found by many studies of metered homes. This applies to standard homes with typical plumbing fixtures.

There is a natural inclination to assume that the lack of water metering and consumption-based billing might cause households to increase their water use. The indoor water use

[30] Baumann, Duane D., Boland, John J., and Hanemann, Michael W., *Urban Water Demand Management and Planning* (New York: McGraw Hill, 1998).

[31] U.S. Environmental Protection Agency, *Water Conservation Plan Guidelines*, Office of Water, Washington, D.C., Document No. EPA-832-D-98-001, August 1998.

recorded in the GVRD study does not support this theory. The fact that the indoor usage was typical of homes that are billed from metered consumption data implies that normal indoor usage is not affected by billing. It is likely, however, that a small minority of homes have extremely high consumption (letting hoses run; allowing leaks to go un-repaired) that the average consumption is affected. Of the 36 homes studied, approximately 40% of the outdoor water usage came from *one* home. Another (confidential) report for a municipality in the GVRD indicates that the top 10% of single-family houses account for 41% of the demand.

It is very reasonable to expect a reduction in demand from the implementation of universal metering but it is difficult to quantify the savings that are attributable to metering alone, as opposed to the other components of a water conservation plan. Based on experience and judgement, savings of 6-12% of total residential demand in Mission have been assumed in estimates of potential water savings from universal metering (combined with an appropriate rate structure). This relatively low range will prevent 'double-counting' and consequent over-estimation of savings.

Other jurisdictions such as Kelowna have reported savings in the 20-percent range, but its circumstances are somewhat different from the GVRD's, due to their drier climate, demographics, and inclusion of other conservation measures.

References: Universal Metering. [32, 33, 34, 35]

14. SEASONAL PRICING (SUMMER SURCHARGE)

Description: This measure would establish a seasonal water rate structure for metered customers to serve as an incentive to reduce (mainly) outdoor water use. Obviously, its impact would be greatly enhanced by universal metering.

For water systems such as the Commission that have significant fluctuations in demand during the year, specifically the summer months when outdoor water use increases, seasonal rates and surcharges can send a message to customers that excessive use costs money. Peak demands are typically created through lawn sprinkling, irrigation, and seasonal industrial operations such as cooling, bottling, canning, fishing, etc. The objective of seasonal rates and surcharges is to encourage more efficient customer water use by shifting demand from peak periods to off-peak periods. If demand is to continue

[32] "Data Collection – Single-Family Indoor and Outdoor Water Use", completed by Kerr Wood Leidal Associates Ltd. and Aquacraft Inc. for the GVRD, January 2005.

[33] Kerr Wood Leidal Gore & Storrie Inc., *GVWD Summary Report on Residential Water Metering*, North Vancouver, B.C., August 1996.

[34] Baumann, Duane, D., Boland, John, J., and Hanemann, Michael, W., *Urban Water Demand Management and Planning* (New York: McGraw Hill, 1998).

[35] U.S. Environmental Protection Agency, *Water Conservation Plan Guidelines*, Office of Water, Washington, D.C., Document No. EPA-832-D-98-001, August 1998.

during peak periods with seasonal rates, customers will pay for the cost of oversized facilities and related operating costs during the peak season.

The GVRD has studied seasonal rate structures in the past, and it was estimated that commercial (i.e. metered) usage could be reduced by 8% if such rates structures were introduced. Single-family residential usage would not be affected in the present unmetered environment (Mission), but could be reduced by up to 13% if full retail metering were implemented.

The timing and format of water bills is important. In order to send the proper price signals, bills should be frequent enough that the effects of irrigation-season behaviour can be captured, and other charges such as sewage should not be included with water bills.

Documented Examples: Seattle, WA.

References: Conservation Pricing.[36, 37, 38]

6.5 POTENTIAL WATER SAVINGS

The estimated potential savings from each measure and for each jurisdiction are summarized in Table 6-3 and Table 6-4 at the end of this section. These tables include ranges for both the anticipated level of savings per customer or usage category, and also the anticipated levels of participation by customers. As discussed above, other DSM initiatives in addition to those listed should be considered in the development of a comprehensive water-efficiency plan.

If the listed initiatives were fully implemented, the City of Abbotsford and the District of Mission could potentially reduce their total average-day demands by between 6% and 34% and between 15% and 48%, respectively.

There are precedents for system-wide savings in these ranges, especially for systems that have high levels of UFW, and it is possible that future improvements to technology will raise those levels even higher. In any case, these estimates should be considered very approximate, and should be refined as better data and experience are accumulated. The calculated savings figures are subject to a number of assumptions as discussed in this report.

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[36] *Greater Vancouver Water District, Seasonal Water Rate Study*, Hilton Farnkopf & Hobson in association with Hagler Bailly Services, Inc, Boulder, Colorado, May 1998.

[37] Baumann, Duane, D., Boland, John, J., and Hanemann, Michael, W., *Urban Water Demand Management and Planning* (New York: McGraw Hill, 1998).

[38] U.S. Environmental Protection Agency, *Water Conservation Plan Guidelines*, Office of Water, Washington, D.C., Document No. EPA-832-D-98-001, August 1998.

6.6 SUMMARY AND SHORT-LISTING OF WATER CONSERVATION OPTIONS

The Water Master Plan includes no programs for water conservation or demand management. Previous recommendations made to DARD have not been implemented. The Commission and its member municipalities face rapid population growth that is stressing its water supplies and triggering the need for substantial capital investments – over $85 million in the next 16 years.

The tables indicate the programs that are recommended (last three columns). These include bylaws, audits, rebates, leakage reduction, metering and pricing measures:

- Low-Flow Toilet Bylaw
- Water Waste Bylaw
- Home Water Audits
- ICI Audits
- Low-Volume Toilet & Waterless Urinal Rebate
- Rain Barrel Rebate
- UFW Reductions
- Public Education
- Universal Metering & Volume-Based Pricing (Mission only)
- Seasonal Pricing (Abbotsford only)

Generally the programs are selected based on cost-effectiveness, that is, the unit cost of the savings are less than the current unit cost of supply ($0.56/m^3). Some programs that do not seem strictly cost-effective (such as public education) are recommended as well on the basis that they are best practices.

Metering may be implemented in Mission (refer to Section 10). Note that the table does not show any costs for metering. Metering should be considered a normal part of water system management and hence should not be assigned to the water conservation 'account'. As discussed elsewhere, the primary reasons for metering are improved system management and fairness in billing.

It is also recommended that an inter-jurisdictional water conservation committee be set up, in accordance with the 1994 report.

Table 6-3: Summary of Conservation Programs for Abbotsford

Conservation Program	Targeted Customers	Estimated Participation			Estimated Unit Savings				Target		Estimated Savings Range (m3/year)			Unit Costs				Estimated Program Costs: Program Unit	Total Number	Particip-ating (Average)	Total Cost (Average, Undiscounted)	Program Impl. Period (years)	Total Savings Over 20 Years (m3, Average)	Cost per Unit Savings ($/m3)	Recommended Plan: Program Included=1	Estimated Saving	Total Cost, Undiscounted
		Low	Avg	High	Low	Avg	High	Component	Value	Unit	Low	Avg	High	Low	Avg	High											
1. Home Water Audit & Retrofit	Res	5%	23%	40%	15	30	45	L/c/d	126,634	pop	34,666	433,326	831,985	$75	$113	$150	per audit	Households	46,400	10,440	$1,174,500	5	7,583,200	$0.15	1	433,326	$1,174,500
2. Low-Volume Toilet & Waterless Urinal Rebate	Res	5%	13%	20%	30	40	50	L/c/d	126,634	pop	69,332	265,773	462,214	$100	$175	$250	per toilet	Toilets	46,400	5,800	$1,015,000	10	3,986,597	$0.25	1	265,773	$1,015,000
	ICI	5%	13%	20%	2	6	10	% of indoor	3,524,965	m3/year	3,525	37,012	70,499	$100	$175	$250	per toilet	Toilets	5,000	625	$109,375	10	555,182	$0.20	1	37,012	$109,375
3. Clothes Washer Rebate	Res	5%	13%	20%	14	17	20	L/c/d	126,634	pop	32,803	108,844	184,886	$250	$425	$600	per washer	Washers	46,400	5,800	$2,465,000	10	1,632,663	$1.51		0	$0
4. Low-Flow Toilet Bylaw	Res	30%	55%	80%	30	40	50	L/c/d	126,634	pop	415,993	1,132,425	1,848,856	$0	$0	$0		Toilets	5,000	2,750	$0	20	11,324,245	$0.00	1	1,132,425	$0
	ICI	70%	83%	95%	2	4	6	% of indoor	3,524,965	m3/year	49,350	125,136	200,923	$0	$0	$0		Toilets	500	413	$0	20	1,251,363	$0.00	1	125,136	$0
5. Landscape & Irrigation Audit & Retrofit	Res	30%	45%	60%	5	10	15	% of outdoor	2,383,836	m3/year	35,758	125,151	214,545	$100	$175	$250	per audit	Households	24,700	11,115	$1,945,125	5	2,190,149	$0.89		0	$0
	ICI	30%	45%	60%	10	15	20	% of outdoor	996,940	m3/year	29,908	74,771	119,633	$500	$1,250	$2,000	per audit	Businesses	2,500	1,125	$1,406,250	5	1,308,484	$1.07		0	$0
6. Rain Barrel Rebate	Res	5%	13%	20%	5	8	10	% of outdoor	2,383,836	m3/year	5,960	26,818	47,677	$25	$50	$75	per home	Households	24,700	3,088	$154,375	10	402,272	$0.38	1	26,818	$154,375
	ICI	5%	13%	20%	5	8	10	% of outdoor	996,940	m3/year	2,492	11,216	19,939	$150	$225	$300	per business	Businesses	2,500	313	$70,313	10	168,234	$0.42	1	11,216	$70,313
7. Efficient Irrigation Rebate	Res	10%	18%	25%	20	35	50	% of outdoor	2,383,836	m3/year	47,677	172,828	297,980	$250	$375	$500	per home	Households	24,700	4,323	$1,620,938	10	2,592,422	$0.63		0	$0
	ICI	5%	10%	15%	20	35	50	% of outdoor	996,940	m3/year	9,969	42,370	74,771	$500	$750	$1,000	per business	Businesses	2,500	250	$187,500	10	635,549	$0.30		0	$0
8. Efficient Landscape Rebate	Res	10%	18%	25%	15	28	40	% of outdoor	2,383,836	m3/year	35,758	137,071	238,384	$175	$263	$350	per home	Households	24,700	4,323	$1,134,656	10	2,056,059	$0.55		0	$0
	ICI	5%	10%	15%	15	28	40	% of outdoor	996,940	m3/year	7,477	33,647	59,816	$375	$563	$750	per business	Businesses	2,500	250	$140,625	10	504,701	$0.28		0	$0
9. ICI Audits	ICI	15%	23%	30%	10	30	50	% of indoor	3,524,965	m3/year	52,874	290,810	528,745	$1,000	$4,500	$8,000	per business	Businesses	2,500	563	$2,531,250	5	5,089,168	$0.50	1	290,810	$2,531,250
10. Water Waste Bylaw	Res	75%	85%	95%	5	13	20	% of outdoor	2,383,836	m3/year	89,394	271,161	452,929	$1.50	$2	$3.00	per resident	Residents	126,000	107,100	$240,975	5	4,745,324	$0.05	1	271,161	$240,975
	ICI	75%	85%	95%	2	4	5	% of indoor	3,524,965	m3/year	52,874	110,155	167,436	$150	$225	$300	per business	Businesses	2,500	2,125	$478,125	5	1,927,715	$0.25	1	110,155	$478,125
	ICI	75%	85%	95%	5	10	15	% of outdoor	996,940	m3/year	37,385	89,725	142,064									5	1,570,181		1	89,725	$0
11. UFW Reductions	S	100%	100%	100%	10	20	30	% of UFW	1,228,337	m3/year	122,834	245,667	368,501	$0	$0	$0						5	4,299,178		1	245,667	$0
12. Public Education	Res	100%	100%	100%	0	1	1	% of indoor	8,428,731	m3/year	0	42,144	84,287	$1.00	$3	$5.00	per resident	resident	126,000	126,000	$378,000	5	737,514	$0.51	1	42,144	$378,000
	Res	100%	100%	100%	1	2	2	% of outdoor	2,383,836	m3/year	23,838	35,758	47,677									5	625,757		1	35,758	$0
13. Universal Metering & Volume-Based Pricing											0	0	0	$0	$0	$0						5	0			0	$0
											0	0	0	$0	$0	$0						5	0			0	$0
14. Seasonal Pricing (Summer Surcharge)	Res	40%		70%	7	10	13	% of outdoor	2,383,836	m3/year	66,747	141,838	216,929	$0.00	$0	$0.00	per household				$5,112,000	2	2,694,927	$1.90	1	141,838	$5,112,000
	ICI	30%		50%	5	7	8	% of outdoor	3,524,965	m3/year	52,874	96,937	140,999	$0.00	$0	$0.00	per business				$568,000	2	1,841,794	$0.31	1	96,937	$568,000
Totals (m3/year)											**1,279,488**	**4,050,581**	**6,821,673**								**$20,732,006**					**3,355,899**	**$11,831,913**
Totals (%)											6.4%	20.3%	34.1%													16.8%	
Customer Code																											
Res = Residential																											
ICI = Industrial/Commercial/Institutional																											
S = System (unaccounted-for and non-revenue water)																											

