REGIONAL DISTRICT
of
NORTH OKANAGAN

TM7 SUMMARY PAPER

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SUBJECT: 2012 Greater Vernon Water Master Water Plan
Technical Memorandum No.7.
Water Treatment

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TM7 PURPOSE:

Water treatment is an important service a water utility provides to ensure that clean, safe drinking water is delivered to domestic customers. A critical component of any utilities' Master Water Plan (MWP) is to identify the long term treatment needs based on legislative requirements and the specific characteristics of water source(s) used for potable water.

While the safety and water quality of Greater Vernon Water (GVW) potable water supply has improved dramatically since the 2002 MWP due to major infrastructure and treatment upgrades, further treatment is still required to meet Provincial standards. TM7 benchmarks the current treatment technologies used to treat GVW's two main potable water sources, analyzes the raw water of each source to identify long term treatment goals and examines the treatment options available to GVW in order to meet Provincial legislation. Lifecycle costing for the treatment options identified is then completed to further assess options.

METHODS:

The development and analysis of treatment options for GVW was completed by:

- Benchmarking the current treatment methods used by GVW for each water source,
- Compiling historic data of the key health and aesthetic parameters of the raw water quality for the main potable water sources (Kalamalka Lake and Duteau Creek) and comparing these to Provincial standards to identify treatment gaps,
- Determining further treatment requirements in order to meet Provincial standards and developing long term treatment goals,
- Evaluating treatment technology options available to GVW for each water source based on the raw water quality and the current treatment levels,
- Estimating the life cycle costs of treatment options, and
- Evaluating the treatment options based on finished water quality, facility sizing to provide the flows and volume GVW requires for each source and lifecycle costs (capital and operational).

RESULTS:

Current Treatment

TM7 provides an overview of all water sources used by GVW but focuses on the two main sources used for the majority of potable water and are provided below:

- Mission Hill Water Treatment Plant (MHWTP) – uses ultraviolet irradiation (UV) and chlorine disinfection to treat water from Kalamalka Lake.

This source primarily services the urban areas of Vernon and Coldstream; however, it is interconnected with the entire system and can be used to service all customers if required except during summer peak irrigation periods. The maximum plant capacity is 58 ML/d with a total annual maximum water license of 8,842 ML/yr.

- Duteau Creek Water Treatment Plant (DCWTP) – this plant uses coagulation, dissolved air flotation (DAF), chlorine disinfection and storage to obtain sufficient contact time to treat water from Duteau Creek Watershed. This source primarily services the more rural areas of Coldstream, Vernon, Electoral Areas B, C, D, Spallumcheen and some urban areas of Vernon (Foothills, Middleton Mountain) and Coldstream. The system is interconnected with the entire system and can be used to service all customers except during summer peak irrigation periods. The maximum capacity of the DAF is 162 ML/d (with no redundancy) with a total annual maximum consumption water license of 34,582 ML/yr.

Other sources include King Edward Lake, Ranch Wells 1 and 2 and Goose Lake which are all separated and supply raw water to agricultural customers for irrigation purposes. Antwerp Springs has two wells which are currently not being used but are planned for use in the agricultural system when a separated pipe line reaches the pump station. Ranch Well 1 and Antwerp Well 2 (Deep Well) are also designated as emergency back up wells for the domestic system.

Provincial Water Quality Standards
Section 2.6 of the *BC Drinking Water Protection Act* states the following:

A water supplier must provide, to the users served by its water supply system, drinking water from the water supply system that:

(a) is potable water, and
(b) meets any additional requirements established by the regulations or by its operating permit.

Potable water is defined as water meeting the standards prescribed by regulation and is safe to drink without further treatment. The Guidelines for Canadian Drinking Water Quality (GCDWQ) published by Health Canada are the standards used by all Canadian provinces and territories, including BC.

