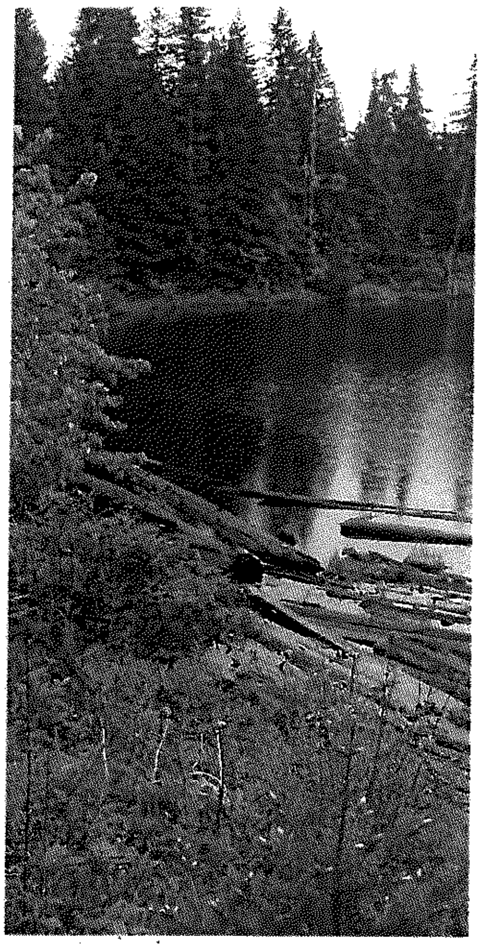
Village of Cumberland



WATER SYSTEM MASTER PLAN

ANDERSONCIVIL
Consultants Inc.

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EXECUTIVE SUMMARY

The Village of Cumberland has recently experienced a rapid increase in development activity, and further demands on the water supply system are anticipated.

The last comprehensive study of the water system was completed in 1986, although a number of smaller studies were undertaken up to 1998. A comprehensive dam safety review was undertaken in 2003 and extended in 2006.

This Water System Master Plan was commissioned to review the historical reports and summarise the sections that were still relevant, to assess and identify recommended improvements for: the source capacity; the supply and treatment systems; and the distribution system.

The watershed has the capacity to supply water for a much larger population. The storage volume is sufficient for the existing and immediate future population; however, as the demand increases, there will be a need to increase the storage volume further. There is undeveloped storage capacity under the existing water licenses.

With the exception of Allen Lake, the existing dams are in fair to poor condition. Work is required to confirm the extent of their deterioration and to bring the hydraulic safety up to the current standards. The cost of this urgent work is significant, but the consequence of a failure is worse.

The existing water treatment is by chlorination, which is the most basic form of treatment. It is not able to protect against the full range of expected pathogens or deal with aesthetic issues. In keeping with current practices in British Columbia, a more comprehensive treatment process is required. This will be an expensive undertaking and planning should start immediately.

The distribution system has been constructed in stages over the last 100 years. Older sections are generally small diameter pipes and many are in poor condition. The leakage loss of water is high (20% annually) and the level of fire protection for commercial, industrial and institutional buildings is poor in many areas. An upgrade programme is recommended to add a few key sections of pipe and to replace older and small diameter mains.

The report indicates estimated costs to implement the recommendations. Works required in the immediate and short-term have been identified. In the case of larger capital expenditure, further detailed studies are recommended to refine the scope and costs.

This report provides a route map to develop the water supply system over the next 10 years. The financial challenges are significant, but the current level of development in Cumberland provides an opportunity to build for the future.

1. UNITS

d	days
h	hours
igpd	Imperial gallons per day
igpm	Imperial gallons per minute
MG	Million Gallons (imperial)
MGD	Million Gallons per day (imperial)
m^3/d	cubic metres per day
ℓ/c/d	litres per capita per day
ℓ/s	litres per second
m	metre
mm	millimetre
mg/ℓ	milligrams per litre
µg/ℓ	micrograms per litre
∅	diameter
ADD	Average Day Demand
MDD	Maximum Day Demand
PHD	Peak Hour Demand
HGL	Hydraulic Grade Line

2. INTRODUCTION

The Village of Cumberland is located in the Comox Valley, south of Courtenay. The Village possesses its own water system which delivers water to its own residents and to the adjacent Royston Improvement District. The water system takes its supplies from two reservoirs located south of the Village: Allen Lake and Henderson Lake. Those reservoirs collect water from the Cumberland and Perseverance Creek Watersheds.

The last comprehensive assessment of the water system was done in 1986 by Dayton and Knight. Other studies have assessed different aspects including the supply trunk main capacity, the dams' safety and the water quality. Twenty years later, some of the suggested upgrades have been realized.

The Village of Cumberland has recently experienced an accelerated economic growth. Many new subdivision projects are under way, and further re-zoning applications are anticipated.

As part of the planning for the future, the Village of Cumberland commissioned AndersonCivil Consultants Inc. to prepare this Water Management Plan. This study provides a review of previous reports, an assessment of the existing system components, recommendations for further studies and steps to be taken in the future to ensure that the system will satisfy a growing population.

3. PREVIOUS REPORTS

The first part of the study was to review all available reports and summarise the content of those that are still relevant. A full list of sources reviewed and consulted is detailed in the References (Section 10).

The following is a summary of the principal information from each of the pertinent previous reports. To avoid error or confusion, units are generally those used in the original reports; occasionally metric conversions have been added.

i) Cumberland Creek Water Supply Study, Dayton & Knight Ltd., 1986

- The village of Cumberland takes its water from a total watershed area of 2,300 acres with an average elevation between 230 and 1,000 m. The Annual Average Precipitation was estimated to be 1,520 mm (60 inches).
- For design purposes, the 1/10 drought annual precipitation was taken to be 1,270mm and the 1/100 drought annual precipitation as 860mm.
- In 1985 the annual average per capita demand was 159 gpd (725 ℓ).
- Watershed yield was estimated suitable for 40,000 people based on the 100 year drought.
- Six storage reservoirs were identified.
- Reservoir 1 – Henderson dam
  - intake for the Cumberland creek watershed
  - washed out in December 1972 and rebuilt in 1973
  - intake el.253.38m, spillway el. 256.0
  - storage 0.8MG with 2.62m depth
- Reservoir 2 – Cumberland Lake (#2)
  - failed in December 1972 and caused the washout out of Henderson dam
  - rebuilt in 1973 with excess flow directed out of Cumberland Creek watershed into Perseverance Creek downstream of Allen Lake dam
  - outlet 400Ø pipe below dam elevation 449.08 m, overflow channel elevation 452.06 m
  - storage 16MG with ≈ 2 m depth
- Reservoir 3 – Hamilton Lake
  - outlet 200Ø pipe below dam elevation 539.97 m, high water mark (with planks) 545.7 m
  - storage 45MG with 4.3 m depth

- Reservoir 4 – Stevens Lake
  - upgraded in 1980 with no additional storage
  - outlet 300Ø pipe below dam elevation 606.27 m, high water mark (with planks) elevation 611.2 m
  - storage 36MG with 4.9 m depth
- Reservoir 5 – Van West Lakes
  - presently draining out of Cumberland Creek watershed, some water may drain to Cumberland Creek watershed under high lake level
  - no storage
- Reservoir 6 – Allen Lake
  - dam reconstructed and raised in 1961-62
  - intake elevation 221.6 m, spillway elevation 225.8 m
  - 80MG with 3.9 m depth

Total storage is assumed to be necessary for 90 days during summer; drought year conditions mean no extra input during that 90 days period. 25% of total storage is assumed to be lost through evaporation and leakage from dams.

For extra storage Allen Lake and Stevens Lake would be best for increasing. They are the most cost-efficient in terms of volume gained for dam construction.

- Existing trunk Mains:
  - intake at Henderson Dam elevation = 256 m
    - ~ 1,300m of 300Ø to junction
  - intake at Allen Lake elevation = 227 m
    - ~ 800m of 300Ø to junction
  - 1050m of 300Ø from junction to water chlorinator
  - 1050 of two separate 300Ø to Dunsmuir Street at First Street and Sutton Avenue
  - capacity estimated at 2.5 MGD

Reports recommend installing a new 300Ø trunk main from junction to chlorination station with new flow control valve at junction to upgrade capacity of system.

ii) <u>Capacity and Upgrading Of Trunk Watermains, Dayton & Knight Ltd, 1991</u>

- Royston is supplied by a 2,800 m long, 200Ø watermain on Dunsmuir Avenue.
- The 200Ø Royston supply main has a theoretical capacity of 1.0 MGD (4,000 m^3/day), based on sufficient water at Dunsmuir Avenue.

- Royston reservoir has a capacity of a little over 1,125 m^3. An altitude valve limits the flow to the Royston reservoir to 600 igpm (45.46 ℓ/s).
- The report recommended that the watermain supplying Royston be doubled with a 250Ø in three phases; 720 m, 1280 m and 975 m to Royston reservoir for a total of 2,975 m.

iii) Allen Lake Dam Study, Dayton & Knight Ltd., 1993

- In 1992 the village built a control valve and chamber at the junction between the Allen Lake system and Henderson Lake systems.
- Allen Lake provides the most cost-efficient and beneficial storage increase for Cumberland water system.

Allen Lake dam is the key storage for Cumberland's water system. It can be filled by both its own watershed and from the Henderson Lake (Cumberland Creek) system.

- Dam consisted of 2 parallel concrete walls with earth fill in between.

Leakage at the toe of the dam measured to be 6 ℓ/s which is 4 to 8 times what was noted in 1985.

Two 1.2 m diameter CMP with stop logs were located at invert elevation 225.8 m passing through the spillway which had an elevation 227.16 m. The dam continuing the spillway had a top elevation of about 228 m.

Stop logs were installed in spring to seal the culverts and one stop log could be installed in the spillway itself to maximize storage. Everything was kept open in winter to allow storm run-off events to go through.

The old intake had 3 openings: 1.28 m, 2.20 m and 3.11 m below the spillway.

The top of the bellmouth was 4.02 m below the spillway elevation.

80MG of storage was assumed over the 4.02 m depth.

- A stability analysis revealed that a rapid drawdown of the lake could result in slumping of the upstream face and a severe earthquake could liquefy portions of the dam.

The study recommended that the present dam be removed and replaced with new structure.

iv) Allen Lake Dam Reconstruction, Operation and Maintenance Manual, Stanley Consulting, 1997

- A new earth fill dam was constructed at Allen Lake during September and October 1996.
- The new dam is 9m high and the crest length is 90m long.
  New crest elevation 231.0m
  Top water el. 229.5m
  Max flood water el. 230.1m
  Crest width, 4.0m
  Low water el. 224.0m
  Storage vol. 120MG
- No stop logs are required to store water with the new installation.
- The spillway was relocated to the north east along with a new channel. The discharge from the spillway crosses the access road downstream.
- Three 400Ø CSP allows flow under the road, while the winter and spring peak flow are directed over the road at a shallow depth. Remedial work and armouring the road embankment was done after a wash-out of the road in the spring of 1997.

v) Allen Lake Water Quality, Dayton & Knight Ltd., 1998

- After poor water quality during summer of 1998 the Village asked for possible options to improve water quality.
- The turbidity and color values were higher than usual and so different solutions were assessed including:
  - change depth and location of intake
  - have adjustable intake level and
  - revise the circulation pattern
- The study indicated that the poor water quality was constant throughout the lake. Extensive warm weather and sunshine during summer of 1998 may be responsible for poor quality.
- There is presence of algae in the water throughout the lake.
- Solutions are all associated with treatment process including filtration and use of chemicals.

vi) Partial Removal of the Main Dam Portion, Hamilton Lake Dam, Cumberland, EBA Engineering Consultants Ltd., 2003

- After the downstream slope of the Hamilton Lake failed in late March 2003, the Village had to dewater the lake to allow either repair or removal of the Hamilton Lake Dam.
- The removal of the dam reduced the available freeboard at Cumberland #2 Lake (the next reservoir downstream of Hamilton Lake) during extreme rainfall events.
- The spillway structure replacing the dam at Hamilton Lake is a temporary structure and should be removed or replaced with a permanent structure before August 2008.
- The current spillway is classified as a dam. It is 3.0 m high (2 m of fill left in place from previous dam structure + 1 m of rip rap of 0.6 m to 1.5 m diameter), with upstream slope of 3H:1V and an overall downstream slope of 10H:1V.
- The spillway has a width of 25m on top and decreases to 8 m to connect with the natural stream channel. The spillway retains 2 m depth in lake and 3 m depth during flood events.
- The new spillway can store 105,643 m3 (28MG) over a 2.4 m depth.

vii) Dam Safety Review, Cumberland Creek Dams, EBA Engineering Consultants Ltd., 2003

This dam safety review offered these recommendations:

- Henderson Lake dam requires borehole investigation and stability analysis.
- Old #1 Dam should be removed because of the risk that it will fail. A failure would provoke a flood wave in Cumberland Creek causing the washout of Henderson Lake dam below.
- Cumberland (#2) Dam:
  - The crest needs to be raised to give adequate freeboard during the design inflow flood.
  - A spillway of adequate capacity is required.
  - The discharge pipe through the dam and control valve requires repair and improvement.
  - The dam requires borehole investigation and stability analysis.