Table 6-4: Summary of Conservation Programs for Mission

Conservation Program	Targeted Customers	Estimated Participation			Estimated Unit Savings				Target		Estimated Savings Range (m3/year)			Unit Costs			
		Low	Avg	High	Low	Avg	High	Component	Value	Unit	Low	Avg	High	Low	Avg	High	
1. Home Water Audit & Retrofit	Res	5%	23%	40%	15	30	45	L/c/d	26,000	pop	7,118	88,969	170,820	$75	$113	$150	per audit
2. Low-Volume Toilet & Waterless Urinal Rebate	Res	5%	13%	20%	30	40	50	L/c/d	26,000	pop	14,235	54,568	94,900	$100	$175	$250	per toilet
	ICI	5%	13%	20%	2	6	10	% of indoor	1,100,000	m3/year	1,100	11,550	22,000	$100	$175	$250	per toilet
3. Clothes Washer Rebate	Res	5%	13%	20%	14	17	20	L/c/d	26,000	pop	6,735	22,347	37,960	$250	$425	$600	per washer
4. Low-Flow Toilet Bylaw	Res	30%	55%	80%	30	40	50	L/c/d	26,000	pop	85,410	232,505	379,600	$0	$0	$0	
	ICI	70%	83%	95%	2	4	6	% of indoor	1,100,000	m3/year	15,400	39,050	62,700	$0	$0	$0	
5. Landscape & Irrigation Audit & Retrofit	Res	30%	45%	60%	5	10	15	% of outdoor	844,000	m3/year	12,660	44,310	75,960	$100	$175	$250	per audit
	ICI	30%	45%	60%	10	15	20	% of outdoor	359,000	m3/year	10,770	26,925	43,080	$500	$1,250	$2,000	per audit
6. Rain Barrel Rebate	Res	5%	13%	20%	5	8	10	% of outdoor	844,000	m3/year	2,110	9,495	16,880	$25	$50	$75	per home
	ICI	5%	13%	20%	5	8	10	% of outdoor	359,000	m3/year	898	4,039	7,180	$150	$225	$300	per business
7. Efficient Irrigation Rebate	Res	10%	18%	25%	20	35	50	% of outdoor	844,000	m3/year	16,880	61,190	105,500	$250	$375	$500	per home
	ICI	5%	10%	15%	20	35	50	% of outdoor	359,000	m3/year	3,590	15,258	26,925	$500	$750	$1,000	per business
8. Efficient Landscape Rebate	Res	10%	18%	25%	15	28	40	% of outdoor	844,000	m3/year	12,660	48,530	84,400	$175	$263	$350	per home
	ICI	5%	10%	15%	15	28	40	% of outdoor	359,000	m3/year	2,693	12,116	21,540	$375	$563	$750	per business
9. ICI Audits	ICI	15%	23%	30%	10	30	50	% of indoor	1,100,000	m3/year	16,500	90,750	165,000	$1,000	$4,500	$8,000	per business
10. Water Waste Bylaw	Res	75%	85%	95%	5	13	20	% of outdoor	844,000	m3/year	31,650	96,005	160,360	$1.50	$2	$3.00	per resident
	ICI	75%	85%	95%	2	4	5	% of indoor	1,100,000	m3/year	16,500	34,375	52,250	$150	$225	$300	per business
	ICI	75%	85%	95%	5	10	15	% of outdoor	359,000	m3/year	13,463	32,310	51,158				
11. UFW Reductions	S	100%	100%	100%	30	40	50	% of UFW	1,650,000	m3/year	495,000	660,000	825,000	$0	$0	$0	
12. Public Education	Res	100%	100%	100%	0	1	1	% of indoor	2,640,000	m3/year	0	13,200	26,400	$1.00	$3	$5.00	per resident
	Res	100%	100%	100%	1	2	2	% of outdoor	844,000	m3/year	8,440	12,660	16,880				
13. Universal Metering & Volume-Based Pricing	Res	90%	95%	100%	6	9	12	% of total	3,480,000	m3/year	187,920	302,760	417,600	$0	$0	$0	
	ICI	90%	95%	100%	6	9	12	% of total	1,480,000	m3/year	79,920	128,760	177,600	$0	$0	$0	
14. Seasonal Pricing (Summer Surcharge)	Res	40%	55%	70%	7	10	13	% of outdoor	844,000	m3/year	23,632	50,218	76,804	$0.00	$0	$0.00	per household
(Requires universal metering)	ICI	30%	40%	50%	5	7	8	% of outdoor	359,000	m3/year	5,385	9,873	14,360	$0.00	$0	$0.00	per business
Totals (m3/year)											**1,070,667**		**3,132,857**				
Totals (%)											16.2%	31.8%	47.5%				
Customer Code																	
Res = Residential																	
ICI = Industrial/Commercial/Institutional																	
S = System (unaccounted-for and non-revenue water)																	

Estimated Program Costs / **Recommended Plan**

Conservation Program	Targeted Customers	Program Unit	Total Number	Participating (Average)	Total Cost (Average, Undiscounted)	Program Impl. Period (years)	Total Savings over 20 Years (m3, Average)	Cost per Unit Savings ($/m3)	Program Included=1	Estimated Saving (m3/year)	Total Cost, Undiscounted
1. Home Water Audit & Retrofit	Res	Households	11,400	2,565	$288,563	5	1,556,953	$0.19	1	88,969	$288,563
2. Low-Volume Toilet & Waterless Urinal Rebate	Res	Toilets	11,400	1,425	$249,375	10	818,513	$0.30	1	54,568	$249,375
	ICI	Toilets	300	38	$6,563	10	173,250	$0.04	1	11,550	$6,563
3. Clothes Washer Rebate	Res	Washers	11,400	1,425	$605,625	10	335,212	$1.81		0	$0
4. Low-Flow Toilet Bylaw	Res	Toilets	1,000	550	$0	20	2,325,050	$0.00	1	232,505	$0
	ICI	Toilets	30	25	$0	20	390,500	$0.00	1	39,050	$0
5. Landscape & Irrigation Audit & Retrofit	Res	Households	8,500	3,825	$669,375	5	775,425	$0.86		0	$0
	ICI	Businesses	300	135	$168,750	5	471,188	$0.36		0	$0
6. Rain Barrel Rebate	Res	Households	8,500	1,063	$53,125	10	142,425	$0.37	1	9,495	$53,125
	ICI	Businesses	300	38	$8,438	10	60,581	$0.14	1	4,039	$8,438
7. Efficient Irrigation Rebate	Res	Households	8,500	1,488	$557,813	10	917,850	$0.61		0	$0
	ICI	Businesses	300	30	$22,500	10	228,863	$0.10		0	$0
8. Efficient Landscape Rebate	Res	Households	8,500	1,488	$390,469	10	727,950	$0.54		0	$0
	ICI	Businesses	300	30	$16,875	10	181,744	$0.09		0	$0
9. ICI Audits	ICI	Businesses	300	68	$303,750	5	1,588,125	$0.19	1	90,750	$303,750
10. Water Waste Bylaw	Res	Residents	35,000	29,750	$66,938	5	1,680,088	$0.04	1	96,005	$66,938
	ICI	Businesses	300	255	$57,375	5	601,563	$0.10	1	34,375	$57,375
	ICI			0		5	565,425		1	32,310	$0
11. UFW Reductions	S					5	11,550,000		1	660,000	$0
12. Public Education	Res	Residents	35,000	35,000	$105,000	5	231,000	$0.45	1	13,200	$105,000
	Res		35,000	35,000		5	221,550		1	12,660	$0
13. Universal Metering & Volume-Based Pricing	Res		35,000	33,250	$0	5	5,298,300	$0.00	1	302,760	$0
	ICI		300	285	$0	5	2,253,300	$0.00	1	128,760	$0
14. Seasonal Pricing (Summer Surcharge)	Res			0	$0	5	878,815	$0.00	1	50,218	$0
(Requires universal metering)	ICI								1	9,873	$0
Totals (m3/year)					**$3,570,531**					**1,871,086**	**$1,139,125**
Totals (%)										28.3%	

Section 7

Costs and Benefits of Water Conservation

KERR WOOD LEIDAL
associates limited
CONSULTING ENGINEERS

7. COSTS AND BENEFITS OF WATER CONSERVATION

7.1 INTRODUCTION

This section assesses the costs and benefits of water conservation, including the potential for water conservation to defer capital projects based on reduced demand. The programs in the recommended water conservation plan are selected in Section 6.

This assessment is an overview based on approximate calculations. More detailed analyses would be required to confirm the actual effects of reduced demand, and the actual resulting benefits. The capital projects considered are those identified in the 2003 updates of the *Water Master Plan* and the *Wastewater Master Plan*. The basic costs and timing are given in those reports.

7.2 METHODOLOGY

The tables following this section estimate some costs and benefits of water conservation using the following assumptions:

1. The needs for capital projects (both water supply and sewage treatment) are triggered by rising peak day water demand. Peak day water demand (PDD) is estimated to be 137.8 ML/day in 2005 and rising at a constant rate of approximately 4.6 ML/day per year over a 20-year planning horizon.

2. If PDD were reduced, then projects that were scheduled for a given year could be deferred until the time in the future when PDD rose to the same level. For example, if the PDD were reduced by 4.6 ML/day, then all projects could be deferred by one year.

3. Financial benefits arise from the deferral of capital expenditures, as well as the associated O&M expenditures (5-10% of capital costs per year).

4. Financial costs arise from the implementation of the water conservation programs (refer to Section 6.6).

5. Non-financial benefits also arise from the intrinsic value that people place on reduced withdrawal of water from the environment, which can be assessed in various ways below).

All costs and benefits are calculated in net present value (NPV) terms. A discount rate of 6% is used throughout.

ECONOMIC VALUE OF WATER

Regarding point (5) above, the intrinsic 'value' of water as a commodity can be considered in the analysis. Water provides benefits as a commodity for agriculture, industry, and households – and as a public good for scenic values, waste assimilation, wildlife habitats, and recreational and other uses. These values are often not included in analyses because they are difficult to estimate in financial terms. However, their inclusion potentially allows price signals to properly reflect community values and guide investments and resource allocation. To aid in cost-benefit analysis under conditions where appropriate price incentives are absent, economists have developed a range of alternative or non-market methods, such as 'willingness-to-pay' (WTP) surveys, for measuring economic benefits.

