# Silver Star Water Utility

# Water Treatment Study

July 2007

Agua Consulting Inc.
"Engineered Water Solutions"

## Abbreviations

| | |
|---|---|
| AES | Atmospheric Environment Service |
| ADD | Average Daily Demand |
| ALR | Agricultural Land Commission |
| AO | Aesthetic Objective |
| AWWA | American Waterworks Association |
| CCI | Construction Cost Indices |
| $Cl_2$ | Chlorine or sodium hypochlorite |
| CPCN | Cert. of Public Convenience and Necessity |
| CPI | Consumer Price Index |
| DAF | Dissolved Air Flotation |
| DBP | Disinfection by-product |
| DSM | Demand Side Management |
| DWPA | Drinking Water Protection Act |
| DWPR | Drinking Water Protection Regulation |
| FF | Fireflow |
| FUS | Fire Underwriters Survey |
| GCDWQ | Guideline for Canadian Drinking Water Quality |
| HGL | Hydraulic Grade Line (slope of water in m/m) |
| Igpd | Imperial Gallons per day |
| Igpm | Imperial Gallons per minute |
| IHA | Interior Health Authority |
| L | litre |
| L/ca/d | Litres per capita per day |
| L/s | litres per second (flow rate) |
| $m^3/s$ | cubic metre per second, (flow rate) |
| mg/L | milligrams/litre ( parts per million) |
| MAC | Maximum Acceptable Concentration |
| MCC | Motor Control Centre |
| MF | multi-family |
| ML | megalitre ( one million litres = 1,000 $m^3$) |
| ML / day | Megalitres per day |
| MDD | Maximum daily demand |
| MIgpd | Million Imperial gallons per day |
| MOE | Ministry of Environment |
| NTU | Nephelometric Turbidity Unit |
| OBWB | Okanagan Basin Water Board |
| OWSC | Okanagan Water Stewardship Committee |
| OCP | Official Community Plan |
| O & M | Operations and Maintenance |
| PET | Potential Evapotranspiration |
| PHD | Peak hour demand |
| PRV | Pressure reducing valve |
| PS | Pump Station |
| psi | pounds per square inch (pressure) |
| PLC | Programmable Logic Controller |
| PST | Provincial Sales Tax |
| PU | Pillow Unit (i.e. housing unit designation) |
| PZ | Pressure Zone (normal HGL in metres) |
| RDNO | Regional District of North Okanagan |
| RPBA | Reduced Pressure Backflow Assembly |
| SCADA | Supervisory Control and Data Acquisition |
| SFE | Single Family Equivalent (equivalent to SF lot) |
| SDWR | Safe Drinking Water Regulation |
| SWTR | Surface Water Treatment Rule |
| TCU | True Color Units |
| TDH | Total Dynamic Head |
| THM | Trihalomethane |
| TOC | Total Organic Carbon |
| TWL | Top Water Level ( metres ) |
| UFW | Unaccounted for Water |
| $\mu$g/L | micrograms / litre ( parts per billion) |
| uS /cm | microsiemens |
| USgpm | US gallons per minute |
| WSC | Water Survey of Canada |
| UV | Ultraviolet |

Image Credit: Front Page aerial photo, Google Earth

Agua Consulting Inc.
"Engineered Water Solutions"
Agua file: 031-02-402

July 13th, 2007

Regional District of North Okanagan
9848 Aberdeen Road
Coldstream, BC
V1V 1Z6

Attention: Mr. Michael Stamhuis, P.Eng
General Manager, Community and Infrastructure Services

**Re: Water Treatment Study –Silver Star Water Utility**

Dear Michael:

We are pleased to present our Water Treatment Study report for the Silver Star Water Utility. This study provides a summary of the following items:

- A data reviewed in the preparation of the report;
- Regulations review summary;
- Water demand assessment and future forecast;
- Water Quality Assessment;
- Review of Water Treatment Options;
- Treatment Site review; and
- Capital and Operational cost estimates.