The GCDWQ provide recommended limits of substances and conditions that affect the quality of drinking water and include microbiological characteristics, chemical and physical parameters, radiological characteristics and list a number of parameters under review. The Province of BC, through the Ministry of Health with enforcement designated to Interior Health, have established drinking water treatment objectives. These objectives follow a multi-barrier approach, which has been established in North America as the most cost effective method to ensure potability of drinking water and includes filtration and at least one form of disinfection treatment to achieve the 4-3-2-1-0 Rule, which refers to:

- 4 log (99.99%) removal or inactivation of viruses,
- 3 log (99.9%) removal or inactivation of protozoa (*Giardia and Cryptosporidium*),
- 2 barriers, minimum, for pathogens,
- 1 NTU turbidity – must be less than 1 NTU, and
- 0 Total Coliforms and E.coli in the treated water.

Table 1 on the following page summarizes the main health and aesthetic water quality parameters of concern from Kalamalka Lake (Kal) and Duteau Creek (Duteau), provides the corresponding Provincial standard and includes commentary on the status of treatment for these parameters. For a full list of parameters examined, refer to TM7.

The long term treatment goals of DBP's for GVW exceeds the GCDWQ standards for THM's and HAA's (Table 1). The current standards are 100 µg/L total for THM's and 80 µg/L total for HAAs, all measured on a locational running annual average.

While these standard levels in the GCDWQ are relatively recent changes, it is worth noting that the US Environmental Protection Agency (USEPA) regulations are more stringent and are set at 80 µg/L and 60 µg/L for THMs and HAAs respectively. This is significant as Health Canada has historically shown a trend of utilizing the USEPA background research and documentation and setting their standards at the same level as the USEPA regulation over time, albeit typically with a time lag of several years. As such, it was anticipated that within term the MWP the Health Canada guidelines will be set to match the present USEPA regulation for DBPs in due course and the long term treatment goals for THM's and HAA's were set to match the USEPA levels.

Kalamalka Lake Water Quality

Kalamalka Lake is unique in which calcium, magnesium, sulphate and alkalinity contribute to a "marl" phenomenon when conditions allow (temperature and pH increase). The process marks a decline in algae density and the drop in phosphorous through co-precipitation, but also increases inorganic turbidity. As the turbidity from the marl is inorganic, water quality notification is not required if the turbidity is less than 3.5 NTU as it does not reduce the UVT.

However, the Kalamalka Lake source is a vulnerable water source as the water quality is directly affected by Coldstream Creek inflow, seiches (wind events) and human activities on and near the lake. There are times where turbidity events are organic in nature and reduce UVT and disinfection effectiveness. These events would require public notification if the Kalamalka Lake source could not be shut off and GVW would be fully supplied by the DCWTP, which has occurred on a number of times since the DCWTP plant was commissioned.

Kalamalka Lake water quality was assessed to determine if a Filtration Deferral could be applied for. In order to qualify for a Filtration Deferral, a set of criteria must be met that relates to raw water quality and treatment levels, which is provided on page 25 of TM7. The Kalamalka Lake source with the current treatment train at MHWTP meets the criteria <u>most of the time but not all times during the year</u>. There are times (late fall and freshet) where the water quality does not fully meet the criteria. There is a potential to obtain a Filtration Deferral for the Kalamalka Lake source by shutting down MHWTP and using Duteau during poor water quality events; however, this would only be considered by Interior Health if the water from the DCWTP met Standards, which it currently does not.

An in-depth 18 year on-going study completed by GVW (in partnership with the District of Lake Country and the Ministry of Forests, Lands and Natural Resource Operations (FLNRO) examines the possibility of extending and deepening the Kalamalka Lake intake with the goal of improving water quality. The study indicates that while increasing the intake depth would marginally improve water quality most of the time, the deeper depths are impacted more from the Coldstream Creek plume during large freshet events than the current depth of 20 m. To combat the differing water quality with varying depths during different conditions, the MWP recommends installing an intake tower with multiple diversion depths. However, a cost benefit analysis indicated that as there is no guarantee of avoiding filtration and minimal benefit to water quality, it is not a recommended option when comparing the costs to construct a tower versus expanding the existing treatment plant with filtration to achieve definitive and guaranteed improvements to water quality.