The intrinsic value of water is unknown but greater than zero; a valuation study could be done to assist in decision-making. Various studies have shown the public's WTP for wetlands, fisheries and similar resources. One study, as part of an unrelated project, asked 343 people in the Central Fraser Valley region how much they would pay for clean water.[39] The study found that the population in that region would pay between \$78 and \$284/year per household, equivalent to \$0.21 and \$0.78 per cubic metre (\$0.50/m^3 average). The WTP for natural lake water or groundwater would be expected to be considerably lower than that. For the purposes of this section of the report, a unit cost of \$0.05/m^3 (one-tenth of \$0.50) has been used.

7.3 RESULTS

Table 7-1 the results; the subsequent tables detail the analyses. The greater part of the benefit arises from deferred capital and O&M costs, but considerable benefits could arise from intrinsic valuation as well (see discussion below).

Table 7-2 shows the estimated benefits in terms of water savings.

Table 7-3 shows the estimated benefits from the intrinsic value of water.

Table 7-4 shows the estimated benefits in terms of deferred capital and O&M costs. The latter have been assumed to be 5% of capital costs per year for water projects, and 10% per year for sewage treatment projects.

Table 7-5 shows the estimated costs of the recommended water conservation programs. It is noted that both costs and benefits are phased in during implementation periods that can be varied in length or staggered in timing.

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[39] A Literature Review of the Economics of Manure Management Options in the Lower Fraser Valley, 1996, DOE FRAP 1996-15, prepared for the BC Ministry of Environment, Lands and Parks.

DISCUSSION OF BENEFIT/COST RATIOS

Table 7-1 shows two different benefit/cost ratios, an 'economic' and a 'financial'. The financial B/C ratio considers only direct financial benefits (from deferred costs) and costs (for program implementation). The B/C ratio of 0.57 shows that direct benefits would be less than direct costs.

However, if the residents of the City and District valued the intrinsic benefits of reduced water usage as a public, environmental and economic good, then an 'economic' B/C ratio could be used to make a case for conserving water. Using an intrinsic value of $0.05/m^3 increases the B/C ratio to 0.77. A slightly higher value would increase the B/C ratio to over 1.0 for the program as a whole. In any case, individual water conservation initiatives are likely to be viable, as discussed elsewhere.

BENEFITS AND LIMITATIONS OF THE ANALYSIS

The cost/benefit analysis is based on simplifying assumptions, only some of which are discussed herein. It is nevertheless capable of expansion as more detail is added. It is also possible to change the mix of recommended programs, as well as input data such as the discount rate; all the tables recalculate automatically.

The analysis considers the entire service area as a whole, whereas more detailed analyses should be done to determine the effects of programs in individual municipalities.

The analysis also assumes that global PDD is the only factor that affects capital programs. In reality, this will be different for water and sewage, and will vary with location in the service system, and the type of project considered.

The analysis is also sensitive to the economic value of water, which may well be higher than assumed. In other words, community values, if integrated into the analysis, may indicate support for conservation projects that could not be justified on purely financial terms.

Table 7-1: Summary of Costs and Benefits of Water Conservation (NPV Over 20 Years)

Estimated Costs of Water Conservation Programs (Table 7-5)	-$11,172,000
Estimated Benefits from Deferred Capital and O&M Costs (Table 7-4)	$6,422,000
Estimated Benefits from Intrinsic Value of Water (Table 7-3)	$2,148,000
Total Benefits Including Economic Value of Water	**-$2,602,000**
'Economic' Benefit/Cost Ratio	0.77
Total Benefits Excluding Economic Value of Water	**-$4,750,000**
'Financial' Benefit/Cost Ratio	0.57

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Q:\2000-2099\2080-009\300-Report\2005-07Final\[Sections6-7-TBLS.xls]7-1 Summary

Table 7-2: Summary of Estimated PDD Reductions by Year (ML/d)

Estimated Peak Day Demand, 2005	137.8	ML/d
Estimated Growth in PDD	4.575	ML/d per year

Conservation Program	Estimated Saving (m3/year)	Estimated Saving, ADD (ML/d)	PDD/ADD Factor	Estimated Saving, PDD (ML/d)	Implementation Period (years)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
						Year No.:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
1. Home Water Audit & Retrofit	522,294	1.43	1	1.43	5	0.00	0.29	0.57	0.86	1.14	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
2. Low-Volume Toilet & Waterless Urinal Rebate	368,903	1.01	1	1.01	10	0.00	0.10	0.20	0.30	0.40	0.51	0.61	0.71	0.81	0.91	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
3. Clothes Washer Rebate	0	0.00	1	0.00	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4. Low-Flow Toilet Bylaw	1,529,116	4.19	1	4.19	20	0.00	0.21	0.42	0.63	0.84	1.05	1.26	1.47	1.68	1.89	2.09	2.30	2.51	2.72	2.93	3.14	3.35	3.56	3.77	3.98	4.19
5. Landscape & Irrigation Audit & Retrofit	0	0.00	3	0.00	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6. Rain Barrel Rebate	51,567	0.14	2	0.28	10	0.00	0.03	0.06	0.08	0.11	0.14	0.17	0.20	0.23	0.25	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
7. Efficient Irrigation Rebate	0	0.00	3	0.00	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8. Efficient Landscape Rebate	0	0.00	3	0.00	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9. ICI Audits	381,560	1.05	1	1.05	5	0.00	0.21	0.42	0.63	0.84	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
10. Water Waste Bylaw	633,731	1.74	3	5.21	5	0.00	1.04	2.08	3.13	4.17	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21	5.21
11. UFW Reductions	905,667	2.48	1	2.48	5	0.00	0.50	0.99	1.49	1.99	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48	2.48
12. Public Education	103,761	0.28	2	0.57	5	0.00	0.11	0.23	0.34	0.45	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
13. Universal Metering & Volume-Based Pricing	431,520	1.18	2	2.36	5	0.00	0.47	0.95	1.42	1.89	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36
14. Seasonal Pricing (Summer Surcharge)	298,865	0.82	3	2.46	2	0.00	1.23	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46	2.46
Total Savings	**5,226,985**	**14.32**		**21.04**		**0.00**	**4.19**	**8.37**	**11.33**	**14.29**	**17.25**	**17.59**	**17.93**	**18.27**	**18.60**	**18.94**	**19.15**	**19.36**	**19.57**	**19.78**	**19.99**	**20.20**	**20.41**	**20.62**	**20.83**	**21.04**
Peak Day Demand without Water Conservation						137.80	142.38	146.95	151.53	156.10	160.68	165.25	169.83	174.40	178.98	183.55	188.13	192.70	197.28	201.85	206.43	211.00	215.58	220.15	224.73	229.30
Peak Day Demand with Water Conservation						**137.80**	**138.19**	**138.58**	**140.19**	**141.81**	**143.43**	**147.66**	**151.90**	**156.13**	**160.37**	**164.61**	**168.97**	**173.34**	**177.70**	**182.07**	**186.43**	**190.80**	**195.16**	**199.53**	**203.90**	**208.26**
Percent Reduction						0.00%	2.94%	5.70%	7.48%	9.16%	10.74%	10.64%	10.56%	10.47%	10.40%	10.32%	10.18%	10.05%	9.92%	9.80%	9.68%	9.57%	9.47%	9.37%	9.27%	9.18%

Table 7-3: Estimated Benefits from Intrinsic Value of Water

Assumed Economic Value of Water $0.05 per cubic metre
Discount Rate 6%

Conservation Program	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**NPV over 20 Years**
	Year No.:	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
1. Home Water Audit & Retrofit	$0	$4,927	$9,297	$13,156	$16,548	$19,514	$18,410	$17,368	$16,385	$15,457	$14,582	$13,757	$12,978	$12,244	$11,551	$10,897	$10,280	$9,698	$9,149	$8,631	$8,143	$252,972
2. Low-Volume Toilet & Waterless Urinal Rebate	$0	$1,740	$3,283	$4,646	$5,844	$6,892	$7,802	$8,587	$9,258	$9,826	$10,300	$9,717	$9,167	$8,648	$8,158	$7,697	$7,261	$6,850	$6,462	$6,096	$5,751	$143,984
3. Clothes Washer Rebate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4. Low-Flow Toilet Bylaw	$0	$3,606	$6,805	$9,629	$12,112	$14,283	$16,169	$17,797	$19,188	$20,364	$21,346	$22,152	$22,798	$23,300	$23,672	$23,927	$24,077	$24,134	$24,107	$24,006	$23,839	$377,311
5. Landscape & Irrigation Audit & Retrofit	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6. Rain Barrel Rebate	$0	$243	$459	$649	$817	$963	$1,091	$1,200	$1,294	$1,374	$1,440	$1,358	$1,281	$1,209	$1,140	$1,076	$1,015	$958	$903	$852	$804	$20,127
7. Efficient Irrigation Rebate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
8. Efficient Landscape Rebate	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
9. ICI Audits	$0	$3,600	$6,792	$9,611	$12,089	$14,256	$13,449	$12,688	$11,970	$11,292	$10,653	$10,050	$9,481	$8,945	$8,438	$7,961	$7,510	$7,085	$6,684	$6,306	$5,949	$184,807
10. Water Waste Bylaw	$0	$5,979	$11,280	$15,963	$20,079	$23,678	$22,338	$21,073	$19,881	$18,755	$17,694	$16,692	$15,747	$14,856	$14,015	$13,222	$12,473	$11,767	$11,101	$10,473	$9,880	$306,946
11. UFW Reductions	$0	$8,544	$16,121	$22,812	$28,695	$33,838	$31,923	$30,116	$28,411	$26,803	$25,286	$23,855	$22,504	$21,231	$20,029	$18,895	$17,826	$16,817	$15,865	$14,967	$14,120	$438,657
12. Public Education	$0	$979	$1,847	$2,614	$3,288	$3,877	$3,657	$3,450	$3,255	$3,071	$2,897	$2,733	$2,578	$2,432	$2,295	$2,165	$2,042	$1,927	$1,818	$1,715	$1,618	$50,256
13. Universal Metering & Volume-Based Pricing	$0	$4,071	$7,681	$10,869	$13,672	$16,123	$15,210	$14,349	$13,537	$12,771	$12,048	$11,366	$10,723	$10,116	$9,543	$9,003	$8,493	$8,013	$7,559	$7,131	$6,727	$209,005
14. Seasonal Pricing (Summer Surcharge)	$0	$7,049	$13,299	$12,547	$11,836	$11,166	$10,534	$9,938	$9,376	$8,845	$8,344	$7,872	$7,426	$7,006	$6,609	$6,235	$5,882	$5,549	$5,235	$4,939	$4,659	$164,349
Total Discounted Savings	$0	**$40,738**	**$76,864**	**$102,496**	**$124,981**	**$144,591**	**$140,584**	**$136,567**	**$132,554**	**$128,558**	**$124,590**	**$119,551**	**$114,684**	**$109,985**	**$105,450**	**$101,076**	**$96,860**	**$92,797**	**$88,884**	**$85,116**	**$81,490**	**$2,148,415**

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Table 7-4: Estimated Benefits from Deferred Capital and O&M Costs

Estimated Growth in PDD	4.575	ML/d per year
Discount Rate	6%	
O&M Factor, Water Projects	5%	per year
O&M Factor, Sewage Projects	10%	per year