- Hamilton Lake dam:
  - The temporary lower spillway must be replaced or removed before August 2008, in accordance with the temporary authorization.
  - If the dam is rebuilt adequate free board and spillway capacity are required.
- Stevens Lake dam:
  - The dam requires borehole investigation and stability analysis.

There are numerous other studies and reports dating back as far as 1955 which addressed the condition of the dams and made recommendations for repair. These reports have not been reviewed or documented for this Master Plan. The reports prepared by EBA Engineering Consultants Ltd. in 2003, and subsequently, clearly identify the recommendations for repair, maintenance and operation of the Village's dams.

4. SUPPLY COMPONENTS

4.1 Assessment of Existing System

The sources for all drinking water in Cumberland are five lakes on two adjacent creeks. On Cumberland Creek, Stevens Lake is at the highest elevation and discharges downstream through Hamilton Lake, Cumberland #2 Lake to Henderson Lake. This watershed is 1,814 acres (734 ha). From Henderson Lake the water is piped through a Pressure Reducing Valve (PRV) to join the Allen Lake supply.

Allen Lake is located on Perseverance Creek which collects Cumberland Creek lower down as it flows to Comox Lake. The Allen Lake watershed is 642 acres (260 ha). From Allen Lake the water is piped to connect with the Henderson Lake supply at the PRV, then downstream in a single pipe to the chlorinator and flow meter.

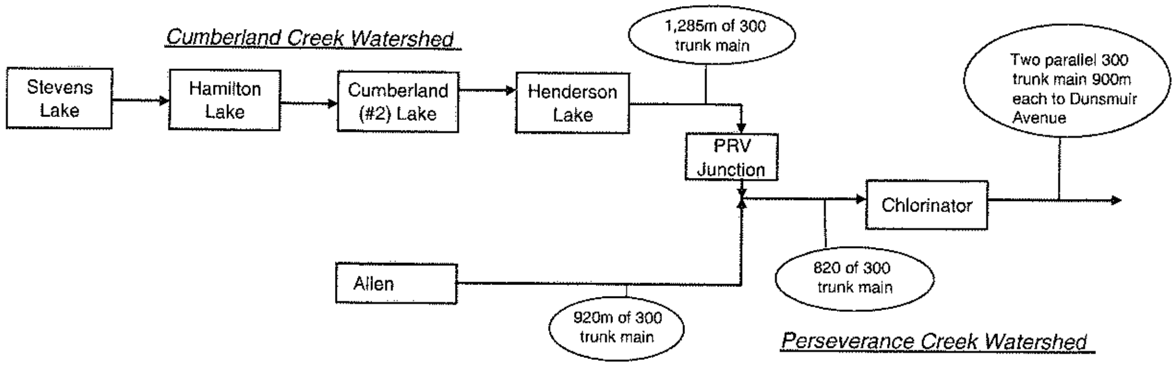
Allen Lake top water level (TWL) is 229.5 m. This elevation supplies the Cumberland distribution system without any further restriction or flow control.

The water in Cumberland Creek is controlled by regulating the discharge from each lake directly into the creek flowing downstream, from Stevens Lake to Henderson Lake, by setting a gate valve on each outlet. Some leakage through each dam contributes to the downstream flows.

The final abstraction is at Henderson Lake (TWL 256 m). This lake has a relatively small volume (3,637 m^3) and serves only to balance the flows into the pipe. Downstream, the PRV is set to control the flow into the Village supply system. If the PRV is set high, the flow from Allen Lake is limited and in fact water from Henderson Lake can be fed to Allen Lake. If the pressure is set lower, more water is taken from Allen Lake to supply the system. (Refer to Operating Instructions, Appendix E.)

The PRV system can be operated as either constant pressure, with flow balancing by Henderson Lake, or as constant flow, with flow balancing by Allen Lake.

Figure 4.1 showing reservoirs and flow path through watershed



4.2 Assessment of Source Capacity

4.2.1 Inventory of Individual Catchment, Lakes and Streams

Table 4.1 - Reservoir data

Reservoirs	Estimated Actual Storage(m^3)	Elevation (m)	Surface (ha)	Depth (m)	Tributary Area (ha)
Henderson Lake	3,600	256	0.2	2.62	72
Cumberland (#2) Lake	72,700	452	1.7	2.9	143
Hamilton Lake	*before 2003* 204,600	552	8.5	4.4	156
	after 2003 106,000	550	4.5	2.4	
Stevens Lake	163,700	611	5.7	4.9	285
Allen Lake	545,500	229.5	12.7	5.5	331

Note: Data taken from Cumberland Creek Water Supply Study-D & K (1986) and Hamilton Lake Dam Decommissioning-EBA (2003)

4.2.2 Review of Water Licences

The Village of Cumberland currently owns two water licenses for diversion (abstraction) purpose. The Village also owns five storage licenses, three on Perseverance Creek and two on Cumberland Creek.

Table 4.2 details the licensed volumes for storage and abstraction at each location.

Table 4.2 – Summary of Water Licences

Licence #	Lake	Abstraction (m^3/day)	Licensed Storage (m^3)	Constructed Storage (m^3)
19538	Allen	2,273		
19539	Allen		185,000	
111029	Allen		175,000	
118187	Allen		185,000	
	Total	**2,273 m^3/day**	**545,000 m^3**	**545,000 m^3**
13872	Henderson	3,400	Nil	3,600
13873	Stevens		176,000	163,700
13873	Hamilton		302,000	106,000 *
13873	Cumberland #2		58,000	72,700
	Total	**3,400 m^3/day**	**536,300 m^3**	**346,000 m^3**
21933	Vanwest	Nil (Included in #13872)	123,300	Nil
	Total		**123,000 m^3**	

* reduced volume after 2003

The following should be noted from the table:

- The point of abstraction is still licensed as the #1 Dam site, and does not appear to have been relocated to Henderson Dam.
- There is no licensed storage at Henderson Lake.
- There is 12,300 m^3 additional storage allowed at Stevens Lake.
- There is 196,000 m^3 additional storage allowed at Hamilton Lake above the existing condition.
- The storage at Cumberland Lake #2 exceeds the license by 14,700 m^3.

- Additional storage of 123,000 m^3 is available if a dam is constructed at Vanwest Lake.
- Allen Lake storage equals the licensed capacity.
- The maximum licensed rate of abstraction is 5,673 m^3/day (1.25 MGD).

Appendix F includes a detailed tabulation of all the water licenses, together with a copy of each one.

4.2.3 Preliminary Assessment of Potential Runoff

The Cumberland Creek Water Supply Study – 1986 (Dayton and Knight) estimated that the Cumberland Creek could yield enough water to supply a population of up to 40,000 people during a 1/100 year drought. For reference, their Chapter 3 is included in Appendix D.

The minimum watershed yield is 6 to 9 times the storage volume; therefore the supply is limited by the storage, not the watershed yield.

A separate study for Kensington Properties has been commissioned in 2007 to evaluate the watershed capacity.

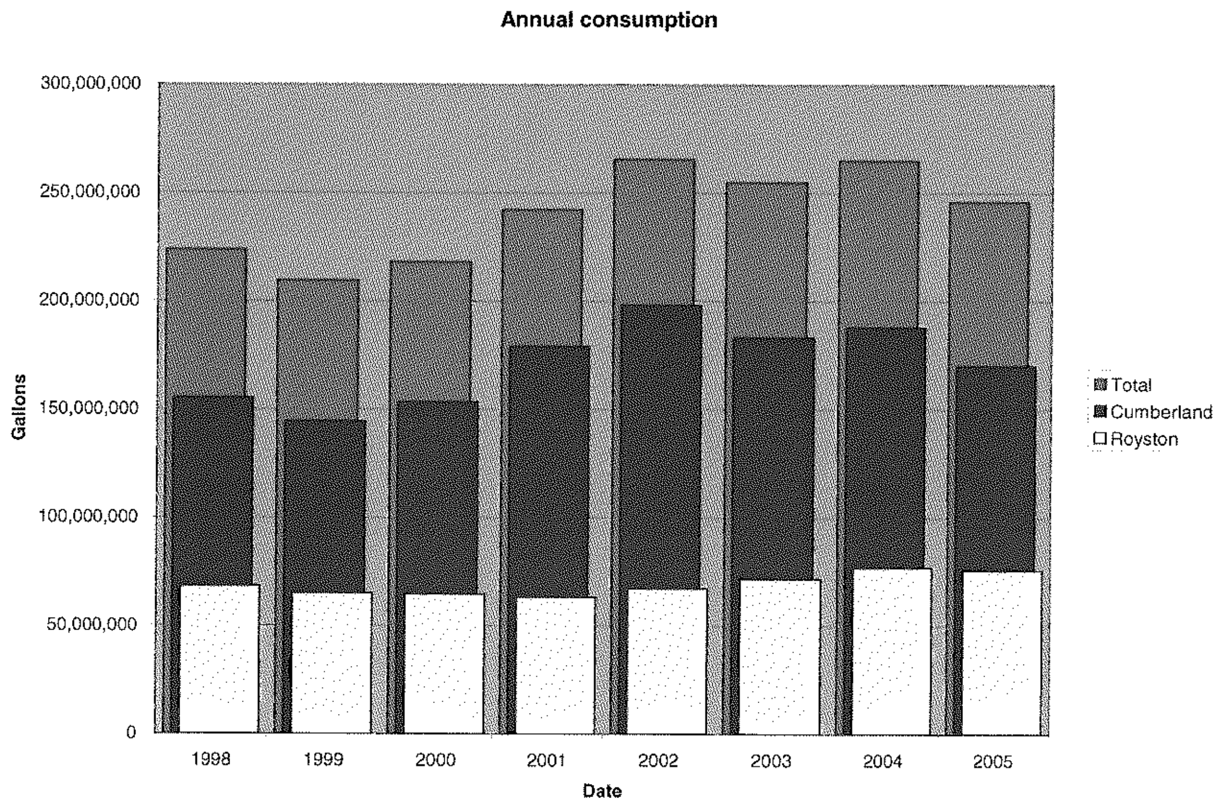
4.3 Water Consumption

4.3.1 Historical Water Use

To determine the existing water consumption pattern of Cumberland and Royston, flow records from 1997 to 2006 were analysed. Annual data from 1982 was available from earlier reports, and from 1994 to 2004 monthly totals from Village data. All water passes through a meter at the chlorinator building. Flows are recorded on 7-day circular charts and by a totaliser. Totaliser recordings and the meter at the Royston tank are manually logged every day from Monday to Friday.