Table 1 – Summary of health and aesthetic water quality parameters of concern for Kalamalka Lake (Kal) and Duteau Creek (Duteau).

Parameter (Unit)	Standard[1]	Parameter Impact to Drinking water	Kal Average (max)	Duteau Average (max)	Long Term Treatment Goals	Comments
Chlorophyll "a" (µg/L)	n/a	Represents algae growth, some algae produce toxins, taste and/or odour issues	2.3 (5.3)	1.1 (1.5)	n/a	Main risk on Kal, if becomes an issue, treatment via clarification would be required.
Colour (TCU)	15	Source of TOC and could be aesthetically unacceptable (i.e. brown colour to water)	3.7 (5.3)	57 (81)	<15	Issue on Duteau, current treatment at DCWTP addresses by reducing colour to < 5 TCU.
Turbidity (NTU)	**<u>0.3/1.0 /0.1</u>**[2]	Increased health risk with increased turbidity as reduces effectiveness of disinfection	1.4 (8.3)	1.5 (10.1)	< 3.5 Kal, < 1 Duteau	Main risk on Kal as no treatment to remove turbidity and water quality is dependent on variable lake conditions, if over 3.5 must go on water quality notification. DCWTP is consistently <0.3 NTU.
Total Coliform (CFU/100ml)	0 per 100 mL[3]	Indicator of bacteria present in raw water	65 (1500)	235 (1700)	Note 1	Neither raw water source meets standard, but current treated water does.
E.coli (CFU /100ml)	**<u>0 per 100 mL</u>**	Indicator of presence of fecal material in source	12 (250)	13 (170)	0 per 100 mL	Neither raw water source meets standard, but current treated water does
Cryptosporidium (Count/100ml)	**<u>Treat if known to exist</u>**	Disease causing organism	51 (408)	0.2 (0.2)	> 3 log removal	Main risk on Duteau as does not meet 3 log removal. Kal meets standard most of the time, except with high turbidity events
Giardia (Count/100ml)	**<u>Treat if known to exist</u>**	Disease causing organism	4.7 (8.1)	0.45 (1.0)	> 3 log removal	Main risk on Duteau as does not meet 3 log removal. Kal meets standard most of the time, except with high turbidity events
TOC - Total Organic Carbon (mg/L)	n/a	Causes formation of THM's and HAA's with chlorination of supply	5.4 (14.8)	17.4 (70.6)	Reduce by 60%	Main risk on Duteau and requires further reduction of TOCs.
pH	6.5 – 8.5	Impacts corrosiveness of water	7.96 (8.71)	7.2 (7.8)	Stable, non-aggressive	Issue on Duteau, low pH is corrosive to metallic pipes, use chemical adjustment.
THM's - Trihalomethanes (µg/L)	**<u>100</u>**	Potential carcinogen	Only one sample exceeds	Most samples exceed	< 80	Main risk on Duteau at end of system (note, reviewing other treatment and operational options to reduce)
HAA's - Haloacetic Acids (µg/L)	**<u>80</u>**	Potential carcinogen	No samples exceed	Most samples exceed	< 60	Main risk on Duteau at end of system (note, reviewing other treatment and operational options to reduce)

Notes
1. Health parameters **<u>bolded and underlined</u>**
2. Standard depends on treatment, < 0.3 is for granular media filtration and <0.1 is membrane filtration with filtration not to exceed 1 NTU (GVW has a exclusion to this of the 1.0 NTU turbidity rule on Kal if turbidity is due to the marl (inorganic) and not impacting UV,
3. Total Coliform – applicable to raw water for filtration deferral with no more than 10% of samples exceeding 100 CFU/100ml in 6 months