Capital Project	Planned Year	Estimated Cost	NPV of Cost in Planned Year	Reduced PDD in Planned Year (ML/d)	Deferred Year	NPV of Cost in Deferred Year	NPV of Capital Savings	NPV of O&M Savings	Total NPV of Savings
WATER PROJECTS (ref 2003 Water Plan Tables 6-4 and 6-5)									
1. Norrish Transmission Main to Plant	2006	$16,000,000	$15,094,340	4.19	2007	$14,310,508	$783,832	$39,192	$823,023
2. MacLure Reservoir Expansion 1	2006	$3,750,000	$3,537,736	4.19	2007	$3,354,025	$183,711	$9,186	$192,896
3. Norrish Creek Treatment Plant Expansion	2005	$12,200,000	$12,200,000	0.00	2005	$12,200,000	$0	$0	$0
4. Cannell Transmission Main	2006	$3,750,000	$3,537,736	4.19	2007	$3,354,025	$183,711	$9,186	$192,896
5. Norrish Transmission Main to Mt. Mary Ann	2009	$6,880,000	$5,449,604	14.29	2012	$4,542,721	$906,884	$45,344	$952,228
6. McKee to Gladwin Extension	2013	$5,450,000	$3,419,397	18.27	2017	$2,709,651	$709,747	$35,487	$745,234
7. Gladwin to MacLure Extension	2013	$2,785,000	$1,747,343	18.27	2017	$1,384,656	$362,687	$18,134	$380,822
8. MacLure Reservoir Expansion 2	2021	$7,800,000	$3,070,441	20.20	2025	$2,373,912	$696,529	$34,826	$731,355
WATER PROJECTS (ref 2003 Wastewater Plan Table 6-8)									
1. Capital Projects 2006	2006	$12,500,000	$11,792,453	4.19	2007	$11,180,084	$612,369	$61,237	$673,605
2. Capital Projects 2011	2011	$2,350,000	$1,656,657	17.59	2015	$1,324,172	$332,485	$33,249	$365,734
3. Capital Projects 2016	2016	$5,000,000	$2,633,938	19.15	2020	$2,063,776	$570,161	$57,016	$627,178
4. Capital Projects 2021	2021	$7,500,000	$2,952,347	20.20	2025	$2,282,608	$669,739	$66,974	$736,713
Total Discounted Savings		**$85,965,000**	**$67,091,992**			**$61,080,139**	**$6,011,854**	**$409,830**	**$6,421,684**

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Table 7-5: Estimated Costs of Water Conservation Programs

Discount Rate 6%

Conservation Program	Total Cost, Undiscounted	Implementation Period (years)	Annual Cost	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	NPV over 20 Years
				Year No.:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1. Home Water Audit & Retrofit	$1,463,063	5	$292,613	$0	$276,050	$260,424	$245,683	$231,777	$218,657	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,232,590
2. Low-Volume Toilet & Waterless Urinal Rebate	$1,380,313	10	$138,031	$0	$130,218	$122,847	$115,894	$109,334	$103,145	$97,307	$91,799	$86,603	$81,700	$77,076	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$1,015,922
3. Clothes Washer Rebate	$0	10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
4. Low-Flow Toilet Bylaw	$0	20	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
5. Landscape & Irrigation Audit & Retrofit	$0	5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
6. Rain Barrel Rebate	$286,250	10	$28,625	$0	$27,005	$25,476	$24,034	$22,674	$21,390	$20,179	$19,037	$17,960	$16,943	$15,984	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$210,682
7. Efficient Irrigation Rebate	$0	10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
8. Efficient Landscape Rebate	$0	10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
9. ICI Audits	$2,835,000	5	$567,000	$0	$534,906	$504,628	$476,064	$449,117	$423,695	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$2,388,410
10. Water Waste Bylaw	$843,413	5	$168,683	$0	$159,134	$150,127	$141,629	$133,612	$126,049	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$710,552
11. UFW Reductions	$0	5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
12. Public Education	$483,000	5	$96,600	$0	$91,132	$85,974	$81,107	$76,516	$72,185	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$406,914
13. Universal Metering & Volume-Based Pricing	$0	5	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
14. Seasonal Pricing (Summer Surcharge)	$5,680,000	2	$2,840,000	$0	$2,679,245	$2,527,590	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$5,206,835
Total Discounted Savings	**$12,971,038**			$0	**$3,897,690**	**$3,677,066**	**$1,084,411**	**$1,023,030**	**$965,122**	**$117,486**	**$110,836**	**$104,562**	**$98,644**	**$93,060**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$11,171,907**

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Section 8

Review of Water Rates

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8. REVIEW OF WATER RATES

8.1 INTRODUCTION

This section reviews the various types of water rate structures in common use, summarizes their pros and cons, and assesses in general terms the effectiveness of the rates in the study area at promoting water conservation.

Both the City of Abbotsford and the District of Mission use declining-block rates. The 1994 report titled *Overview of Water Conservation / Demand Management* (prepared for the then Dewdney-Alouette Regional District) recommended that the rates be changed to inclining-block in order to promote water conservation.

8.2 SUMMARY OF CURRENT RATES

CITY OF ABBOTSFORD

The City of Abbotsford has universal metering and so charges almost all customers on a volume basis. Residential users and greenhouses are charged $0.56/m^3 with no minimum fee. ICI customers are charged on a declining-block scale as shown in Table 8-1, also with no minimum fee.

Table 8-1: Variable Charge for Abbotsford

Volume Block	$/m^3
1 – 10,000 m^3	$0.56
10,001 – 100,000 m^3	$0.46
>100,000 m^3	$0.38

The declining-block rate is intended to help attract large industries to the area.

Unmetered customers are charged an annual flat rate of $270 per premise.

DISTRICT OF MISSION

The District of Mission meters only ICI and agricultural customers. These are charged on a declining-block scale as shown below, with a meter charge (Table 8-2) plus a volume charge (Table 8-3).

Table 8-2: Variable Charge for Mission

Volume Block	$/m^3
Up to 300 m^3	$0.42
On next 300 m^3	$0.34
On next 300 m^3	$0.31
On next 300 m^3	$0.28
On balance	$0.21

Table 8-3: Meter Charge for Mission (per Quarter)

Meter Size	Minimum Charge Per Quarter
16	$31.66
19	$45.56
25	$45.56
32	$45.56
38	$45.56
50	$50.63
75	$50.63
100	$164.59
150	$164.59

In the Lower Mainland, only the larger municipalities tend to have variable meter charges. For comparison purposes, these are compared in Table 8-4.

Table 8-4: Annual Meter Charge Comparison ($/year)

Meter Size (mm)	Vancouver	Chilliwack	Surrey	Mission
16	132	56	60	127
19	132	56	60	182
25	144	62	75	182
38	168	76	93	182
50	210	94	123	203
75	426	141	246	203
100	522	206	288	658
150	672	371	543	658
200	1044	536	639	

Unmetered residential customers in Mission are charged an annual flat rate of $192.12 for most types of housing.

8.3 TYPES OF RATE STRUCTURES

A cost-of-service approach to setting water rates allocates costs to each customer or customer class based on the theory of cost causation. Most rate structures are designed to recover costs but some are more likely to promote water conservation through price signals.[40]

Most rate structures include a fixed plus a variable charge. The fixed charge recovers fixed costs, while the variable charge is based on consumption.

FIXED CHARGES

Water utilities use many different types of fixed charges in their rate designs. Three commonly used fixed charges are service charges (also called customer charges), meter charges, and minimum charges.

Service Charge

This type of fixed charge is the same for all customers. It typically recovers costs for meter reading and billing, and other costs that the utility incurs equally per customer or per account. These costs are not a function of the amount of consumption a customer uses. An example of a service or customer charge is $3.00 per bill. This charge might be applied to all customers or it might be specifically designed for each customer class.

A service charge or customer charge is normally easy to calculate, implement, and understand. A service charge is usually lower than other types of fixed charges.

Meter Charge

A meter charge is a fixed fee that increases with meter size, such as is used in Mission. Often this fee is the same by meter size for all classes of customers. It typically recovers the same costs as a service charge plus other customer-related costs that change as a function of meter size, such as meter tests, repairs, and replacements.

Because meter charges vary by meter size, they may be more complicated to explain and require additional data to allocate costs to each meter size in a fair and equitable manner. In addition to Mission, the Cities of Vancouver, Richmond and Surrey, as well as the District of Chilliwack, use meter charges.

Minimum Charge

A minimum charge is a fixed fee that includes an allotment of water consumption for which a customer is billed regardless of whether or not the water is used. The allotment

[40] This discussion based on AWWA Manuals *M1 – Water Rates* (1983) and *M34 – Water Rate Structures and Pricing* (1999), American Water Works Association, Denver, CO. The text of this section includes edited excerpts from these manuals.

is generally set at a low level based on the assumption that most customers use at least that amount of water. Also, some utilities may view this charge as a means to recover costs associated with investments to which all customers should contribute, regardless of whether they consumed water during that billing period.

This fee typically recovers the same costs as a service or meter charge plus the allotted units of consumption allowance multiplied by the consumption rate. For example, if the City had a service charge of $3.00 per bill and a consumption charge of $0.56 per cubic metre and it wanted to set a minimum charge that included 100 m^3, the minimum charge would be $59.00 per bill ($3.00 + $56.00).

Minimum charges generally result in the highest fixed fees. They may be criticized for being unfair in that they charge a customer regardless of consumption, and so can be considered to work counter to conservation goals. Utilities often assume that a minimum charge increases revenue stability but, because the consumption allotment for a minimum charge is often set at a low level, a utility may actually receive little benefit in that regard. The amount of revenue generated from the consumption component of the minimum charge is revenue that, for the most part, would normally be generated from water sales using the consumption charge.

A minimum charge often is structured as a ‘disappearing’ charge that fixes the minimum amount to be collected from the customer and incidentally allows him a given amount of water under the minimum charge. The amount of water allowed is simply determined by the quantity that the customer could buy under the applicable volume rates. Under this type of rate, the minimum charge ‘disappears’ in that when usage exceeds the amount allowed under the minimum charge, the regular rate schedule prevails.

VARIABLE CHARGES

The rate design for metered water sales usually includes a charge per unit of water consumed. This charge, often called a **consumption charge**, is variable in that the amount the customer pays varies based on the amount of water the customer consumes. The most obvious cost component of the municipalities’ cost is to purchase wholesale water from the Commission.

The following paragraphs briefly describe the three basic types of consumption charges, as well as a fourth variation that could be used with any of them:

Uniform Rate

The charge per unit volume (cubic metres) remains constant for all metered consumption of water on a year-round basis. As a customer uses more water, the bill increases at a steady rate per unit of consumption.

Most municipalities in the Lower Mainland use this rate structure.

Declining-Block Rate

Declining-block rates divide a customer's consumption into blocks of usage and charge more for the initial units of consumption and less for subsequent units. The variability in the unit rates among the rate blocks is generally a function of the respective costs of producing service to the various classes of customers. This type of rate structure is generally considered to work against conservation and is not usually recommended.

Both Mission and Abbotsford use this rate structure.

Inclining-Block Rate

Inclining-block rates also divide consumption into usage blocks but charge less for the initial units of consumption and more for subsequent units. Therefore, in contrast to the declining-block rates, this type of structure promotes water conservation.

In the GVRD, only Delta uses this rate structure.

Seasonal Rate

A fourth type of rate structure is the seasonal rate. Under this type of structure, the price for consumption is based on the time of year. A utility usually charges more per unit of consumption during the peak-demand season and less during the low-demand season. Often a uniform block consumption charge is used for each season, but increasing and decreasing block consumption charges may also be used. Utilities usually separate the charge into two seasons (i.e. summer and winter), but it is possible to have more seasonal divisions.

No municipalities in the Lower Mainland use this rate structure.

HISTORICAL PERSPECTIVES

Dual systems of charges (fixed and variable) to recover water costs can be used only for metered customers. Unmetered customers must be charged a fixed fee but the fixed fee may vary among customer types based on meter size or potential water use. For example, utilities may use a fee per connection that varies with lawn area, number of fixture units, number of hospital beds, number of bar stools, irrigated acreage, number of barbershop chairs, etc.