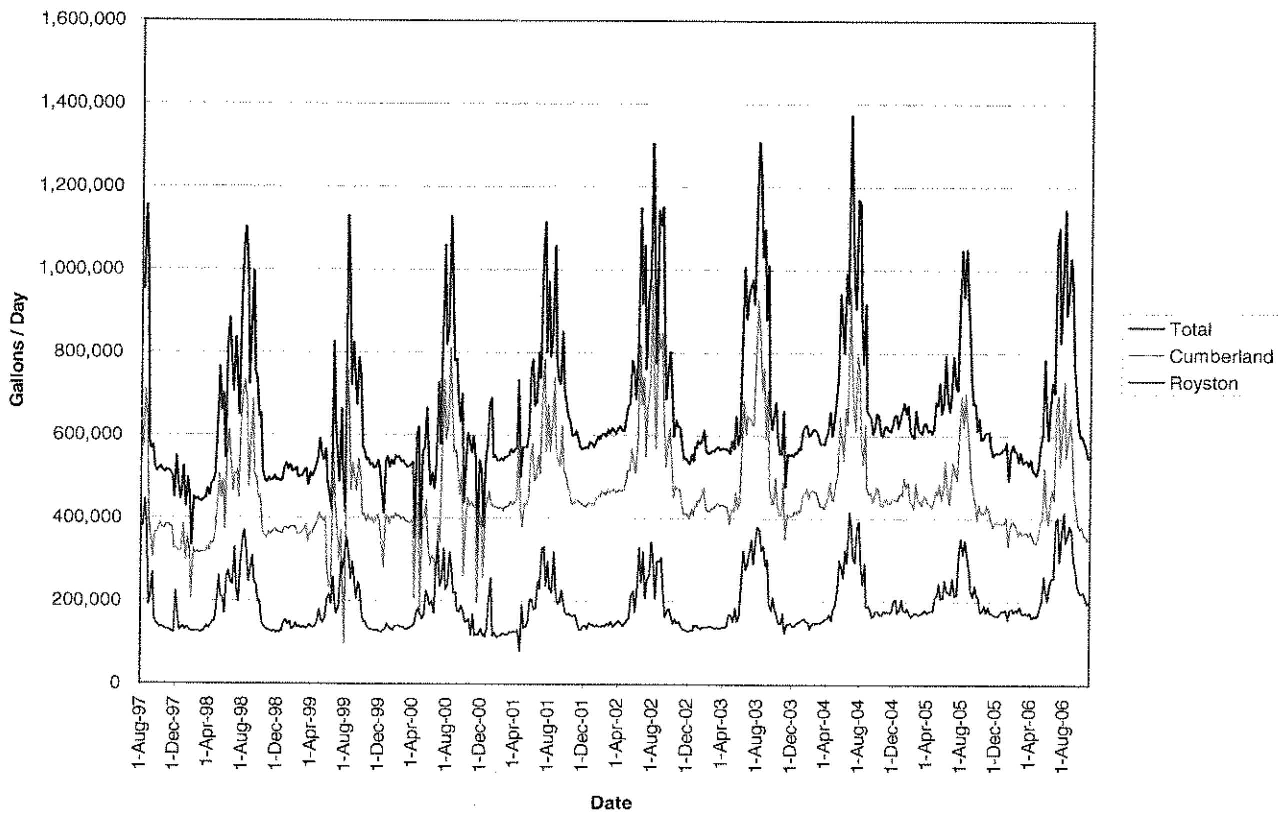
The manual records for the last ten years were entered into a spreadsheet for analysis. For the ten years of records, weekly values were entered for total flows and for Royston flows; by subtraction, the Cumberland flow is calculated. These results are displayed in Chart 4.1 Annual Consumption, and Graph 4.1 Weekly Flow Rates.

Chart 4.1 – Annual Consumption



For the peak months, daily records were analyzed and the weekly charts examined. The graph for weekly flows shows the pattern of consumption throughout the full year. Consumption is lowest from November to May each year. June, July and August are the highest, with the shoulder seasons dependent on the weather pattern experienced in each year.

Graph 4.1 – Weekly Flow Rates



The population for Cumberland and Royston was calculated from the number of water services connected in each year and using the Statistics Canada data for average people per house in each jurisdiction.

Data for 1986 is 2.57, and for 1991 is 2.66 people / dwelling. A uniform 2.62 was applied to later years. Similar data gave a value of 2.68 people / dwelling to use for Royston.

Census figures for total population were correlated where available.

Table 4.3 – Past Population

Year	Cumberland		Royston		Total Population
	Water connection	Population	Water connection	Population	
1985	797	2,000	678	1,800	3,800
1987	795	2,000	692	1,840	3,840
1988	792	2,000	706	1,880	3,880
1989	790	2,000	720	1,915	3,915
1990	787	2,000	735	1,955	3,955
1991	785	2,000	750	1,995	3,995
1992	806	2,099	756	2,012	4,111
1993	828	2,203	762	2,025	4,228
1994	850	2,313	768	2,037	4,350
1995	873	2,428	774	2,049	4,477
1996	897	2,548	780	2,062	4,610
1997	921	2,562	786	2,075	4,636
1998	946	2,576	792	2,087	4,663
1999	972	2,590	798	2,100	4,690
2000	998	2,604	804	2,144	4,748
2001	1,000	2,618	811	2,187	4,805
2002	1,001	2,623	817	2,190	4,812
2003	1,008	2,641	820	2,198	4,839
2004	1,014	2,657	828	2,219	4,876
2005	1,021	2,675	839	2,249	4,924
2006	1,046	2,741	853	2,286	5,027

Based on these records the average annual, average summer and peak day demands were determined. These are shown in Table 4.4 below.

Table 4.4 – Water Consumption 1997 – 2006

	Cumberland (ℓ/c/d)	Royston (ℓ/c/d)
Average Annual	830	425
Average Summer	1,100	575
Peak Day (Summer)	1,600	825
Peak Hour	2,430	n/a

*Note – includes system losses and community uses.

For comparison, the following Table 4.5 shows typical design standards for municipal water systems on Vancouver Island. The City of Nanaimo is the only water system to be fully metered.

Table 4.5 – Typical Design Standards

	Average Day Demand (ADD)	Maximum Daily demand (MDD)	Peak Hour Demand (PHD)
MMCD	600L	1200L	1800L
City of Nanaimo	455L	1,135L	1,820L
District of North Cowichan	682L	1,364L	2,046L
City of Courtenay	635L	2,100L	3,000L
District of Campbell River	635L	2,100L	3,000L

4.3.2 Detailed Analysis of Records

Additional selected data was abstracted from the circular charts. By inspection, typical charts were selected for analysis. (Refer to Appendix G).

The charts show the instantaneous total supply to Cumberland and Royston combined. The flow to Royston shows clearly when their reservoir is filling – the total flow steps up or down by a fixed amount. The duration of the reservoir filling depends on the rate of demand downstream. On peak summer days the tank is filling for 20 hours out of 24. This is not a big margin for emergencies or increased demand. The flow to Royston shows approximately 22.7 ℓ/s (≈ 300 igpm – with variation from 280 to 340 igpm).

Dayton & Knight, 1991, noted that the Royston tank is filled with an altitude valve that limits flow to 600 igpm (45.46 ℓ/s).

At night, in winter, and when the Royston flow is off, the charts show a minimum flow of approximately 70 igpm. This is interpreted to be a constant system leakage loss. It is equivalent to 170 ℓ/c/d. This is 20% of the Average Annual Demand (Table 4.4). Anything over 10% is generally considered to be high.

A review of Cumberland consumption rates, and subtracting the losses, provides a good approximation of the average annual domestic demand. This exercise identifies the consumption rate as 660 ℓ/c/d. This number is a more reasonable domestic demand for un-metered connections.

For the existing combined population of Cumberland and Royston, the summer Peak Day Demand on the Lakes and supply mains is 71 ℓ/s (937 igpm, 1.35 MGD).

By observation and interpretation of the circular charts for peak weeks, the Peak Hourly Demand for the existing combined population is 98.5 ℓ/s (1,300 igpm) taken from June 16th - 22nd, 2004, flow chart. It is also during that same period that the Cumberland water system experienced its highest day demand over the last 10 years of records.

The Peak Hourly Demand for Cumberland alone is estimated at 76 ℓ/s (≈ 1,000 igpm). This is equivalent to 2,430 ℓ/c/d (535ig/c/d). A similar interpretation was not performed for Royston, although the duration and frequency of flow to the tank contains this information.

4.3.3 Allocation of Demand

Until 1996, the demands of Cumberland and Royston were similar, particularly in summer. From 1996 to 1998, the Royston demand dropped significantly to approximately half what it would have been projected to reach.

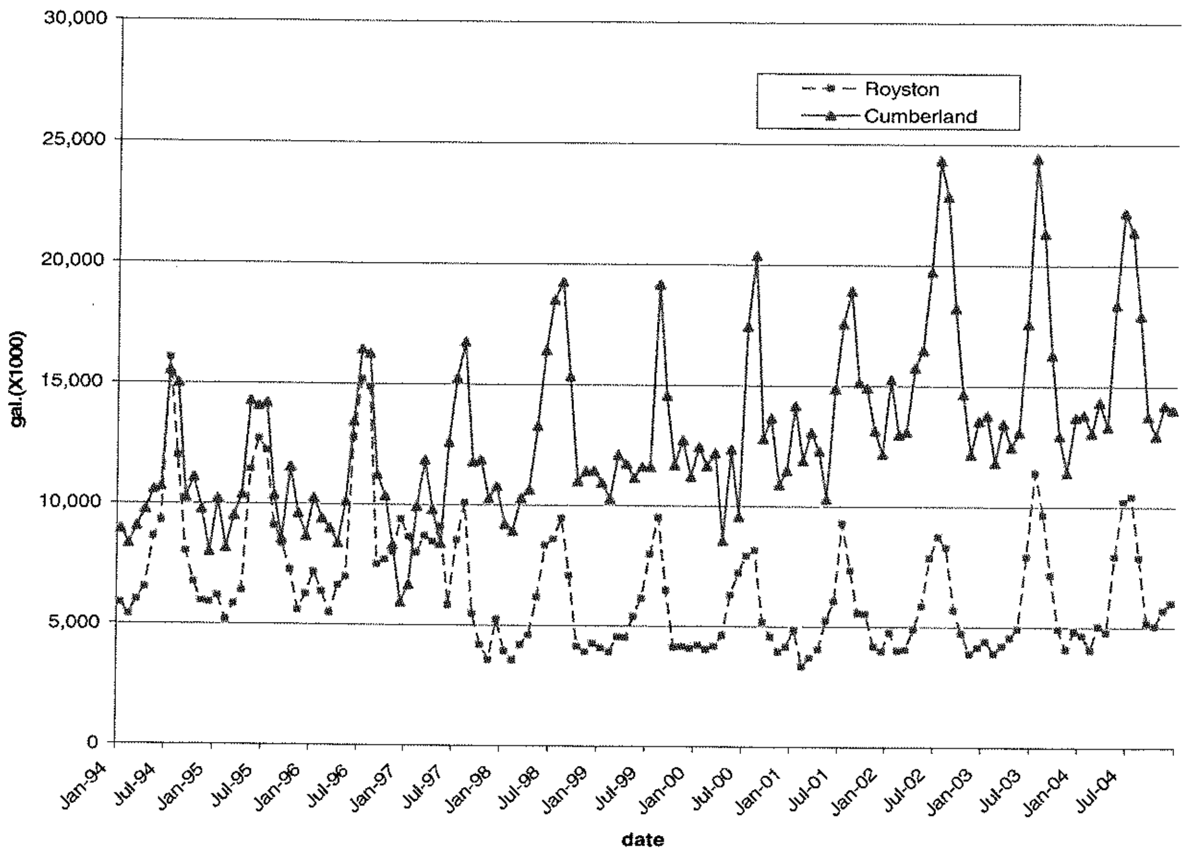
In 1997 Royston Improvement District implemented universal metering of all water supplied. This reduced consumption in a number of ways including:

- Consumer awareness of the value of the resource and more prudent use of water.
- Identification of leakage and wastage on private property by customers.
- Clear identification of the loss of water from the point of purchase from Cumberland to the point of sale to customers.

This reduction in demand in Royston is consistent with the experience of other metered communities on Vancouver Island. The reduced demand allows existing infrastructure to service a greater population without the expenditure of significant additional capital.

The following Graph 4.2 shows the Cumberland and Royston consumption based on monthly totals from 1994 to 2004.