Duteau Creek Water Quality

The Duteau Creek system is sourced from a creek. Creeks, as with all running water sources have highly variable water quality which can change with weather events with no warning. In addition to the variable turbidity, with high turbidity events correlating to freshet and storm events, other parameters of concern include TOC, THM's and HAA's, colour, and the presence of *Giardia* and *Cryptosporidium*. The current treatment train at Duteau has stabilized the turbidity to < 0.3 NTU and reduced the colour and TOC significantly. Nonetheless, the Provincial drinking water objective for treatment (4-3-2-1-0 Rule) is not achieved and hence filtration is recommended. Additional treatment is required to further reduce the TOC to reduce disinfection by-products (DBP's) to meet the GCDWQ.

Evaluation of Treatment Options

In keeping with GVW long term treatment goals, this report assumes that both Duteau and Kalamalka source water require filtration, with the priority being filtration on Duteau due to the higher risk associated with not meeting the 3 log reduction or inactivation for protozoa. In addition, water from Duteau requires a strategy to reduce the disinfection by-products.

There are numerous filtration options for GVW. Table 2 provides a summary of the filtration technologies considered. Chloramination was also considered as a secondary method of disinfection as it would result in lower generation of THM's and HAA's, however, this method also generates other unfavourable DBP's and is a potential risk to fish bearing waters by uncontrolled discharges (i.e. water main breaks). Chloramination may be an option to consider in the future on the Duteau system.

Table 2 - Comparison of Filtration Options for GVW

Filtration Process	Advantages	Disadvantages	Short-listed for GVW	Recommended Filtration Options and costs
Granular Media Filtration	• Low maintenance • low operation and maintenance (O&M) cost, • commonly used at Okanagan facilities	• Larger footprint	Yes	Recommended for MHWTP due to water quality and current treatment. Will require a pilot at the pre-design stage to ensure the best option.
Granular Activated Carbon, Filtration-Sorption	• Low O&M, • limited specialized operator training	• Larger footprint, • high cost of carbon generation replacement	No	
Biological Filtration	• Low maintenance, • low O&M cost, • very effective for organics and ammonia removal	• Larger footprint, • need an ozone generation system • potential operator health concerns	Yes	Recommended for DCWTP based on a pilot study completed as it will also reduce disinfection by-product precursors.
Low Pressure Membrane filtration	• Potentially smaller footprint	• High O&M costs • proprietary system	Yes	Not chosen as other lower costs options available to GVW.

Evaluation of Lifecycle Costs

Lifecycle costing is an evaluation of all the costs incurred over the expected life of a facility and includes O&M and capital costs. The benefit of completing lifecycle costing is to identify options that may have a lower capital cost but higher O&M costs that could make these options more expensive over the life of the facility. To determine the O&M costs, the existing O&M costs for both the MHWTP and DCWTP were established using historical data provided by GVW. These costs were then used to estimate O&M cost for each plant with filtration based on different capacities. Capital costs were estimated based on unit prices established in TM4 for a variety of flows and plant capacities. Table 3 provides a summary of lifecycle costs for the treatment options recommended with further details provided in TM7.

Table 3 – Lifecycle costs for the filtration options recommended for MHWTP and DCWTP

	MHWTP Granular Media Filtration		DCWTP Biological Filtration	
Flow (ML/day)	Capital	Annual O&M	Capital	Annual O&M
50	n/a	n/a	$20 M	$2.0 M
58	$30 M	$1.4 M	n/a	n/a
100	$53 M	$2.1 M	$25 M	$2.2 M
150	n/a	n/a	$30 M	$2.4 M
200	$78 M	$3.6 M	$43 M	$3.0 M

Costs for different plant flows and capacities were estimated to accommodate a comparison of the nine (9) different long term conceptual water supply options for GVW examined in further detail in TM9.