From a municipality's standpoint, both revenue stability and equity are generally enhanced as appropriate types of costs are recovered through fixed costs. However, it is commonly accepted that as the fixed fee component of the rate structure increases, the customers' ability to control the size of their bills decreases to some extent. This relationship needs to be considered as utilities become more active in trying to affect demand through price signals.

8.4 RATE STRUCTURES THAT PROMOTE CONSERVATION

Water rate structures play an essential role in communicating the value of water to water customers, promoting long-term efficient use. Increasing-block rate structures most effectively encourage efficient water use. For example, the AWWA literature cites a study in which monthly water use records of 101 customers were measured in the city of Denton, Texas. Summer water use records from 1976 to 1980 during a decreasing-block rate period were compared to summer use records from 1981 to 1985 during an increasing-block rate period. It was found that the decreasing-block rate scenario encouraged greater water use, whereas the increasing-block rate scenario resulted in a reaction to the price increase and a corresponding decrease in water use.

Similarly, Western Resource Advocates, a non-profit environmental law and policy organization, conducted a Smart Water study of regional water use. WRA found a correlation between cities with dramatically increasing block rates and those with the lowest per-capita consumption levels. Along with other conservation and efficiency programs, effective rate structures can help stretch existing water supplies further and avoid much of the cost and controversy that result from large new water development projects. If designed appropriately, increasing block rates can

- provide water at low prices for basic and essential needs, so all customers can afford it;
- reward conserving customers with lower unit rates for water; and
- assign water supply and development costs proportionately to the customers who place the highest burden on the supply system, and on the rivers that feed the supplies; and

It is emphasized that this type of rate design would still maintain a stable revenue flow to the utility.

8.5 SUMMARY

The City of Abbotsford has universal metering and so charges almost all customers on a volume basis. Residential users and greenhouses are charged $0.56/m^3 regardless of amount consumed. ICI customers are charged on a declining-block scale so that the unit price decreases with consumption. This is done to attract and retain industry.

The District of Mission meters only ICI and agricultural customers. These are charged on a declining-block scale beginning at $0.42/m^3. Other customers are charged an annual fee of $270.

Declining-block rates do not promote water conservation, and for this reason should be gradually phased out over time. The phasing could be done over a period of about five years so that industries are not overly burdened.

Section 9

Review of Meter Reading Frequency in Abbotsford

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9. REVIEW OF METER READING FREQUENCY IN ABBOTSFORD

9.1 INTRODUCTION

This section reviews the meter reading frequency in the City of Abbotsford. The 1994 report titled *Overview of Water Conservation / Demand Management* (prepared for the then Dewdney-Alouette Regional District) recommended that Matsqui (Abbotsford) increase the frequency of meter reading from one to four times per year. The City has recently (2002 and 2003) considered increasing the frequency, but each time has chosen to retain the current program.

All of the City's approximately 24,000 water connections are metered. The City currently reads water meters once per year, and also bills customers once per year as part of their annual property tax assessment.

Choosing the meter reading and billing frequency should be examined as a business case that considers not just obvious labour costs, but also less obvious or harder-to-qualify benefits such as improved customer service, cash flow, and staff efficiency.

The following documents were reviewed as part of this task:

1. Report to Mayor and Council No. ENG 12-2003, by Rick Bomhof, Operations Manager, Subject: Water Meter Reading, dated November 13, 2003.

2. Report to Mayor and Council No. COR02-2002, by Judy Lewis, Len Stein and Rick Bomhof, Subject: Water Utility Billing Frequency, dated March 5, 2002.

3. Memo Re: Cost Analysis – Quarterly Reading – Outsourcing Reading & Billing, by Kent Martin, BCG Services, dated February 24, 2003.

It should be noted that the City has also considered (in 2003) contracting out meter reading and billing services, but elected not to pursue this option.

9.2 BEST PRACTICES IN METER READING AND BILLING

This section provides a brief overview of meter reading and billing practices in order to provide context.

METER READING TECHNOLOGIES

About 80% of the City's meters are at the property line and use touch-read technology. This is an intermediate technology between 'manual' meter reading and true 'automatic' meter reading. Unquestionably, manual meter reading is being phased out in favour of modern technology. The most prevalent (and economical) technology is the touch-pad system that is used by the City. Data is read through a probe placed near the touch-pad, and recorded in a hand-held datalogger. Other technologies, generally classified as Automatic Meter Reading (AMR) require no meter readers but rather transmit data remotely.

Currently the City has no plans to change to AMR technology. The analysis in this report assumes that touch-read technology would continue to be used.

METER READING PRACTICES

Larger cities tend to have specialized meter readers, while the meter readers in the smaller municipalities tend to undertake other tasks as well. Utilities often seek ways to create job classifications that are clearly defined, but with both breadth and depth of assignment possibilities, and with appropriate performance incentives. Increasing the frequency of meter reading should somewhat increase the efficiency as well, since individuals will spend more of their time on that task, allowing the job description to focus more on speedy and safe data acquisition, and less on follow-up and other types of work.

BILLING - GENERAL

Billing must be frequent enough that customers can alter their consumption patterns in response to their bills. If behaviour modification is a priority, then water charges should not be 'hidden' or combined with other charges such as sewerage or property taxes.

Good billing systems are perceived as fair and understandable by customers. Billing complaints, when they occur, must be dealt with promptly. Consumption patterns should be identified, so that consumers are alerted to high consumption, and the utility is alerted to faulty meters. Tracking of consumption patterns should be done by appropriate billing software. Inconsistent readings should be promptly reconciled, and faulty meters immediately replaced.

PAYMENT PROCESSING

The timeliness and accuracy of remittance processing are critical to good service and good cash flow. Efficient processing requires equipment that is appropriate to the type and volume of payments, generally in the context of an organization-wide strategy for revenue collection. Increasingly, customers are demanding debit, credit-card, and on-line services. Commercial and wholesale customers may also want electronic remittance services. The technology is designed and selected to keep pace with customer demands.

BILLING, ACCOUNTING, AND AUDITING

Sometimes thought of as 'backroom functions', billing, accounting and auditing (quality control) have a direct and important influence on customer service. Utilities often link these functions to their customer service organization. Employees can see clear relationships between the direct customer services they provide, and the quality-control functions the utility desires. In the absence of this linkage, employees may be less alert to potential inaccuracies and not as motivated to take action when they notice errors. They should feel a personal sense of responsibility for account and meter accuracy. This is more likely to happen if these functions are part of a larger customer service organization.

9.3 Reading and Billing Costs

As noted, the City has estimated the costs of moving to more frequent – likely quarterly – reading and/or billing. Since the City has invested considerable effort in this regard, this report reviews the costs only briefly, for the purpose of confirming their overall validity.

Current Situation

Currently it takes 4 men 8 weeks to read 24,000 meters. This is equivalent to 150 reads per man-day or $1.60 per read:

(24,000 reads) / (4 men x 8 weeks x 5 days) = 150 reads/man-day

(4 men x 8 weeks x 40 hours x $30.00/hr) / (24,000 reads) = $1.60 per read.

The overall cost is approximately $38,000 per reading cycle. It is understood that this figure includes some related activities such as follow-up for high-consumption accounts and so on. The reading rate of 150 reads per day is considered reasonable given the relatively low density in many parts of the City. Higher-density communities typically experience reading rates of over 250 reads per man-day but obviously many factors affect this.

The City has also estimated that moving to quarterly reads would increase the annual cost to approximately $113,000. This is equivalent to $1.15 per read, presumably reflecting expected efficiency improvements, as would be expected (see discussion under 'Meter Reading Practices' above). In reality, the unit costs could prove to further decrease over time, as meter readers become more experienced and efficient and development becomes more dense.

Currently there is very little cost for billing, since the water billing is included on the tax assessments. The City estimates that, if separate water bills were produced quarterly, the cost for billing and collections would be roughly $250,000 per year. This is equivalent to $10 per customer per year, or $2.50 per bill. The unit cost per bill is typically difficult for utilities to determine accurately because of the need to assess costs across two or more departments, and because of uncertainty about which items are 'billing' costs and which are simply normal overhead costs. Key factors that can influence billing costs include the following:

- number of billing cycles per year (number of bills generated);
- what cost items are included on the bill (water alone, water and sewage, etc.);
- accounting and audit costs;
- customer service levels; and
- ease of data integration with existing (or new) billing system.

The unit cost of $2.50 is relatively low compared to the BCG Services estimate (roughly $3.65 per bill) and other jurisdictions such as the City of Surrey (estimated $4.60 per bill). (The costing spreadsheet used elsewhere in this report contains a section where a detailed billing cost analysis can be done, if this is desired and the data is available.)

Overall, the City's estimates are reasonable, and within the ranges typically seen. If the City wished to move ahead with assessing the business case for increasing the frequency of meter reading, then more detailed analyses would be warranted, but the existing analyses provide a reasonable basis for the purposes of this report.

9.4 BENEFITS OF HIGHER READING/BILLING FREQUENCIES

The benefits of increased frequency are more difficult to quantify than the costs. As noted in the introduction, some benefits are monetary (such as improved cash flow) but most are non-monetary (such as improved management).

The main benefits are discussed in the following paragraphs.

IMPROVED CASH FLOW FOR THE CITY

Improved cash flow is one of the main reasons for increasing billing frequency: BC Gas (now Terasen) took over meter reading from BC Hydro largely to increase frequency from bi-monthly to monthly.

The City has estimated that, for quarterly billing, the increase in interest income would be $100,000 to $120,000 per year. This amount would partly but not wholly offset the increased costs.

IMPROVED BUDGETING FOR CUSTOMERS

The customer has smaller and more frequent bills to pay, making them easier to budget for. The bills would be more like other utility bills (such as Hydro, gas and phone) that depend on usage, and less like a tax bill that depends on factors outside the customer's control.

IMPROVED RESPONSE TO LEAKS AND HIGH CONSUMPTION

Customers would be able to detect leaks and high consumption sooner, thereby saving money and reducing water demand on the system. City records indicate that the complaint rate is less than 1%. This is considered low by industry standards – rates as high as 15% have been reported – indicating good billing management on the part of the City.

It may be that, given more frequent bills, customers would be better able to detect abnormal consumption patterns that they simply do not notice because their bills come only once per year. Also, the water portion of the bill would be relatively smaller than the tax portion, and as a consequence may receive less scrutiny.

In summary, the low incidence of complaints may indicate under-reporting, rather than absence, of leaks. A study of water usage in over 1,000 households all over North America found that leakage averaged 14% of usage.[41] A similar study of 36 homes in Greater Vancouver found that leakage averaged 9%.[42] Both studies found great variability, with a few homes having extreme rates of leakage – up to 25% or even 50% of usage.

If more frequent billing could reduce residential leakage by even 1% of usage, this would represent a saving of about 100,000 m^3/year, with a value to the customers of $56,000.

IMPROVED INCENTIVE TO SAVE WATER

More frequent reminders to customers of the costs of high consumption should motivate them to save water. Evidence indicates that this saving would derive from three main usage components:

- outdoor usage (reduced likelihood of 'forgetting' sprinklers and running hoses);
- leakage generally (increased likelihood of attending to known or discovered leaks); and
- egregious usage (see below).

Studies (including the two cited in the previous sub-section) indicate that a small minority of customers use extreme amounts of water on a continuous basis. This may be for reasons of apathy or simple inattention.

It is noted that customers are unlikely to reduce their indoor water usage (except leakage) since this is not strongly affected by metering or pricing.

SEASONAL SURCHARGES

Quarterly billing provides the ability to charge seasonally higher rates in the summer. As noted, the savings could be substantial, averaging 240,000 m^3/year, with a value to the customers of over $130,000.