Graph 4.2 – Monthly Water Consumption

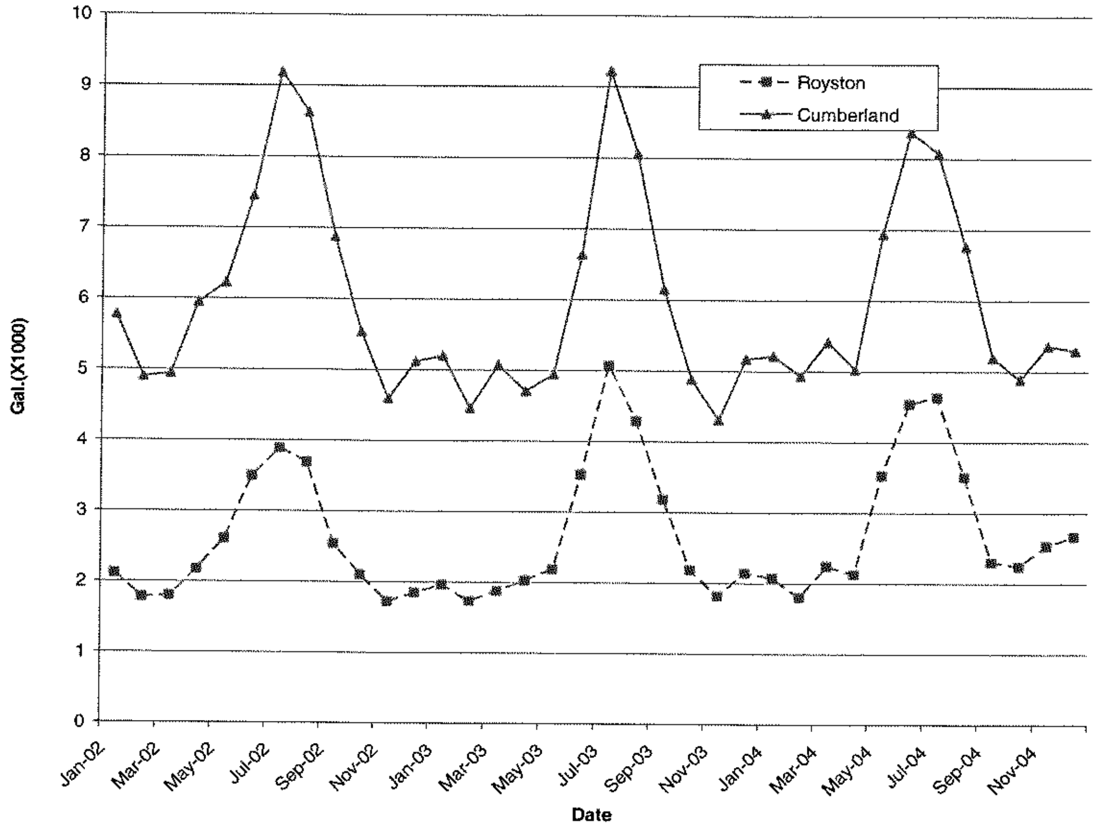


The average and peak demands for Cumberland includes commercial, industrial, institutional and public use of water. Without more information it is not possible to separate these uses from domestic consumption. With the exception of public use (e.g. the water park), the remainder will be approximately uniform throughout the year.

The per capita average and peak demands by Cumberland are approximately double those of Royston.

This is shown clearly on Graph 4.3 below.

Graph 4.3 – Monthly Water Consumption per Capita



4.3.4 Assessment of Required Storage

With climate change, longer dry periods may become more and more frequent over the years. Long term weather records show negligible precipitation in July and August and very little in June and September. In 2006, there was no significant precipitation from the end of May until late October – 150 days. The Village of Cumberland must ensure it has enough storage to supply the average summer day demand for the entire dry period.

The storage period is based on observation of the water demand, which increases rapidly in early June and falls off in late September. This represents four months of higher demand. An analysis of historical lake levels or precipitation records might yield a different period. The figure of 120 days is considered suitable for the Master Planning level of this study.

No allowance has been made for any lake recharge by flow from groundwater in the late spring. This is beyond the scope of this study.

By analysis of consumption records 1998 – 2006, the total consumptions per capita over the 120 summer days are:

Table 4.6 – Summer Water Consumption

	Total Summer Consumption (m^3)	Population	Per Capita (m^3)
Royston	154,000	2,200	70
Cumberland	364,500	2,700	135
Total	518,500	4,900	

Projection of future demands are addressed in detail in Section 7.

The storage licenses on both Perseverance and Cumberland Creeks represent a total of 877 Acre-feet (1,080,000 m^3). The Vanwest Lakes license could provide the Village with 100 Acre-feet (123,000 m^3) more storage, but this storage has not yet been developed.

In Perseverance Creek, the Village of Cumberland possesses three storage licenses, which are all used with Allen Lake. Those three licenses reflect the upgrades done to the dams. The first one is 150 Acre-feet (185,000 m^3) dated from 1897, another one was acquired in 1968 for an additional 150 Acre-feet (185,000 m^3) and lately in 1996 a third one was added for 142 Acre-feet (175,000 m^3) more.

The estimated storage volume is 120 MG (545,000 m^3) in Allen Lake (Stanley, 1997). This is the maximum allowed by the licenses.

In Cumberland Creek, the Village has a license to store up to 435 Acre-feet (535,000 m^3) dated from 1897. Currently the Village is storing about 76 MG (346,000m^3) in four lakes on the creek. This reflects the lowered Hamilton Lake (2003). The total volume of existing storage (Table 4.1) is 891,500 m^3.

Based on the existing license, another 189,000 m^3 (41 MG) storage could be added on Cumberland Creek.

Lake surface evaporation in the summer is based on the surface area. Values for the evaporation rate are from "Comox Lake – Water Survey Canada – Calculated Average Monthly Lake Evaporation for the Period 1951 – 1980".

June	125.8 mm	
July	143.1 mm	
August	116.5 mm	
September	66.4 mm	
Total:	451.8 mm	(0.452 m)

Total evaporation volume from each lake is shown in Table 4.7 below.

Table 4.7 – Surface Evaporation

Lake	Surface Area (m^2)	Evaporation (m^3)
Stevens	56,500	25,540
Hamilton	87,500	39,550
Cumberland #2	17,500	7,910
Allen	127,000	57,400
Total	**288,500**	**130,400**

This evaporation volume must be included in the total storage requirements.

As noted above, the total existing storage is 891,000 m^3 (196 MG). Subtracting the evaporation leaves 761,000 m^3 (152 MG) for water supply demand. With the typical projected 120 day demand of 518,500 m^3, there is still 32% storage left. For the actual consumption June – September 2006 (4 months) of 560,000 m^3 there was 26% excess storage. The 2006 consumption in Cumberland was affected by water restrictions imposed in August and September.

None of the water licences include any provision for minimum release of flows downstream. Current practice is to require a release with all new approvals. Since an approval will be required for reconstruction of Henderson Lake dam, it is possible that adding a guaranteed minimum release might be part of these negotiations.

The low flow release would be required to sustain downstream fish and aquatic environment. Target flows are usually 10% of Mean Annual Discharge (MAD) and are established in agreement with Fisheries and Oceans Canada (DFO).

Flow monitoring was conducted in Perseverance Creek in 2005, although the results were inconclusive due to missing information in flow gauging (Perseverance Creek Flow Monitoring Study 2005, DFO, May 31, 2006). Further study will be required to obtain the technical basis to establish a suitable minimum flow release.

As an estimate of the potential impact on storage volume, a release of 10 ℓ/s (135 gpm) over 120 days would represent 104,000 m^3. This is approximately the total volume stored in Hamilton Lake, or the volume lost when the spillway was lowered.

4.4 Assessment of Existing Supply Mains

Presently the water is conveyed from the sources through 300Ø ductile iron and AC (asbestos cement) mains. From the intakes of each lake, Allen and Henderson, it runs through separate trunk mains until it reaches the PRV junction. Here the pressure from Henderson Lake is reduced to approximately match Allen Lake. From this point, the supply runs in a single 300Ø pipe for a total length of 820 m to the chlorination station. Past the chlorinator the trunk main is then duplicated in two pipes that run to the distribution system at Sutton Drive and First Street on Dunsmuir Avenue. (Refer to Figure 4.1).

The Cumberland Creek Water Supply Study, 1986, Chapter 5, identified a highpoint on the route from the PRV to the chlorinator. This may limit the capacity of the main and the ability to achieve peak flows from Allen Lake alone.

Since the reservoirs serve as supply and storage for the Cumberland water system, the trunk main must have the capacity to supply either of *maximum day + fire flow* or *peak hour* demands, whichever is the greater.

Royston is served by a supply line running in Dunsmuir Avenue and Royston Road to the Royston Tank. This includes 2,000 meters of 200Ø AC pipe from the 300Ø trunk main to Union Rd and a new 800 meters of 300Ø PVC running along Royston Road from Union Road under the Inland Island Highway to the Royston tank.

Cumberland should ensure it is able to supply Royston's Maximum Day Demand (MDD). Because Royston is supplied from a reservoir, it is not necessary to provide Peak Hour Demand (PHD) or fire flow directly through the Cumberland supply. The Royston tank should have the necessary storage to handle peak hour demand and fire flows in excess of MDD.

4.4.1 Scope of Improvements

Assuming a friction coefficient of C =130 and a high point 6 m higher than the Pressure Reducing Valve (PRV) located midway to the chlorinator, the capacity of the trunk main would be approximately 83 ℓ/s (1.6 MGD) to keep a minimum residual pressure of 35 kPa (5 psi) at the high point. A detailed survey is required to confirm the profile as it is critical to the capacity of the pipeline.

To achieve minimum fire flows together with MDD, Henderson Lake needs to be contributing to the system.

When both sources are contributing to the system and with the proper PRV settings, a total flow of 165 ℓ/s can be conveyed through the trunk main while keeping a minimum pressure of 5 psi in the trunk main. The current MDD is 71 ℓ/s, leaving 94 ℓ/s for fire flow or PHD.

One scenario to upgrade the capacity of Cumberland system would be to build a storage facility in the village to store fire protection volume and balance Peak Hour

Demand. Doing so would mean that the Supply Trunk would have to handle MDD alone, thus 94 ℓ/s would be made available for extra demand.
This equals:

≈ 9,844 people more @ 825 ℓ/c/d (metered demand) or
≈ 5,076 people more @ 1,600 ℓ/c/d (unmetered demand)

The additional storage should be located close to the Allen Lake elevation (229 m) for balancing. Unfortunately there is no land close to this elevation, even north west of the existing development. Additional study is required.

Another scenario is to duplicate the trunk with a parallel pipe. A pipe 450 mm diameter would allow a total flow of 320 ℓ/s with the right PRV settings. After subtracting the current MDD, 249 ℓ/s is available for fire flow or PHD.

At present, Royston is supplied by a single main line along Royston Rd. Recently about two thirds of that supply line was upgraded by the Ministry of Transportation to 300 mm PVC. Assuming C = 130 for ductile iron and AC, and C = 150 for PVC, the supply line going to Royston can carry up to 114 ℓ/s. This exceeds the current MDD for Royston (23 ℓ/s).

The supply line to Royston is currently limited by the 200 mm main from Ulverston Road to Union Road. It is not considered useful to upgrade this section to 300 mm until the supply main has been duplicated as above.

After upgrading the trunk main from the dams and completing the remaining section of Royston Supply line between Ulverston Ave and Union Rd, the capacity to Royston could be increased up to 150 ℓ/s. This should serve a total population of 9,425 people in Royston given the right storage volume at the reservoir.

5. TREATMENT COMPONENTS

5.1 Assessment of Existing System

For this Master Plan, CH2M Hill was commissioned to provide an assessment of the existing system, a discussion of alternatives and preliminary cost estimates for treatment. Their report is included in Appendix C and should be read for a more detailed discussion of the issues and alternatives. Some issues are summarised below.

Cumberland is currently treating its water only by gas chlorination. This is used to keep the water free of harmful bacteria and some other pathogens. Photos taken of the chlorination station equipment are in Appendix I.

The existing treatment process cannot improve aesthetic parameters such as colour, or eliminate all pathogens. However, it can potentially create taste and odour problems.

In 1998, Dayton & Knight recommended a treatment plant to deal with the water quality issues from Allen Lake.

5.2 Identify Treatment Alternatives

Treatment is required to protect public health. Viruses, bacteria, Giardia and Cryptosporidium are all potentially present in the surface water sources. By current policy, VIHA are looking for treatment which provides 4-log removal or inactivation of viruses, 3-log inactivation of Giardia, and 2-log inactivation of Cryptosporidium.

The following three broad classes of treatment process were identified:

- Rapid rate filtration
- Membrane filtration
- Slow sand filtration

Each of these processes has strengths and weaknesses when applied as a solution to Cumberland. However, all will produce equally clean, safe and pleasant drinking water.

5.3 Special Issues

At present Cumberland has no storage in the system downstream of the two source lakes; all balancing of peak flows is achieved by direct withdrawal from the source. As noted in Section 4.3.1, the Peak Hour Demand (PHD) is typically 50% greater than

Maximum Day Demand (MDD). A Water Treatment Plant (WTP) designed for PHD would cost approximately 50% more than one for MDD.

For economical reasons it is necessary to construct balancing storage downstream of the WTP process.

Another consequence of the current Cumberland configuration is that the whole system relies on the working pressure from Allen Lake elevation. Most WTP processes include an open water surface at some point. This means that any pressure from upstream is lost at the WTP; the downstream supply pressure depends on the WTP elevation. This implies that the WTP must be located at an elevation of 224 m (Allen Lake low water level).

The adjacent valleys are steep sided and no obvious site has been identified. It will be necessary also to construct an all-weather access road and power supply to this location.