[41] *Residential End Uses of Water*, AWWA Research Foundation, Denver CO, 1999.

[42] "Data Collection – Single-Family Indoor and Outdoor Water Use", completed by Kerr Wood Leidal Associates Ltd. and Aquacraft Inc. for the GVRD, January 2005.

BETTER SYSTEM PLANNING

More frequent meter reading allows more detailed analysis of demand patterns. The importance of this benefit, though difficult to quantify, should not be overlooked.

9.5 OPTIONS FOR MORE FREQUENT READING AND BILLING

A number of options have been proposed, including the following:

1. Read and bill annually (status quo).
2. Read and bill quarterly (as in Chilliwack).
3. Bill annually but read more frequently to detect leaks and improve system planning.

A number of additional options could be explored as well, including monthly billing (as in Kelowna), and increasing reading frequency in the summer only. It should be noted as well that switching to some type of automatic or radio read system (as in West Vancouver) would allow much more frequent reads without increasing labour costs. Reading could also be done jointly by another utility such as BC Hydro.

There is no single optimal number of billing cycles per year, since optimality will depend on how the utility values the intangible benefits described above. In any utility, including the City of Abbotsford, there will be several schools of thought about this and similar issues. The school that is strongly interested in water conservation, customer service and data management will tend to favour, all things being equal, more frequent billing.

9.6 SUMMARY

The City reads its approximately 24,000 water meters once per year, and bills customers once per year as part of their annual property tax assessment. If water conservation is a priority, then water charges should not be combined with other charges in this way, since the price signal is ‘hidden’. For this reason it is recommended that separate water bills be issued monthly or quarterly. The benefits of more frequent and clear billing include the following:

- Improved Cash Flow for the City: For quarterly billing, the increase in interest income would be $100,000 to $120,000 per year. This amount would partly but not wholly offset the increased costs.

- Improved Budgeting for Customers: The customer has smaller and more frequent bills to pay, making them easier to budget for. The bills would be more like other utility bills (such as Hydro, gas and phone) that depend on usage, and less like a tax bill that depends on factors outside the customer's control.

- Improved Response to Leaks and High Consumption: Savings of at least 100,000 m^3/year should be realizable, with a value to the customers of $56,000.

- Improved Incentive to Save Water

- The Ability to Implement Seasonal Surcharges: Monthly or quarterly billing would provide the ability to charge seasonally higher rates in the summer. The savings could be 240,000 m3/year, with a value to the customers of over $130,000.

- Better System Planning: More frequent meter reading would allow more detailed analysis of demand patterns. This benefit, though difficult to quantify, is crucial to future planning.

Section 10

Review of Metering for Mission

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10. REVIEW OF METERING FOR MISSION

10.1 INTRODUCTION

This section reviews the possibility of universal metering in the District of Mission. The review is at an overview level in order to confirm the main costs, benefits and assumptions of the proposal.

The District's proposal is contained in an internal report dated June 10, 2003. In essence, the proposal is to meter all of the District's 8,500 service connections, over a 15-year project, using radio technology.

Mission would be only the second jurisdiction in the Lower Mainland to adopt radio technology universally: in June 2004 the District of West Vancouver started to implement a similar universal metering program using radio technology. It is estimated that approximately 10,800 meters will be installed over two years to complete the program. The project involves retrofitting meters that will be mounted outside in meter pits at the property lines. The meters will be read monthly and billed quarterly.

10.2 BEST PRACTICES IN METERING

This section provides a brief overview of metering practices in order to provide context. Metering is done to manage the system, ensure equity, generate revenue, and encourage conservation. Meters are therefore the ‘cash registers’ of the supply system, and determine the accuracy of charges to the customers. While metering is often linked organizationally with the engineering department, it also needs to be functionally interdependent with billing and revenue services.

METER LOCATION AND INSTALLATION TYPE

Meters can be generally classified as in-pit or in-building. Pit-mount meters placed at the property line provide less opportunity for illegal taps upstream of the meter, and often provide much easier access to the meter for maintenance. This is particularly true for residential installations. The cost of pit-mount meters is generally higher than that of in-house mount, and the need for separate fire lines or building sprinklers can also complicate pit-mount installations.

Nevertheless, the trend is for new meters to be pit-mounted, for the reasons given above (access and security). With a regular testing program in place, some 10% to 15% of the installed meters need to be accessed, which is difficult to do if they are in peoples’ basements.

Meter installations typically include a shutoff valve, a meter idler, the meter itself, an encoded register, a data cable, and a data transmitter (touch-pad or radio). Some municipalities (such as Surrey) have a comprehensive set of installation standards covering most typical situations. Such standards are necessary regardless of the choice between pit-mount and in-building meters.

METER SELECTION

Utilities that follow best practices have guidelines for meter sizing (Ottawa Carleton is a good example). In the absence of guidelines, meters are often over-sized but rarely undersized. Over-sizing leads to increased costs (usually to the customer) and reduced revenues (due to under-recording at low flows).

The smaller sizes of water meters are positive displacement (PD) types. Above 38 mm or 50 mm size, compound types are usually specified. These are essentially two meters in one body, which extends the accuracy range. Compound meters should be preceded by strainers; PD meters have integral strainers. Very large meters (200 mm and above) are usually custom-engineered; turbine or magnetic meters are frequently used in these sizes.

VENDOR SELECTION

There is no ‘best practice’ in vendor selection. Many utilities prefer not to be ‘captive’ to a single supplier, or for historical reasons are forced to continue accepting the products of several vendors. Other utilities, especially smaller systems, prefer to standardize on a single product to facilitate procurement and stocking, and eliminate cross-vendor compatibility problems. Compatibility issues become more important with radio and other advanced technologies. The District therefore needs to consider this issue in implementation.

The major meter manufacturers include Invensys (formerly Sensus/Rockwell), Neptune (formerly Schlumberger), Badger, Hersey, Kent, and ABB.

METER MAINTENANCE

Meters need to be maintained, tested, calibrated and replaced over time, just like any other asset. Failed and low-reading meters cause complaints and lost revenue. Efficient utilities therefore strive to have consistent meter maintenance and replacement programs. The American Water Works Association (AWWA) C700 standard has specific testing periods for the various sizes and types of meters.

10.3 SUMMARY OF PROPOSED PROGRAM

CAPITAL COSTS

Meters and Registers

The District has estimated the cost to retrofit a water meter with meter box and radio transmitter at the property line on an existing service to be $750 in non-traffic areas and $1,125 in traffic (driveway) areas. These estimates are in line with detailed cost estimates that KWL recently completed for the GVRD[43].

Mission estimates that the cost of future new installations would be significantly lower because the property owner/developer would bear the cost of installing the meter box and setter. Mission would pay $300 to supply a 19 mm meter and radio unit for installation by the contractor during house construction. This cost is also reasonable.

Meter and Battery Replacement

Unlike touch-read technology, radio transmitters require new batteries after a number of years. Mission has assumed a battery life of 20 years but if it wanted to be more conservative it could use a life of 15 years. In any case it would likely replace the whole meter/register/transmitter package at that time. The estimated cost to replace the meter and battery is $260. A battery typically costs $30 and the average cost of a 19 mm meter body is $88 (30+88 = $118) plus labour + time value of money. The total cost would be in the order of $260.

OPERATING COSTS

Meter Reading Costs

The estimated cost is $1.42 per read. This compares to an estimated cost per read for the City of Abbotsford of between $1.15 and $1.60 for touch-read (refer to Section 7.3). Mission's estimate is reasonable for the initial period but it is noted that the cost per read will drop dramatically once sufficient numbers of radio units are in place that economies of scale will exist.

KWL's estimate uses $0.35 per read, assuming use of an automatic, vehicle-mounted receiver. This is based on 5,000 reads per day and four billing cycles per year.

It should be noted that the radio transmitter is the same regardless of the type of receiver used. Therefore the District can initially use a hand-held data recorder (HHD) equipped with an RF module, or a vehicle equipped with a more sophisticated meter reading transceiver and computer (mobile or drive-by). The HHD, though, can be used from a vehicle, and it is not necessary for the meter reader to get out of the vehicle to take a

[43] Reference to report 251.110.

reading. The vehicle merely needs to be within (typically) about 100 m. This application is also ideal for internally-mounted meters where access may be problematic, and for difficult, dangerous, or costly-to-read meters.

Billing Costs

The estimated cost is $5.90 per meter per bill. This estimate is considered conservative and the actual cost could be less once the program is implemented – refer to the discussion in Section 9.3.

KWL's estimate uses $5.00 per bill. This number is difficult to estimate (since billing involves several departments), but the quoted value is similar to values reported by the City of Vancouver (1999) and the City of Langley (2003).

Maintenance and Testing Costs

Mission estimates that 2% of all meters will require some repair or replacement each year. This percentage would have to gradually increase over time to reflect a meter life of about 20 years.

The AWWA C700 standard recommends that 19 mm bronze meters should be tested every 8 to 12 years. Assuming an installed base of 8,500 meters, this would require testing a minimum of 8,500 meters / 12 years = 708 meters per year, or about 8% of the installed inventory. However, this can be reduced by using statistical sampling methods as explained in the *AWWA Manual of Water Supply Practices: Water Meters – Selection, Installation, Testing, and Maintenance (Manual M6)*. This can significantly reduce annual meter testing costs. Specifics of such a sampling program need to be determined for each situation, but a much smaller number of meters – say 100 – selected randomly, can typically be tested per year, regardless of the overall meter population.

Large meters (50 mm and over) would have to be tested more frequently but these constitute a small fraction of the ultimate meter population.

Meter maintenance and testing would be done together, so the same number is used for the number of meters maintained annually. If each meter were assumed to take ½ hour to test and service based on AWWA's recommended testing requirements, then the costs would be roughly as outlined in Table 10-1.

An allowance should also be made for the initial capital cost of a meter shop, tools, and test bench.

Table 10-1: Estimated Annual Costs for Meter Maintenance and Testing

Description		Value
Time for test/maintenance per meter:	Hours	0.5
Time for testing/maintenance of small meters:	Hours	50
Assumed meter shop labour rate:	$/Hour	$45
Labour for testing/maintenance:		$2,250
Assumed annual transportation cost (20 km/day @ $0.40/km):		$2,000
Assumed related freight and shipping, postage, records management, and other:		$5,750
TOTAL		**$10,000**

IMPLEMENTATION

The proposal is based on installing roughly 800 meters per year over 15 years. If desired, it would be possible to significantly accelerate this implementation period. As noted, West Vancouver will install over 10,000 meters in just two years. The City of Surrey installs over 2,400 meters per year in new residential buildings, in addition to large numbers of retrofits under its $9 million voluntary metering program.

Faster implementation would allow the District to reap the benefits of metering sooner. The full management benefits – such as the ability to measure leakage and track demand patterns – would not be realized until essentially all the meters were installed.

It is recommended that the District consider this option.

10.4 METER READING TECHNOLOGY OPTIONS

For comparison purposes, this section uses a costing model to develop and analyze potential options for technology installation scenarios, as summarized in Table 10-2.

Table 10-2: Summary of Meter Program Cost Estimates

Scenario	Net Present Value
Touch-read	$8,749,653
Drive-by radio-read	$10,361,415
Fixed-base radio-read	$10,894,430
District's estimate (radio-read)	$12,688,000

The costs were estimated using a costing model that both documented assumptions and calculated costs. The costs are detailed in the appendices. It is emphasized that the costs in this table have been estimated at a preliminary level but reflect realistic assumptions.

The District's estimate for the overall cost of the metering program are assessed to be conservative: approximately $12.7 million vs. $10.3 million estimated by KWL.

The cost estimates are further detailed in the appendices of the final report.

10.5 SUMMARY

The District has considered implementing universal metering with radio-read technology. This program would be progressive, and the District would be only the second jurisdiction in the Lower Mainland (after West Vancouver) to do this. The use of radio technology would allow the District to easily bill monthly. The benefits of metering include the following:

- Metering provides an effective means of managing water system operations, facilitates water auditing, and provides essential data for system performance studies, facility planning, and the evaluation of conservation measures.
- Water audits evaluate the effectiveness of metering and meter reading systems, as well as billing, accounting, and loss control programs.
- Metering consumption of all water services provides a basis for charging users fairly and equitably – high users pay more, and thrifty users can reduce their bills.
- Metering encourages the efficient use of water. Although very conservative values for savings are used in this report, it is typical for water usage to drop by 20-30% overall, and up to 40% during peaks.
- Improved Cash Flow for the District (see above).
- Improved Budgeting for Customers.
- Improved Response to Leaks and High Consumption
- The Ability to Implement Seasonal Surcharges

Metering is not considered primarily a water conservation measure and the implementation cost should not be expected to be immediately offset by reduced demand. Most (though perhaps not all) of the cost of metering should be considered a normal part of water system management and hence should not be assigned to the water conservation 'account'.

The implementation period for metering should be relatively short, 2 to 5 years, in order to realize the benefits as soon as possible.

Section 11

Water Leak Detection

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11. WATER LEAK DETECTION

11.1 INTRODUCTION

This section provides a brief discussion of leak detection at an overview level. Detailed information about leak detection programs for the Abbotsford and Mission systems could be used to refine the discussion. Information that could be discussed includes current practices, problems, concerns, and goals from the Abbotsford and Mission Operations Departments.

The available statistics (Section 5) indicate that leakage is moderate in Abbotsford (less than 10%) but high in Mission (more than 20%).

11.2 ISSUES IN LEAK DETECTION

Extensive research on leakage detection technology, as well as detailed discussions of leak detection methods and best practices, are available from many sources, particularly the American Water Works Association. Much of this literature, however, is not directly applicable because of the unique conditions in the study area. For example, the soils in many areas are low permeability, meaning that leaks are forced to the surface (glacial tills in the uplands, clayey silts in the Fraser and other river deltas). The area that seems most affected by UFW (Mission) is also mostly unmetered.

The key to cost-effective leak detection planning is to customize the literature to the study area context. The Commission and the Municipalities have limited resources to apply to leak detection, and generally do not feel that leakage is excessive.

The main current challenges are managerial: collecting, storing and disseminating data in a systematic and planned way that can form the basis for program design.

The soil conditions should determine the leakage policy. Leaks may be easy to detect in glacial tills because the water comes to the surface. Technical leakage detection programs therefore should be concentrated on the areas that are underlain by sand and gravel, including both river fans and sand/gravel deposits.

11.3 PROPOSED APPROACH TO LEAKAGE DETECTION PLANNING

In the study area, leakage detection programs should be designed around soil conditions and improved management:

- Use GIS-based surficial geology information, overlain with watermain information, to prioritize the areas to target for technical leakage detection programs – essentially those underlain by sand and gravel.
- Use the GIS database to further prioritize based on pipe age, material, and joint types.
- Use literature and experience from other jurisdictions to develop tools for managing, prioritizing and reporting on UFW generally and leakage specifically.

The key to this approach is a GIS model that combines surficial geology information (soil types) with watermain information (age, material, pressure) to prioritize the leakage detection programs for each municipality. KWL has used such models in the past to assess seismic risks to watermains. The GIS model can be expanded as information is gathered over time.

Section 12

Summary and Recommendations

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12. SUMMARY AND RECOMMENDATIONS

12.1 SUMMARY

The key points in this report are summarized as follows:

WATER SUPPLY SYSTEM

1. The Commission draws its municipal water supply from Norrish Creek, Cannell Lake, and several groundwater wells in Abbotsford.

2. Most of the water supply is obtained from Norrish Creek. The Dickson Lake dam supplements water supply on Norrish Creek during low flow periods.

WATER LICENCES

3. The Commission holds two water licences for storage at Dickson Lake totalling 15,900 ML per year, and three water licences to divert water from Norrish Creek up to a combined maximum of 141.5 ML per day.

4. The largest water licence for the Norrish Creek water supply system includes a provision that flow released from Dickson Lake must exceed the intake withdrawal by 0.085 m^3/s whenever the flow over the intake weir is less than 1.42 m^3/s.

5. The Commission holds two water licences for storage at Cannell Lake totalling 1849 ML per year, and two water licences to divert water from Cannell Lake up to a maximum of 9.1 ML per day. Recent water withdrawals at Cannell Lake have exceeded the water licence limit.

HYDROLOGIC DATABASE

6. With funding from the Commission, Water Survey of Canada operates a hydrometric station above the Norrish Creek intake. There is also a WSC station downstream on the Norrish Creek fan.

7. The Commission manually measures lake levels at Dickson Lake regularly. Water level data for Cannell Lake is measured automatically by a station in the dam forebay.

8. The Commission measures releases from Dickson Lake and flow downstream of the Norrish Creek intake using hydraulic weirs. Water withdrawals from Norrish Creek and Cannell Lake are both metered.

9. There are limitations in historical precipitation measurements collected at Dickson Lake and the Norrish Creek intake. Records from the Dickson Lake station are

particularly scattered and unreliable. The closest Environment Canada climate station to Norrish Creek and Cannell Lake is Mission Westminster Abbey.

10. The BC Ministry of Environment snow course network includes a station above Dickson Lake.

WATER WITHDRAWALS

11. Average monthly water withdrawal (2000-2004) at the Norrish Creek intake ranges from 44.1 ML/day (January) to 65.9 ML/day (July).

12. Average combined monthly water withdrawal (2000-2004) from both Dickson Lake and Cannell Lake ranges from 55.8 ML/day (January) to 76.9 (July).

NORRISH CREEK INTAKE WEIR

13. The Norrish Creek intake weir controls the water level at the intake. The weir is also used to monitor flow passing to the lower creek system.

14. Flow release from Dickson Lake must exceed the intake withdrawal by 0.085 m^3/s whenever the flow over the intake weir is less than 1.42 m^3/s. The threshold of 1.42 m^3/s corresponds to a measured stage of approximately 0.34 m at the intake weir.

CANNELL LAKE STAGE-STORAGE RELATIONSHIP

15. The current stage-storage relationship uses the assumption of constant change in storage with elevation. This assumption is not valid for small lakes. Other data show that incremental storage volume at Cannell Lake increases at a rate of 2 to 4% per metre of elevation.

16. Independent data suggest that the current estimate of maximum licensed drawdown (about 274.65 m, based on the current stage-storage relationship) may be too high. The actual value may be less than 274 m. An update of the stage-storage relationship is warranted.

DICKSON LAKE STAGE-STORAGE RELATIONSHIP

17. The current stage-storage relationship for Dickson Lake involves a linear relationship between the spillway crest elevation and a low water elevation of 617 m.

18. Re-analysis of the available 1975 contour drawing suggests that the stage-storage relationship may be non-linear, with a licensed maximum drawdown of 618.2 m.

DICKSON LAKE WATER YIELD MODEL

19. A water yield model is used to predict whether inflow during a dry winter would be sufficient to recharge Dickson Lake from maximum drawdown to full pool before the next year's drawdown cycle commences.

20. The analysis assumes that the reservoir is at its minimum elevation on November 1 and that there is no outflow from the lake until it begins to spill.

21. For each of the three driest winters on record, the estimated inflow is sufficient to fully recharge the reservoir. The refill period is between six and seven months.

22. A frequency analysis based on total winter precipitation suggests that the driest winter on record (2000/01) has an estimated return period of slightly less than 100 years.

23. The frequency analysis indicates a preliminary probability of less than 1% per year that winter inflow will be insufficient to fully recharge the reservoir. This probability is dependent on drawdown patterns for the previous and subsequent summer seasons.

POSSIBLE RAISING OF DICKSON LAKE DAM

24. Dickson Lake has never been drawn down to more than half of its licensed drawdown; therefore, there is not presently a strong hydrologic justification for raising the dam. Nevertheless, several advantages could be realized by raising the dam, including decreased pumping costs and improved ability to meet fish flow requirements and future increases in water demand. A feasibility study would be needed to investigate this issue and determine whether this would be a cost-effective undertaking.

25. If Dickson Lake dam is raised, the possibility of achieving a full gravity discharge facility should be considered.

26. If storage at Dickson Lake is increased and fully utilized, the probability of dry-year winter inflows being insufficient to completely refill the reservoir will increase.

CURRENT DICKSON LAKE OPERATING CURVES

27. The operating curve for Dickson Lake has several areas that could be improved. These include the stage-storage relationship, integration with the Water Shortage Response Plan, and allowing for seasonal variations in demand.

28. Most importantly, the operating curve should reflect limitations on supply imposed by pump capacity. When Dickson Lake is at its maximum drawdown elevation, the existing pumps can supply less than 13% of the amount indicated by the operating curve.

CLIMATE CHANGE IMPACTS

29. The Lower Mainland is affected by cyclical variations in Pacific Ocean surface temperatures. These variations primarily affect precipitation, accounting for up to 45% of the annual precipitation variance in southwest B.C.

30. On top of natural climatic variability, there is growing evidence of human-induced climate change.

31. Of greatest concern to the Commission is the potential for higher winter temperatures (implying earlier peak runoff) and higher summer temperatures (implying greater evaporation).

32. If snowmelt occurs earlier in the year, the "low flow" season on Norrish Creek will be extended, requiring increased use of storage reserves from Dickson Lake.

33. Increased evaporation during the drawdown season would have a minor effect on storage reserves at Dickson Lake.

WATER SUPPLY SOURCE UTILIZATION

34. The Commission could benefit from an integrated regional source utilization program. The three key aspects to an integrated source utilization program include:
    - a sound hydrologic understanding of each water source;
    - operating plans to optimize the use of each water source; and
    - a Water Shortage Response Plan to effectively manage water supplies during peak demand periods.

35. The operating plan for the Commission's water supply system should focus on the Norrish Creek component since it supplies the most water. The water supply infrastructure can best be operated on the flow at the Norrish Creek intake. The need for water conservation can be based on the level of water storage at Dickson Lake.

36. Table 4-2 provides an operating plan for the Norrish Creek water source (including Dickson Lake) based on previous work by KWL.

37. Figure 4-1 provides a guideline for designation of water Shortage Response Plan stage based on Dickson Lake level.

WATER SHORTAGE RESPONSE PLAN

38. The Central Fraser Valley Water Commission implemented a four-stage Water Shortage Response Plan (WSRP) in 1994.

39. The 1994 WSRP is very similar to the one developed by the Greater Vancouver Regional District in 1993. The GVRD strengthened its WSRP after it was demonstrated to be successful during the 2003 drought.

40. The Commission's WSRP could easily be updated to correspond closely to the revised GVRD WSRP. This would take advantage of work already done by the GVRD and place water conservation in a more regional context for residents of the Lower Mainland.

41. The most relevant changes would involve strengthening the conservation measures for each Stage (particularly for municipalities), eliminating Stage 1 and introducing a new Stage 4 for extreme droughts, and synchronizing the start and end dates for sprinkling restrictions.

SEVERE DROUGHT ISSUES

42. Several temporary water supply measures are identified for possible implementation during emergency conditions resulting from a severe drought. These measures are typically complex and costly, and would require various regulatory approvals.

WATER DEMANDS IN ABBOTSFORD

43. The City of Abbotsford uses about 20 million cubic metres of water per year, or about 480 litres per person per day calculated as an aggregate value based on a service population of 114,000.

44. The estimated residential usage is 297 litres per person per day, which is in line with North American averages.

45. Unmetered usage is estimated to be 6%, which is considered low (i.e. good) by North American standards.

WATER DEMAND IN MISSION

46. The District of Mission uses about 6.6 million cubic metres of water per year, or about 695 litres per person per day calculated as an aggregate value based on a service population of 26,000.