All treatment processes that use chemical addition for flocculation generate a backwash waste. This requires special treatment before discharging to the environment. Although a municipal sewage treatment plant is often the ideal place to discharge this waste, the distances are likely to preclude this in the case of Cumberland. The capital cost of a backwash processing facility must be included.

Further studies are recommended to identify a suitable site and make preliminary process selection.

6. DISTRIBUTION COMPONENTS

6.1 Assessment of Existing System

The Village of Cumberland monitors its water consumption with meters located at the chlorination station and at Royston reservoir. The Village of Cumberland does not meter individual connections and so the average daily consumption per capita is estimated based on water consumption shared equally by all its residents.

The current distribution system has PVC, Asbestos Cement, Ductile Iron, Steel and Cast Iron pipes. The distribution system is generally old, with only a few upgrades over time.

In some locations the village still has 50 mm diameter water pipes. These small pipes in the system can not deliver significant fire flows.

Based on the MMCD Design Guidelines:

- The system must be able to handle the peak hour demand with a minimum allowable pressure in the system of 300 kPa (43 psi).
- The system must be able to handle maximum day demand plus the required fire flow with a minimum allowable pressure of 150 kPa (20 psi).
- The maximum allowable design velocity at design flow should be 3.5 m/s.

6.2 WaterCad Modeling

The Village water system was modeled using WaterCad by Bentley Systems. The simulation model used in this study is built based on the database provided by McElhanney from their recent work for developers. The database includes: junction locations and elevations, pipe diameters, length and friction coefficients as well as the distributed demands. Verifications were made on the database. The water demands were adjusted to match the consumption rates obtained in this report.

The model is a mathematical representation of the system. The accuracy of the models depends on the calibration process. Calibration can be performed with onsite flow and pressure test results. The calibration process defines the friction coefficients, which may vary a lot depending on the pipe material and age and the corrosiveness of the water. Even an un-calibrated model is still a good representation of the system's behaviour under different conditions; the model is a useful tool to identify weak points and areas that need improvements.

Once built, the Model allows simulation of different scenarios under several boundary conditions. The MMCD guidelines specify that a water system with fire protection must handle minimum fire flows of:

- 60 ℓ/s for single family residential
- 90 ℓ/s for multiple family residential
- 150 ℓ/s for Commercial & Institutional
- 225 ℓ/s for Industrial

The simulations were made under unadjusted friction coefficients. A calibration process should be performed in order to get accurate results.

Simulations were done with Maximum Day Demand (MDD) and fire flows.

Under the optimum PRV settings, the system responds well in residential areas and is able to handle the minimum required fire flow of 60 ℓ/s during the maximum day demand. The higher fire flows to most commercial and institutional zones are not adequate and need improvements to meet MMCD standards.

6.2.1 Residential Areas

Figure 6.2.1 - North West Area (Available fire flows and residual pressures)

The system in this high area can deliver the minimum required fire flow for Single Family dwellings. For the schools, institutions and multiple dwellings in that area, the fire flow available is below the requirements of 150 ℓ/s.

The model did not include the pipes under construction at Coal Valley Estates. These are expected to marginally improve the available flows. The model assumed that the main on First Avenue north of Windermere Avenue is 200 mm. If it is still the original 50 mm, then the replacement is required.

Due to the low available pressure in this area, it is expected that this portion of the system will be the first to experience problems in the future if no upgrades are made to increase the capacity of the trunk main. Twinning the trunk main with a 450 mm would provide enough capacity to satisfy the 150 ℓ/s fire flow for institutional zones.

Figure 6.2.2 - South East Area (Available fire flows and residual pressures)

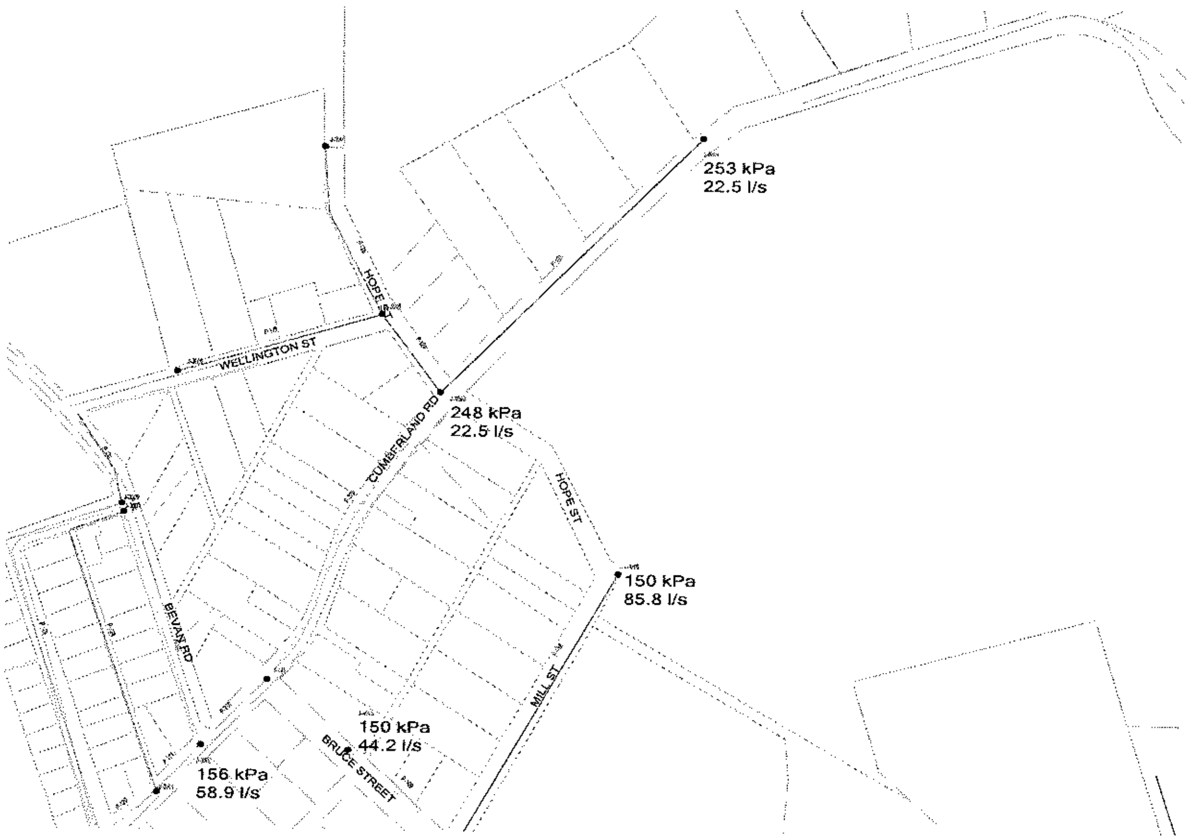
In the south east part of the village, the system can not deliver the required fire flows because of small watermain diameters. This old portion of the village is mostly supplied by 100mm pipes with some 50mm pipes still in use. The MMCD specifies that 100mm pipes should only be use in cul-de-sac of 80m or less. Upgrading the trunk main will not have any significant effect on this portion of the system. Figure 6.2.2 shows the available fire flows.

6.2.2 Commercial zone

Figure 6.2.3 - Dunsmuir Ave (Available fire flows and residual pressures)

The current fire flows available on Dunsmuir Ave are insufficient based on the MMCD recommended 150 ℓ/s for commercial zoning. Generally the fire flow available will increase to 240 ℓ/s when the supply main is twinned, and without any other improvements.

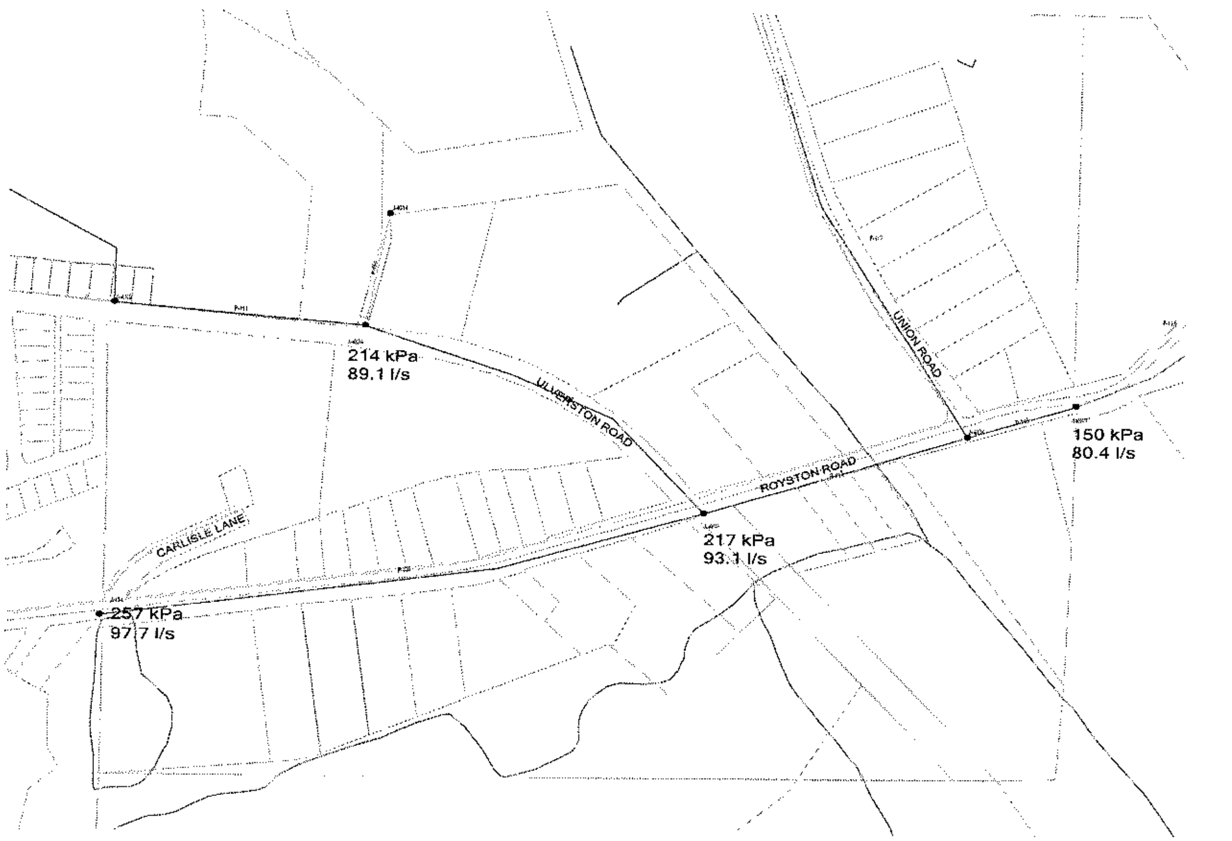
Figure 6.2.4 - Cumberland Road (Available fire flows and residual pressures)



The commercial development on Cumberland Rd does not get adequate fire flow. A 100 mm pipe segment located under Cumberland Road (between Primrose Street and Hope Street) forms a constriction. This small diameter conduit reduces the flow going north on Cumberland Road.