47. Since the District is not metered, it is not possible to calculate residential usage, but this could be estimated by monitoring a statistically significant number of houses.

48. Similarly, water losses cannot be directly calculated. The given statistics, however, suggest that leakage and losses are much higher in Mission than in Abbotsford, likely over 25%. This could be quantified by further analysis, but an implied conclusion is that accelerated leak detection should be considered.

OPTIONS FOR WATER CONSERVATION AND DEMAND-SIDE MANAGEMENT

49. The Water Master Plan includes no programs for water conservation or demand management. Previous recommendations to DARD have not been implemented.

50. At the same time, the Commission faces rapid population growth that is stressing its water supplies and triggering the need for substantial capital investments – over $85 million in the next 16 years.

51. This report develops a recommended water conservation program consisting of bylaws, audits, rebates, leakage reduction, metering and pricing measures, namely:

    - low-flow toilet bylaw;
    - water waste bylaw;
    - home and ICI water audits;
    - low-volume toilet and waterless urinal rebate;
    - rain barrel rebate;
    - UFW reductions;
    - public education;
    - universal metering and volume-based pricing (Mission only); and
    - seasonal pricing (Abbotsford only).

52. If the recommended measures were fully implemented, the City of Abbotsford and the District of Mission could reduce their total average-day demands by between 6% and 34%, and between 15% and 48%, respectively.

COSTS AND BENEFITS OF WATER CONSERVATION

53. The needs for capital projects (both water supply and wastewater treatment) are triggered by rising water demands. If the peak day demand were reduced, some projects (and their associated O&M costs) could be deferred, thereby resulting in savings. Customers would also save money from reduced consumption.

54. Financial costs arise from the implementation of the water conservation programs, while environmental or economic costs arise from the extraction of water.

55. The following table shows two different benefit/cost ratios, an 'economic' and a 'financial'. The financial B/C ratio considers only direct financial benefits (from deferred costs) and costs (for program implementation). The B/C ratio of 0.57 shows that direct benefits would be less than direct costs.

56. However, if the residents of the City and District valued the intrinsic benefits of reduced water usage as a public, environmental and economic good, then an 'economic' B/C ratio could be used to make a case for conserving water. Using an intrinsic value of $0.05/m^3$ increases the B/C ratio to 0.77. A slightly higher value would increase the B/C ratio to over 1.0 for the program as a whole.

Estimated Costs of Water Conservation Programs	-$11,172,000
Estimated Benefits from Deferred Capital and O&M Costs	$6,422,000
Estimated Benefits from Intrinsic Value of Water	$2,148,000
Total Benefits Including Economic Value of Water	**-$2,602,000**
'Economic' Benefit/Cost Ratio	0.77
Total Benefits Excluding Economic Value of Water	**-$4,750,000**
'Financial' Benefit/Cost Ratio	0.57

WATER RATES

57. The City of Abbotsford has universal metering and charges almost all customers on a volume basis. Residential users and greenhouses are charged $0.56/m^3 regardless of amount consumed. ICI customers are charged on a declining-block scale so that the unit price decreases with consumption. This is done to attract and retain industry.

58. The District of Mission meters only ICI and agricultural customers. These are charged on a declining-block scale beginning at $0.42/m^3. Other customers are charged an annual fee of $270.

59. Declining-block rates do not promote water conservation, and for this reason a gradual phasing out of these rate structures would be consistent with a comprehensive water conservation plan, and would also be consistent with past recommendations.

METER READING AND ACCOUNT MANAGEMENT IN ABBOTSFORD

60. The City of Abbotsford reads its approximately 24,000 water meters once per year, and bills customers once per year as part of their annual property tax assessment.

61. If water conservation is a priority, then water charges should not be combined with other charges in this way, since the price signal is 'hidden'.

62. The potential benefits of more frequent and clear billing include the following:

- improved cash flow for the City;
- improved budgeting for customers;
- improved response to leaks and high consumption;
- improved incentive to save water;
- the ability to implement seasonal surcharges; and
- better system planning.

METERING IN MISSION

63. The District intends to implement universal metering with radio-read technology. This program would be progressive, and the District would be only the second jurisdiction in the Lower Mainland (after West Vancouver) to do this.

64. The use of radio technology would allow the District to easily bill monthly. The benefits of metering include the following:

    - provides effective means of managing water system operations, facilitates water auditing, and provides essential data for system planning and evaluation;
    - provides a basis for charging users fairly and equitably – high users pay more, and thrifty users can reduce their bills;
    - encourages the efficient use of water;
    - improves cash flow for the district;
    - improved budgeting for customers;
    - improved response to leaks and high consumption; and
    - enables implementation seasonal surcharges.

65. Metering is considered primarily a management tool, not a water conservation tool, and the implementation cost should not be expected to be immediately offset by reduced demand.

WATER LEAK DETECTION

66. The main challenges to leak detection are not technical but managerial: collecting, storing and disseminating data in a systematic and planned way that can form the basis for program design.

67. The soil conditions should determine the leakage policy because leaks are easier to detect in glacial tills where the water comes to the surface. Technical leakage detection programs, therefore, should be concentrated in the areas that are underlain by sand and gravel.

12.2 RECOMMENDATIONS

Based on the findings of this report, it is recommended that the Commission:

WATER LICENCES

1. Apply for an additional water licence on Cannell Lake to ensure that current use is in conformance with licensed limits.

HYDROLOGIC DATABASE

2. Continue to support the WSC hydrometric station on Norrish Creek above the intake.

3. Continue to upgrade the Dickson Lake facilities to monitor lake level and flow release.

4. Create a set of standard operating procedures to improve the reliability of the precipitation gauge at the Norrish Creek intake.

5. Add an automatic, all-season precipitation gauge at Dickson Lake to refine the relationship between precipitation at Mission Westminster Abbey, Norrish Creek Intake, and Dickson Lake.

6. Formalize procedures for processing and archiving all hydrologic data, with appropriate quality control provisions.

7. Consider working with the BC Ministry of Environment toward upgrading the Dickson Lake snow course to an automated snow pillow.

DICKSON LAKE FLOW RELEASE

8. Clearly establish the maximum flow release from Dickson Lake attainable with the current pump system under varying drawdown conditions.

9. Consider upgrading the pump facilities to meet short-term requirements.

CANNELL LAKE STAGE-STORAGE RELATIONSHIP

10. Update the stage-storage relationship for Cannell Lake based on recent survey data. If recent survey data is not available, perform a boat-based, GPS-linked survey of the near-shore areas of the lake at high water followed by a land survey at low water.

DICKSON LAKE STAGE-STORAGE RELATIONSHIP

11. Update the bathymetry of Dickson Lake by performing a boat-based, GPS-linked survey of the near-shore areas of the lake at high water followed by a land survey at low water.

12. Update the Dickson Lake stage-storage relationship based on the new bathymetry data. Assess related changes to the maximum reservoir drawdown elevation.

DICKSON LAKE WATER YIELD MODEL

13. Create a more detailed hydrologic model of the Dickson Lake watershed to better estimate reservoir refill potential at current and future storage levels. The model should address snowpack accumulation and depletion to accurately reflect timing of inflows, and should investigate lake seepage and concurrent water supply outflows under nominal and drought.

14. Perform scenario-based inflow analyses using the more detailed watershed model to improve estimates of the probability that the reservoir will not refill over a given winter season.

POSSIBLE RAISING OF DICKSON LAKE DAM

15. Undertake a feasibility study to evaluate the benefit and cost of raising Dickson Lake Dam. This analysis should consider the possibility of converting the existing pump discharge system to a gravity outlet.

CLIMATE CHANGE IMPACTS

16. Use a more detailed watershed model (such as the one described above) to explore potential impacts of climate change on the water supply.

17. Review water supply management activities as new information on climate change becomes available.

SEVERE DROUGHT ISSUES

18. Prepare an emergency plan for supplying water in the event that licensed storage at Dickson and Cannell Lakes is exhausted during a severe drought.

19. Consider defining a strategy for implementing any pre-requisite measures required by the resulting emergency plan (e.g. agreements-in-principle with regulatory authorities, emergency tie-ins, "package" filtration or disinfection systems, etc.).

WATER SUPPLY SOURCE UTILIZATION

20. Adopt the suggested Norris Creek operating plan outlined in Table 4-2.

21. Develop operating plans for Cannell Lake and the groundwater wells.

22. Define a strategy for collectively using the operating curves to identify the most appropriate stage of the Water Shortage Response Plan.

WATER SHORTAGE RESPONSE PLAN

23. Adopt the WSRP outlined in Table 4-4, with updated stages and restrictions to reflect those of the GVRD's updated WSRP.

24. Adopt the guideline for WSRP stage designation (Figure 4-1) based on Dickson Lake level.

25. Synchronize start and end dates for twice-per-week (Stage 1) sprinkling restrictions with those outlined in the GVRD plan to provide mutual reinforcement and common public relations opportunities.

WATER DEMAND

26. Continue to collect water demand data, and expand the analysis to generate statistics that are useful for planning purposes (indoor and outdoor water usage by customer type and per person; unmetered usage and losses, etc.).

WATER CONSERVATION

27. Implement the water conservation program outlined in this report.

28. For each conservation program, determine the associated benefits (avoided marginal operating costs, revenue recovery, and deferred or avoided capital costs) to confirm its net benefit (or cost).

29. Prioritize each program based on water and cost savings.

30. Set up an inter-jurisdictional water conservation committee, in accordance with a previous (1994) report.

WATER RATES

31. Phase out declining-block rates over time.

32. Complete the phasing over a period of about five years so that industries are not overly burdened.

METER READING AND ACCOUNT MANAGEMENT IN ABBOTSFORD

33. Issue water bills monthly or quarterly.

34. Issue water bills that are separate from and not combined with other charges such as property taxes or garbage.

METERING IN MISSION

37. Implement universal metering as intended.

38. Use a relatively short implementation period for metering, 2 to 5 years, in order to realize the benefits as soon as possible.

39. Consider the cost of metering as a normal part of water system management and hence do not assign them to the water conservation 'account'.

WATER LEAK DETECTION

40. Implement a leakage detection planning and management program as follows:

- use GIS-based surficial geology information, overlain with watermain information, to prioritize the areas to target for technical leakage detection programs – essentially those underlain by sands and gravels;

- use the GIS database to further prioritize based on pipe age, material, and joint types; and

- use literature and experience from other jurisdictions to develop tools for managing, prioritizing and reporting on UFW generally and leakage specifically.

41. Expand the GIS model as information is gathered over time.

42. Commence the water leak detection program in the District of Mission, since that is where the benefits are likely to be highest.

OTHER WATER CONSERVATION MEASURES

43. Expand future demand forecasts to incorporate the critical peak season usage.

44. Address limitations in the current water use data to facilitate a more refined analysis of current water use characteristics, and the potential for conserving water. Meter information should be collected and classified as to volume, customer type, service size, number of units (for stratas), and other relevant information.

45. Further analyze and disaggregate the components of ICI indoor, ICI outdoor, unclassified metered consumption, system losses, and UFW.

46. Undertake appropriate fieldwork, studies, and database management initiatives. These include audits, selective monitoring, documentation of O&M usage, metering, and GIS integration of data. This will require co-ordination of the annual reporting of all compiled information. It is noteworthy that this data would also have many other beneficial uses such as the calibration of both water and wastewater computer models.

47. Monitor changes in water use and water savings from conservation on a regular, ongoing basis so that demand forecasts and planning requirements can be revised accordingly.

48. Monitor and evaluate the effectiveness of all water conservation programs over time. In this regard, the effectiveness of the existing programs should be evaluated, taking into account climatic, demographic, and other factors.

12.3 REPORT SUBMISSION

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