6.2.3 Industrial

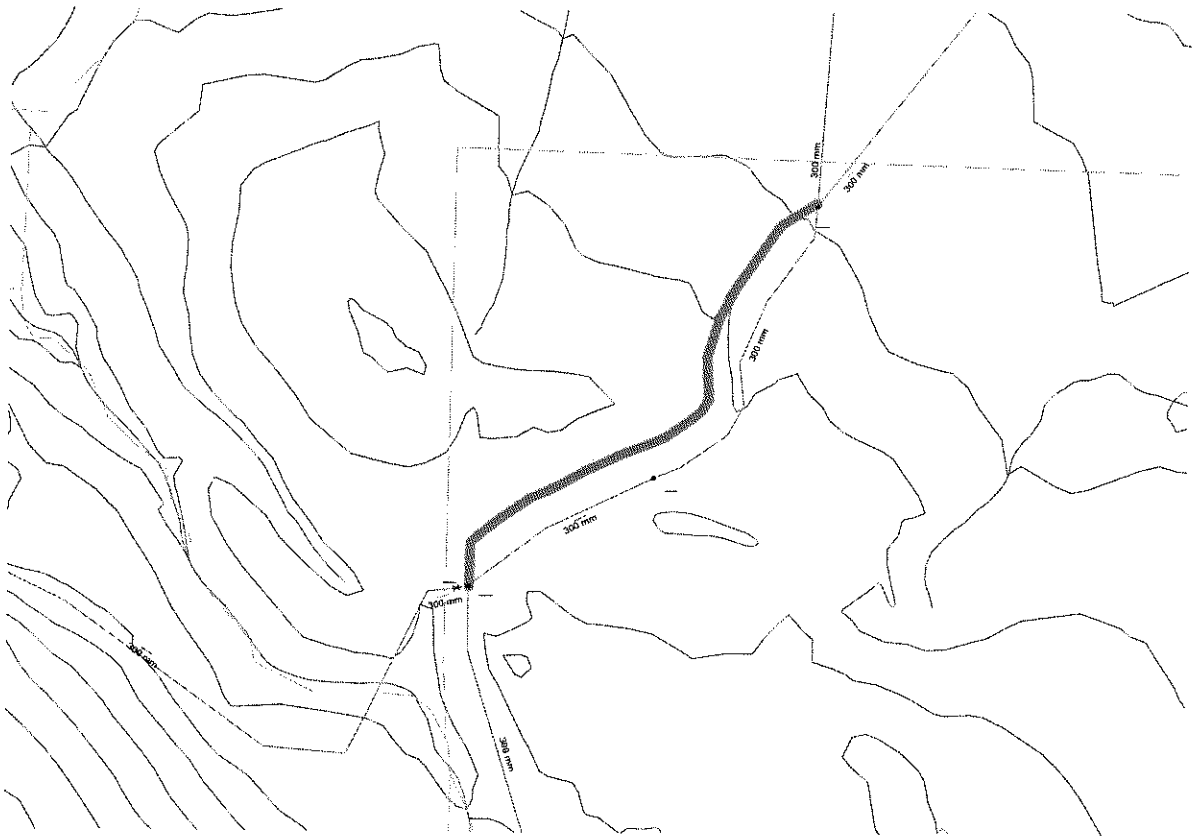
Figure 6.2.5 - Ulverston Avenue / Dunsmuir Avenue (Available fire flows and residual pressures)



The minimum required flow recommended by the MMCD for industrial zoning is 225 ℓ/s. The pipe diameter in this area is a 200 mm. That size of conduit can hardly deliver such flow. Duplicating the trunk would improve the situation but would not alone satisfy the required fire flow. Having sprinkler requirements for these buildings could reduce the minimum required fire flow by up to 50%.

6.3 Recommended Scope of Improvements

Fig.6.3.1 – Duplicating the Trunk Main



As noted in Section 6.2, there are several areas of low available fire flows in the distributions system. Twinning the trunk supply main is effective for many of these areas. The main would be twinned with a new 450 mm from the PRV to the chlorinator. In the model simulations, the hydraulic grade line (HGL) was maintained at a minimum pressure of 35 kPa above the high point on the trunk main.

This improvement has a significant benefit in the North-west area (Egremont north of Maryport). Available fire flows in this area of institutional buildings and townhouses will increase to about 180 ℓ/s. This is a significant improvement in the level of fire protection.

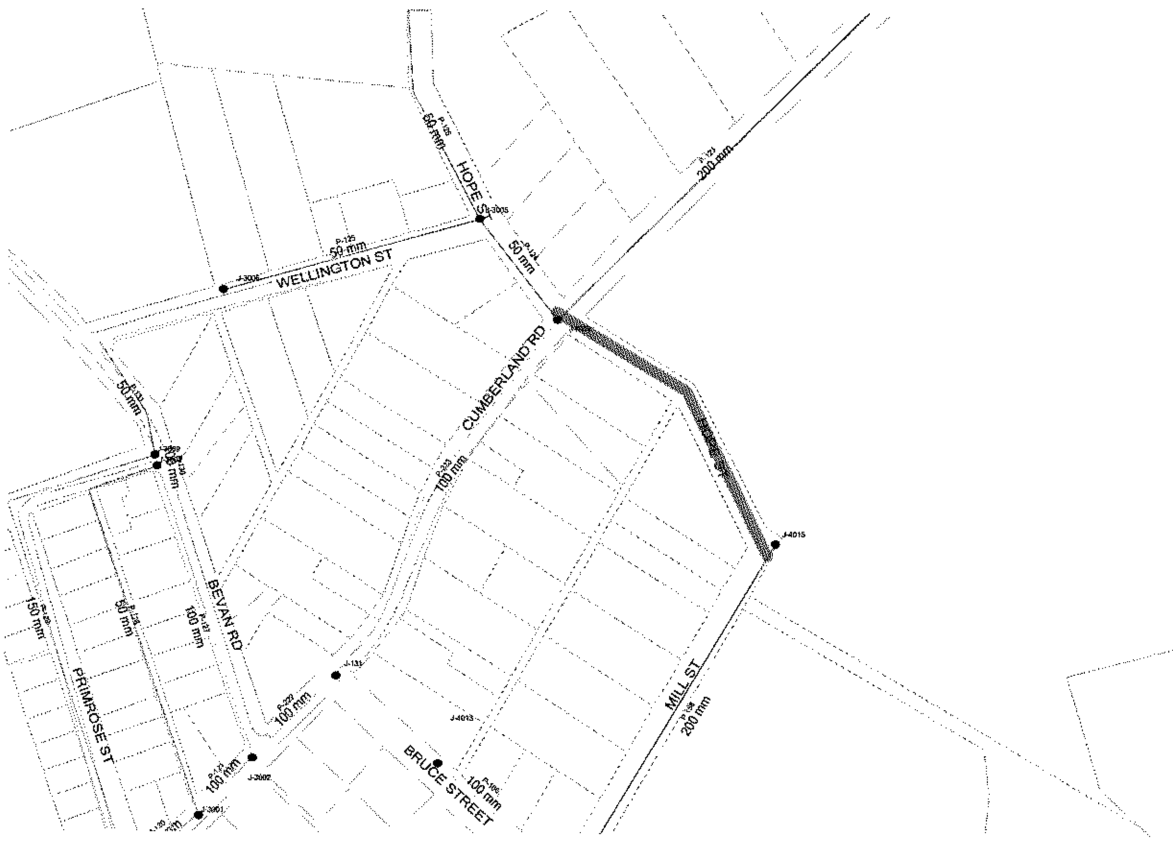
Fire flow in the commercial area of Dunsmuir Avenue are also improved significantly.

Figure 6.3.2 – New pipe on 4th Street

The system in the south east part of Cumberland should be upgraded to provide adequate fire flow to the residential zone. To improve the situation a new 150 mm pipe along 4th Street should be installed between Dunsmuir Avenue and Keswick Avenue to provide adequate fire protection in the south east area. With this improvement all junctions can provide over 60 ℓ/s at a minimum 140 kPa residual pressure, except at the dead ends of 100 mm lines.

General replacement of small diameter mains is recommended in Section 8.4.4. However, that alone would not be sufficient, and the additional loop recommended here is required.

Fig.6.3.3 – Link under Hope Street



To improve fire protection on Cumberland Road, a 200 mm link on Hope Street from Mill Street to Cumberland Road would considerably increase the fire flow available. This would be a new pipe requiring less work than replacing the entire 100 mm segment under Cumberland Road. With this improvement alone, available flows at the end of the line on Cumberland Road increase to 84 ℓ/s at 157 kPa.

With the addition of twinning the trunk supply main (Figure 6.3.1), the available flows become 110 ℓ/s at 150 kPa.

Fig.6.3.4 – Royston Supply Line

To ensure good service to the growing population of Royston, the remaining 200 mm section under Royston Road should be upgraded to 300 mm. This improvement should be performed only after the trunk supply main has been twinned.

Anticipated improvements by others on Union Road or between the Comox Valley Parkway and Royston Road have not been modelled in this analysis. A more comprehensive study is required to confirm the diameter for any upgrade required to serve Royston in the future.

7. TRIGGERS FOR IMPROVEMENTS

7.1 Population Projections

The Cumberland water system supplies 1,046 connections in the Village (2006) and 874 connections (2006) in Royston Improvement District. Population densities are based on Census Canada data (2005 data is not yet available).

Cumberland has an estimated population of 2,700 people and is expecting an accelerated growth in the near future. Over the last decade the population was almost stagnant with only a slight rise in population over the last few years. Lately a wave of development in the Comox Valley has occurred and is now well underway. It is expected to continue for several more years. An estimate of the population growth in the near future is given in Table 7.1. Projected growth in Cumberland is based on subdivisions currently in the approval and construction stages, then a future rate of 2.0% per annum.

Based on the Village of Cumberland OCP, it is expected that within the next 5 years Cumberland's population will go up 35% to 3,650 people. OCP revision and rezoning is discussed below.

For Royston, Table 7.1 shows the future population projection from the Local Area Plan at 2%. Development is currently going on and data shows a higher growth rate this year over the last several years. Although it is expected that Royston will increase its population faster in the next several years, it would be improbable that Royston would experience a growth rate as high as Cumberland without incorporation or the installation of sewers. Such an analysis is beyond the scope of this study.

Table 7.1 – Past Population and Future Projection at Existing Zoning

	Water Connection			
Year	Cumberland		Royston	
	Connection	Population	Connection	Population
1985	797	2,000	678	2,000
1990	787	2,000	735	2,000
1995	873	2,428	774	2,049
2000	998	2,604	804	2,144
2005	1021	2,675	839	2,249
2010	1365	3,576	927	2,486
2015	1520	3,982	1,024	2,744
2020	1678	4,396	1,131	3,030
2025	1853	4,854	1,248	3,345
2030	2045	5,359	1,378	3,694

Revisions to the OCP and subsequent rezoning are now under consideration (January 2007) that would increase the level of residential development. Based on current information, it is projected that an additional 1,500 units could be added with current applications. At a density of 2.6 people per unit this would be an additional 3,900 people. This has been allocated over 15 years.

Based on a recent analysis by the Village Planning staff, the potential for rezoning outside the existing Urban Containment Boundary (UCB) is 1,552 units. At 2.6 people per unit this population will be 4,035. Potential development within the UCB has been included in the current and projected development.

The servicing report for Trilogy Lands (McElhanney Consulting Services Ltd.) indicates a total population equivalent (including non residential) of 4,345 people for these lands.

These give a total potential population increase of 8,380. Although this might be considered an extreme scenario, these numbers have been distributed over 25 years and are included in Table 7.2 and Graph 7.1.

Graph 7.1 – Population Projections

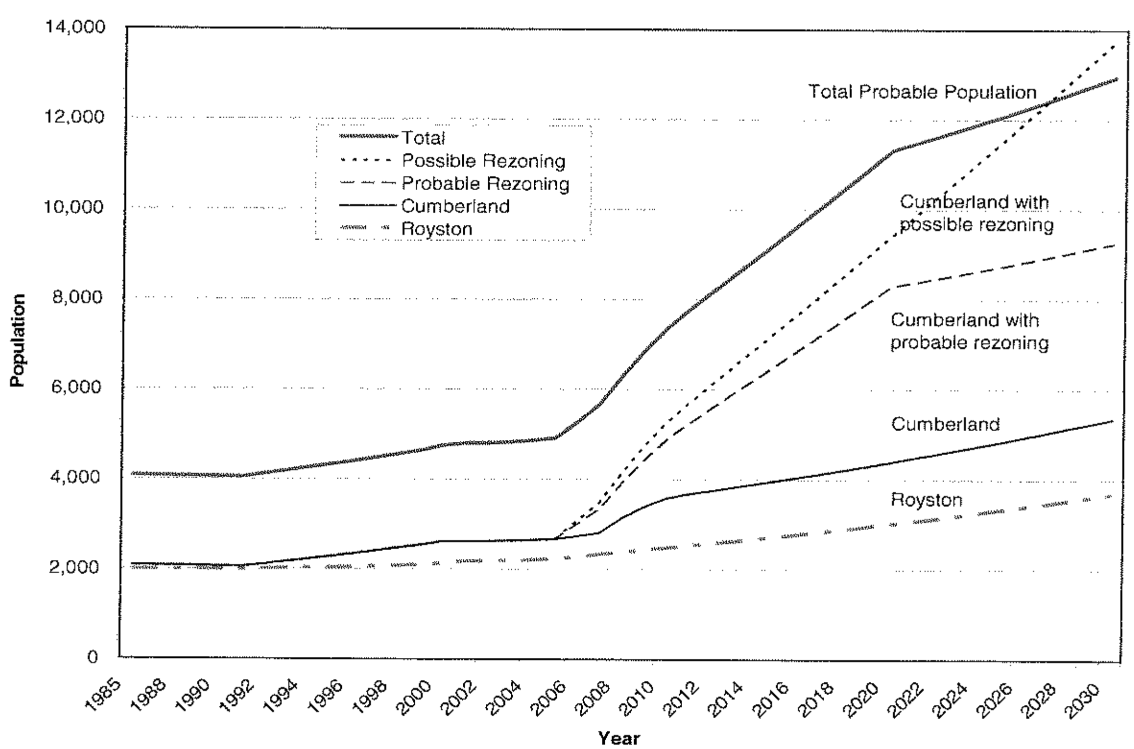


Table 7.2 – Future Population and Rezoning Impact

Year	Cumberland						Royston	
	Water connection	Population	Probable Re-zoning	New Total	Possible Re-zoning	Total	Water Connection	Population
2005	1021	2,675		2,675		2,675	839	2249
2006	1046	2,741	260	3,001	335	3,076	853	2286
2007	1073	2,811	520	3,331	670	3,482	874	2342
2008	1196	3,134	780	3,914	1,006	4,139	891	2389
2009	1292	3,385	1,040	4,425	1,341	4,726	909	2437
2010	1365	3,576	1,300	4,876	1,676	5,252	927	2486
2011	1404	3,678	1,560	5,238	2,011	5,690	946	2535
2012	1432	3,752	1,820	5,572	2,346	6,098	965	2586
2013	1461	3,827	2,080	5,907	2,682	6,509	984	2638
2014	1490	3,904	2,340	6,244	3,017	6,920	1004	2691
2015	1520	3,982	2,600	6,582	3,352	7,334	1024	2744
2016	1550	4,061	2,860	6,921	3,687	7,749	1045	2799
2017	1581	4,143	3,120	7,263	4,022	8,165	1065	2855
2018	1613	4,225	3,380	7,605	4,358	8,583	1087	2912
2019	1645	4,310	3,640	7,950	4,693	9,003	1108	2971
2020	1678	4,396	3,900	8,296	5,028	9,424	1131	3030
2021	1711	4,484	3,900	8,384	5,363	9,847	1153	3091
2022	1746	4,574	3,900	8,474	5,698	10,272	1176	3152
2023	1781	4,665	3,900	8,565	6,034	10,699	1200	3216
2024	1816	4,759	3,900	8,659	6,369	11,127	1224	3280
2025	1853	4,854	3,900	8,754	6,704	11,558	1248	3345
2026	1890	4,951	3,900	8,851	7,039	11,990	1273	3412
2027	1927	5,050	3,900	8,950	7,374	12,424	1299	3481
2028	1966	5,151	3,900	9,051	7,710	12,860	1325	3550
2029	2005	5,254	3,900	9,154	8,045	13,299	1351	3621
2030	2045	5,359	3,900	9,259	8,380	13,739	1378	3694

This date by which future populations will be reached is conjecture. Targets may be achieved earlier or later, but the projections are considered typical over the long-term.

7.2 Source Storage

As developed in Section 4.3.4 above, the lakes are required to store 120 days summer supply. At present there is sufficient volume for the current population and immediate development.

As developed in Section 4.3.4 above, the per capita volume required for the un-metered services in Cumberland is 135 m^3. The per capita volume required for the metered services in Royston is 70 m^3.

There are a number of scenarios to project future demand for storage:

Scenario #1: - Development in Royston in accordance with Table 7.1, demand at 70 m^3/person.

- Development in Cumberland in accordance with Table 7.1, demand at 135 m^3/person.

Scenario #2: - Development in Royston in accordance with Table 7.1, demand at 70 m^3/person.

- Development in Cumberland for existing un-metered customers at 135 m^3/person, and future metered customers at 70 m^3/person.

Scenario #3: - Development in Royston in accordance with Table 7.1, demand at 70 m^3/person.

- Development in Cumberland with new customers at 70 m^3/person and all existing customers changing to metered consumption at 70 m^3/person within 5 years.

Scenario #4: - Development in Royston in accordance with Table 7.1, demand at 70 m^3/person.

- Development in Cumberland with new customers at 70 m^3/person and all existing customers changing to metered consumption at 70 m^3/person within 5 years.

- New development from Probable Rezoning (Table 7.2) in Cumberland, 3,900 people, at 70 m^3/person over 15 years.

In the following table, when new storage is required, there is an allowance for an additional 104,000 m^3 for compensation flow as discussed in Section 4.3.4 above.

Table 7.3 – Future Storage Requirements

Scenario #1		No rezoning, no metering in Cumberland			
Year	Cumberland Population @ 135 m^3/person	Cumberland Population @ 70 m^3/person	Royston Population @ 70 m^3/person	120 Day Storage Volume	Additional Storage
2005	2,675		2,249	518,524	
2010	3,576		2,486	656,799	
2015	3,982		2,744	729,638	
2020	4,396		3,030	805,580	148,580
2025	4,854		3,345	889,425	232,425
2030	5,359		3,694	981,997	324,997
Scenario #2		No major re-zoning, metering new connections			
2005	2,675	0	2,249	518,526	
2010	2,675	901	2,486	598,217	
2015	2,675	1,307	2,744	644,705	
2020	2,675	1,721	3,030	693,709	
2025	2,675	2,179	3,345	747,814	
2030	2,675	2,684	3,694	807,549	150,549
Scenario #3		No major rezoning, metering all connections			
2005	2,675		2,249	518,524	
2010		3,576	2,486	424,339	
2015		3,982	2,744	470,827	
2020		4,396	3,030	519,832	
2025		4,854	3,345	573,936	
2030		5,359	3,694	633,672	
Scenario #4		Metering all connections, probable rezoning			
2005	2,675		2,249	518,524	
2010		4,876	2,486	515,339	
2015		6,582	2,744	652,827	
2020		8,296	3,030	792,832	135,832
2025		8,754	3,345	846,936	189,936
2030		9,259	3,694	906,672	249,672

Note:	Existing storage volume	891,500 m^3
	Evaporation (June – September)	130,400 m^3
	Available existing volume	761,100 m^3
	Potential compensation flow	104,000 m^3
	Existing licensed storage volume	1,080,000 m^3

Scenario #5 for Possible Rezoning was not developed separately. The trigger date is advanced approximately 3 years.

Conclusions:

- If Cumberland continues to develop existing zoned lands and without the implementation of metering, additional storage will be required soon after 2015.
- If Cumberland implements metering only for new customers (effective 2006) then existing storage could be sufficient until approximately 2025.
- If Cumberland implements metering for all customers, the existing storage will be sufficient for the foreseeable future (2035).
- With full metering, the projected development of additional land by re-zoning will trigger the need for additional storage within approximately 10 years.

7.3 Supply Mains

As discussed in Section 4.4 above, the single supply main from the junction PRV to the chlorinator limits the available peak flows.

Although there is capacity to accommodate further population and still meet Peak Hour Demand (PHD) there is a limit on the available fire flows at present. Typically there is sufficient for domestic protection, but flows for commercial, industrial and institutional protection are limited.

An immediate study to confirm the location and diameter for the duplication is recommended.

Separate studies (McElhanney for Trilogy Development) have identified the need to upgrade this main for the development near the Inland Island Highway (Lot 4).

7.4 Treatment Plant

The existing treatment process is limited to chlorination. Due to concerns with potential turbidity, the Health Inspector has ordered installation of a turbidity meter. This will not improve the treatment, but should identify times when chlorination may be ineffective.

Due to the source of water from surface lakes, and the presence of seasonal algae, the chlorination can easily cause taste and odour. A filtration system has been recommended as the solution to this problem.

Lake sources are potentially the source of giardia lamblia and cryptosporidium contamination. Chlorination is not particularly effective against these, and either filtration or ultra-violet is required for these pathogens.

With the Drinking Water Protection Act, standards and expectations in BC have been raised. Without any additional development or more customers, there is a need to improve the water treatment process.

Generally the system will be designed with hydraulic capacity for long term needs (20 – 30 years) and equipment will be installed for the short-term (5 – 10 years).

The requirement for upgrading the treatment process is immediate and requires planning and construction in the next few years.

Future expansion and improvements will depend on the level of development and future raising of the accepted water quality standards.

7.5 Distribution System

7.5.1 Overall

The existing distribution system is old, and parts of it may date from the earliest years in Cumberland. These sections contribute to the high overall leakage and system loss (Section 4.3.2).

Some older sections are reported to suffer from frequent breakage and difficulty of repair.

Much of the water system was designed and installed before the current level of fire protection became standard. Pipes that were only installed to provide domestic water (e.g. 50 mm diameter) do not contribute locally to fire hydrant flows or overall to system capacity.

Areas of the Village with a strong network of 150 mm diameter pipe have good fire protection capacity, and excellent redundancy for maintenance and emergencies. There are however, a limited number of lines in the north / south direction. One or more additional north / south links would improve the system.

The need for all these improvements exists already.

Some additional improvements will be required to support additional development in the north-west area and to the east of the existing Village.

We recommend an immediate study to identify those pipes in the existing distribution system which should be replaced due to age and small diameter.

7.5.2 North-West Area

In this area the high ground causes a number of challenges (Section 6.2.1):

- Low customer pressure at high demand times.
- Reduced fire protection flows.
- Reduced pressures during fire flows elsewhere.

These system deficiencies exist at present and should be addressed in the near future.

Potential system improvements include:

- Increased mains size more directly to the high areas.
- A separate upper pressure zone with direct connection from the trunk supply main at Sutton Drive.
- A balancing reservoir at high elevation.

Separate studies are currently under way for developers who wish to extend the distribution system to the north and west. We recommend that the Village carefully review the Terms of Reference for these studies to ensure that they also address the issues identified above.

8. COST ESTIMATES

Construction cost estimates have been prepared for the improvements proposed in this report to improve the existing storage, supply and distribution system for the Village of Cumberland and Royston Improvement District.

- Costs are only for the water system.
- Costs are in 2007 dollars and the estimates are Class C. Refer to Appendix L for definition of Class C Estimate.
- An allowance for engineering, surveying and construction contingency is shown, but not costs for legal, property, financing and other similar items.
- Increases to operational, maintenance or other ongoing costs have not been included.

8.1 Lake Source and Dams

Extensive repairs and upgrades have been recommended in the Dam Safety Review, Cumberland Creek Dams (EBA, December 2003). It is beyond the scope of this study to identify these costs or priorities beyond the recommendations and estimates previously provided by EBA. A separate costing exercise should be commissioned.

The costs for replacement of Hamilton Lake dam have been provided by EBA previously and are included in Appendix B. Supplementary letters in 2006 provide clarification on some of the original costs.

These costs are summarized as follows:

Item	Cost
Dewatering	$ 10,000
Dam construction	$700,000
Engineering	$150,000
Contingency (15%)	$129,000
Total	**$898,000**

No immediate further increase in storage is recommended by this Water Master Plan, and no additional capital costs are required.

Additional storage for future developments would be best provided at Hamilton Lake by increasing the capacity of the dam and associated structures at the same time as the repair. Assessing these costs is beyond the scope of this study.

In 2003 EBA recommended improvements to several of the other dams on Cumberland Creek. Costs for these improvements follow. A factor of 25% to increase the costs from 2003 to 2007 is included for each.

Cumberland (#2) Lake

Item	**Cost**
Upgrade and repair dam	$ 35,000
New spillway	$ 30,000
Engineering	$ 31,000
Subtotal	**$ 96,000**
Inflation (25%)	$ 24,000
Contingency (20%)	$ 19,000
Total	**$139,000**

Stevens Lake

Item	**Cost**
Embankment upgrade	$ 7,000
Engineering	$ 5,000
Subtotal	**$12,000**
Inflation (25%)	$ 3,000
Contingency (20%)	$ 2,400
Total	**$17,400**

Costs were not provided for the recommended improvements at Henderson Dam or for removal of the Old #1 crib.

Based on costs above, an allowance of $20,000 for Henderson Dam is recommended.

Previous attempts to remove the old #1 dam have not been successful due to the challenging location. An allowance of $50,000 is recommended.

In 2004 EBA recommended a programme to install piezometers and conduct a geotechnical slope stability assessment of four dams.

Item	**Cost**
Geotechnical site investigation	$ 11,000
Slope stability analysis	$ 3,300
Temporary access bridge	$ 3,000
Engineering	$ 8,000
Subtotal	**$ 25,300**
Inflation (15%)	$ 3,800
Contingency (20%)	$ 5,100
Total	**$ 34,200**

8.1.1 Watershed Safety and Operations

An inspection by CGI Insurance Bureau Services for the municipal insurance agency is detailed in their 2006 report (Appendix E). Some of these recommendations overlap with those of the Dam Safety Review (2003). Costs are not duplicated.

No costs were included previously. We estimate the cost of effecting these improvements as follows:

- Backflow and cross connection programme — $ 25,000
- Limit water source access with:
  - Signs — $ 10,000
  - Gates — $ 30,000
  - Selective fencing — $ 50,000
- Update Emergency Procedures Manual — $ 15,000
- Develop risk and loss control programme — $ 35,000

Total: $165,000

Based on the Dam Safety Review, 2006, the following additional actions are recommended:

- Install V-notch weir downstream of all dams for leakage measurement $ 6,000
- Raise Allen Lake secondary and saddle dams $ 5,000
- Develop Operations, Maintenance and Surveillance Manual $ 3,000

Total $14,000

8.2 Supply Main

Twinning of the existing single section of the supply main is recommended. This may follow a lower route through undeveloped forest in order to avoid the high point on the road.

Item	Cost
Clearing alignment	$ 10,000
820 m 450∅ PVC	$275,000
Valves & Fittings	$ 18,000
Allowance for rock	$ 70,000
Construction Subtotal	**$373,000**
Engineering (15%)	$ 56,000
Contingency (20%)	$ 75,000
Total	**$504,000**

8.3 Treatment Plant

A new comprehensive treatment process is recommended. Cost Estimates are included in the report by CH2M Hill (Appendix C) and are summarized below.

Item	Cost
Detailed study for treatment process and location	$ 100,000
Land acquisition	Unknown
Phase 1 treatment plant construction	$ 5,500,000
Clearwater Reservoir (4,000 m^3)	$ 2,500,000
Engineering (10%)	$ 800,000
Contingency (15%)	$ 1,200,000
Total	**$10,100,000**

In addition, an extensive long term water sampling and analysis programme is recommended in order to provide design data for the treatment process (CH2M Hill report, Appendix C). For a 2-year programme, allow $35,000.

8.4 Distribution System

8.4.1 New Pipe on Fourth Street

This pipe runs from Dunsmuir Avenue to Keswick Street on Fourth Street. There is no existing pipe on this route.

The costs include import backfill and surface restoration.

Item	Cost
290 m 150 mm ∅ PVC	$ 70,000
Valves, fittings & hydrants	$ 16,000
Allowance for rock	$ 25,000
Construction Subtotal	**$111,000**
Engineering (15%)	$ 17,000
Contingency (20%)	$ 22,000
Total	**$150,000**

8.4.2 Link on Hope Street

This pipe runs from Mill Street to Cumberland Road on Hope Street. There is no existing pipe on this alignment.

The costs include import backfill and surface restoration. Rock is not expected here.

Item	Cost
250 m 200 mm ∅ PVC	$ 61,000
Valves, fittings and hydrants	$ 14,000
Construction Subtotal	**$ 75,000**
Engineering (20%)	$ 15,000
Contingency (20%)	$ 15,000
Total	**$105,000**

8.4.3 Royston Supply Line

This pipe replaces an existing 200 mm pipe on Royston Road from Ulverston Avenue to east of Union Road.

The cost includes import backfill and surface restoration. No significant rock is expected on this alignment.

Item	Cost
370 m 300 mm ∅ PVC	$136,000
Valves, fittings and hydrants	$ 17,000
Services and abandon existing pipe	$ 40,000
Construction Subtotal	**$193,000**
Engineering (15%)	$ 29,000
Contingency (20%)	$ 39,000
Total	**$261,000**

8.4.4 Distribution System Replacement

The existing distribution system contains extensive small diameter lines. Typically these would have been installed in the early days before modern design standards were applied.

The following quantities shown in Table 8.1 – Existing Small Diameter Pipes are based on information shown on the overall record drawings and summarized in the water model. They may not be correct in detail, but provide an overall target for replacement.

Older pipe materials are AC, Cast Iron and Steel. Newer pipe materials are Ductile Iron and PVC.

Table 8.1 Existing Small Diameter Pipes

Diameter	Material (older)	Length	Material (newer)	Length
100 mm	AC	2,070	DI	1,661
	CI	2,244	PVC	392
	Steel	1,639		
Total		**5,953**		**2,053**
	x 50%	**2,976**		
50 mm	CI	223		
		1,474		
			PVC	90
Total		**1,697**		**90**

Assuming that 50% of the older 100 mm pipe and all of the older 50 mm pipe should be replaced due to age, condition or for better fire protection, the total length for replacement is 4,675 m.

The costs include import backfill, new services, surface restoration and an allowance for rock.

Item	Cost
4,675 m 150 mm ∅ PVC	$1,168,750
Valves, fittings and hydrants	$ 175,000
Allowance for new services	$ 200,000
Allowance for rock	$ 250,000
Construction Subtotal	**$1,793,750**
Engineering (15%)	$ 270,000
Contingency (20%)	$ 356,250
Total	**$2,420,000**

There is extensive water loss in the system, probably from leakage (Section 4.3.2). A separate study and investigation is recommended to locate the works sections, and schedule these for early replacement:

- Water Loss Study $25,000

The following Table 8.2 – Cost Summary and Priorities includes the costs developed above, together with budget estimates for other recommendations in Section 9.

Preliminary priorities have been identified as follows:

- Immediate – works or studies that should be undertaken in 2007 to improve safety or to provide detailed information for capital planning in subsequent years.
- Short-term – works or studies that should be completed in 2007 or 2008 for improvement in health or safety of the system.
- Medium term – works that should be completed within 5 years to accommodate development or improve long-term security of the supply.

Some of these works may be funded through new development. Allocating costs or identifying sources of funding is beyond the scope of this study.

Table 8.2 – Cost Summary and Priorities

	Immediate	Short-Term	Medium
Watershed and Dam			
Hydrologic watershed assessment		25,000	
Replace Hamilton Dam		859,000	
Upgrade Cumberland #2		139,000	
Repair Stevens		17,400	
Rebuild Henderson		20,000	
Remove old #1		50,000	
Slope stability study	34,200		
Hydrographic survey, mapping, lake volumes	8,000		
Study alternatives to rebuild Hamilton	10,000		
Insurance recommendations	165,000		
Dam Safety recommendations	14,000		
Demand management strategy	10,000		
Supply main & Treatment			
Trunk main twinning	4,000		500,000
Source water sampling & analysis	35,000		
Treatment plant site study		100,000	
Water treatment plant			10,000,000
Distribution System			
Criteria for servicing high areas	5,000		
Strengthen distribution system		255,000	
Upgrade line to Royston			261,000
Study water system improvements	25,000		
Upgrade and replace distribution system			2,420,000
Water loss study	25,000		
Fire flow sprinkler study	5,000		
Totals	**340,200**	**1,504,400**	**13,181,000**

9. CONCLUSIONS AND RECOMMENDATIONS

9.1 Conclusions

The following is a summary of the conclusions developed in this Water Master Plan:

- The 1986 assessment of the watershed projects a comfortable excess of runoff to supply Cumberland's needs for the foreseeable future. A current study underway is expected to confirm and refine this conclusion.
- The Village has licensed storage rights sufficient for many years into the future. The dams do not yet retain the full licensed volumes.
- The Vanwest license only gives additional storage volume, without any additional abstraction. Previous reports included construction costs estimates that indicate that this may be an expensive place to construct more storage.
- The Village has sufficient licensed abstraction rights for existing demands, although the maximum daily rate was reached in the summers of 2002, 2003 and 2004. Demand management would extend the capacity significantly.
- The dams at Allen Lake are in good condition, and only minor repair and maintenance is required.
- All the dams on the Cumberland Creek system – Stevens, Hamilton, Cumberland #2 and Henderson – are in various stages of deterioration. The required remediation is well documented in recent reports.
- Reports state that the #2 and Henderson dams on the Cumberland Creek system do not have sufficient freeboard or spillway capacity in a major flood event. The downstream consequences for damage and loss of life are significant. The cost of repair will be much less that the cost of replacement after a loss.
- The existing supply main capacity is limited by a section of single pipe between the PRV chamber and the chlorinator building. Twinning this section significantly improves fire protection throughout the Village. Duplication also provides system security through redundancy.
- All the balancing storage in the system is in Allen and Henderson Lakes. There are no reservoirs downstream in the distribution system.
- The existing water treatment is by gas chlorination. This is not effective against all pathogens (e.g. viruses, giardia, cryptosporidium), and does not meet the requirements of the Drinking Water Protection Act and the policies of VIHA.
- A study is required to meet the challenge of finding a site for a new water treatment plant at the necessary elevation with sufficient level ground.

- Parts of the existing distribution system may date from the late 1800's. Many sections are serviced with pipes in poor condition. Areas with small diameter pipes have limited fire protection.
- The water consumption within the Village is high, and requires significant storage to provide water in summer. The water consumption in Royston Improvement District was halved after the introduction of full metering.
- Development within the current OCP (2004), without significant rezoning and without metering does not require additional storage for al least 10 years.
- The potential level of development, with OCP revisions and rezoning, will require both significant demand management (metering) in the short-term and capital expenditure for increased storage after 2015.

9.2 Recommendations

The following are recommendations developed in this Water Master Plan. These are developed from analysis in this study and from detailed recommendations in the other reports listed in Section 10 – References. These recommendations have been grouped under separate headings for guidance, but may cover more than one component of the system.

<u>Watershed</u>

- Conduct a study of the watershed to project the available water, particularly in future drought conditions (currently underway for others by CH2M Hill).
- Conduct a hydrological assessment of the watershed to assess the impact of future logging on water quality and the effect on dam safety from major runoff events.

<u>Lakes and Dams (source and storage)</u>

This list of detailed recommendations made in recent dam safety reports is extensive. Only a summary of these recommendations is included. Other recommendations developed in this study are given in more detail:

STUDIES:

- Conduct a study on Perseverance Creek to asses existing and natural flows to provide a basis for negotiating future compensation release.
- Update water quality analysis of Allen Lake and develop operating recommendations.
- Complete geotechnical stability analyses for Stevens and Cumberland #2 dams.

- Conduct hydrographic surveys of Allen and Cumberland #2 lakes; obtain existing survey of Hamilton Lake (EBA); map contours of Stevens Lake from 2006 air photos; prepare stage/storage graphs and tables for each lake.
- Study alternative configurations for rebuilding Hamilton Lake dam.
- Study options to control demand to within licensed capacity. Water use restrictions may reduce peaks; fully metered consumption will reduce the basic summer demand.
- Develop leakage reduction plan, including replacement of sections of distribution system (see below).

CAPITAL:

- Reconstruct Hamilton Lake dam to recommendations of configuration study (above).
- Raise secondary crests at Allen Lake to match main dam crest.
- Raise freeboard at Cumberland #2 dam.
- Remove Old #1 dam and debris in ravine.

OPERATIONAL:

- Clear vegetation from slopes and abutment margins at all dams.
- Install V-notch downstream on all dams to monitor leakage (Stevens already equipped).
- At Allen Lake clear spillway channel and address erosion on left abutment of Secondary Dam.
- Replace log booms upstream of all spillways.
- Develop Operations, Maintenance and Surveillance Manual for all dams.
- Update and extend Public Safety Management Plan.
- Record dam inspections and operational data on a regular basis in a formal format (including lake levels and V-notch flows).

Treatment:

- Conduct a study to determine probable footprint and location for future Water Treatment Plant (WTP).
- Undertake 18-month supply water quality monitoring programme to include two summer periods. Sample Allen and Henderson Lake sources separately. These analyses are required for WTP process selection and pre-design.

Supply Main

- Conduct a pre-design and route alignment for the supply main twinning, including profile survey and HGL modelling.
- Develop operational practices for the PRV system, and record adjustments in operations logs.

Distribution:

- Conduct a survey to determine alternatives and design criteria for improving or extending distribution system to higher areas. This study would establish the Village operational requirements for the system extensions, and Terms of Reference for development studies.
- Conduct a detailed study to establish priorities for watermain replacement in the distribution system; priorities to be based on age and condition of pipes, and capacity of small diameters.
- Conduct a study to review the fire flow requirements of the commercial, institutional and industrial buildings. Confirm that these flows are available, or identify the improvements required.
- Conduct a study to review the impact on fire flow requirements for commercial, institutional, industrial and multi-family buildings if these are fully sprinklered. Identify the potential cost saving in the supply and distribution systems from lower hydrant flows if sprinklers were to be required in all existing buildings.

10. REFERENCES

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APPENDIX A

Disclaimer

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- This report was prepared by AndersonCivil Consultants Inc. (the Consultant) for use by the Village of Cumberland. The material in it reflects the best judgement of the Consultant in light of the information available to the Consultant at the time of preparation. Any use that any third party makes of the report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. The Consultant accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.