Please review this report and contact us with any comments and/or additional information that you wish included with the final report.

Yours truly,
Agua Consulting Inc.

Bob Hrasko, P.Eng.
Principal
RJH/rh

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# CONTENTS

# 1. INTRODUCTION

## 1.1 GENERAL

This final report and enclosed drawings outline the existing system and proposed upgrades/expansion to the water supply, disinfection and distribution systems for the Silver Star Utility. In addition this report also considers the options for improved water treatment for the resort. This work comes at the request of the Regional District of North Okanagan (RDNO) and in acceptance of our proposal dated February 14th, 2007.

## 1.2 EXISTING WATER SYSTEM

Silver Star Mountain Resort is located 22 km northeast of Vernon, BC in the Monashee mountain range. The village centre is located at an elevation of approximately 1,600m with residential and commercial properties surrounding. The entire ski resort encompasses over 1,200 ha of mountain terrain.

The Regional District of North Okanagan has owned the domestic water system at Silver Star Mountain since 1991 and have operated the system since 2000. The resort continues to develop and in 2006, the new 224 ML Vance Creek Reservoir was constructed by Silver Star Resort. The RDNO is responsible for the water system while Silver Star is responsible for ensuring the source water supply.

The present water treatment for the mountain consists only of disinfection with sodium hypochlorite. A package cartridge system water treatment plant also exists on the mountain, however it is under capacity and expensive to operate. As a result, the RDNO has not used the filters for several years.

The existing water system consists of seven fractured bedrock wells with a total capacity of approximately 6.4 L/s. This does not include the recently installed Well No. 13. Two existing open storage reservoirs (Paradise Lake and Mid-Tee Reservoir) collect runoff from spring freshet and are used to supplement peak day demands during ski season. All water is chlorinated before entering a 1,720 $m^3$ closed concrete storage reservoir which provides storage for fire protection and for disinfectant contact time. The entire distribution system is supplied by gravity and is also looped. A SCADA system is used to monitor the system and an alarm dialer provides notification of any system malfunctions. A new open reservoir (Vance Creek site) was constructed at the end of 2006 but has yet to be commissioned.

Table 1.1 on the following page provides a technical summary of the key infrastructure features for the water system. Table 1.1 corresponds to Figure 1.1 which is a map identifying the location of the key features.

**Table 1.1 Key Infrastructure Components**

| I.D. | Location | Description / Information |
|---|---|---|
| Surface Water Sources | | |
| S-1 | Mid-Tee Reservoir | Open surface earth berm reservoir,<br>collects surface runoff and groundwater springs<br>HWL = 1641.70 m Volume = 4.50 ML |
| S-2 | Paradise Reservoir | Collects surface runoff during spring freshet<br>earth berm reservoir<br>HWL = 1718.60 m Total Volume = 61.3 ML Useable Volume = 44.5 ML |
| S-3 | Vance Reservoir<br>(Pending approval) | Collects surface runoff during spring freshet<br>earth berm reservoir, HDPE liner<br>HWL = 1658.0 m Total Volume = 224 ML Useable Volume = 216 ML |
| Wells | | |
| W-1 | Above Mid Tee | Capacity 0.00 L/s May provide 1.67 L/s but only in emergency conditions |
| W-2 | Southernmost well | Capacity 2.22 L/s Fed through 75mm main to Mid-Tee building |
| W-3 | South of Mid-Tee | Capacity 0.85 L/s Fed through 75mm main to Mid-Tee building |
| W-4 | Ski Run E of village | Capacity 0.56 L/s Chlorinated and pumped directly into the water distribution system |
| W-5 | At culvert E of Silver Star Road | Capacity 1.27 L/s Fed through 75mm main to Mid-Tee building |
| W-10 | At Peak | Capacity 0.44 L/s fed through 50mm main to 150mm main from Paradise Res. |
| W-12 | Below Well 2 | Capacity 1.06 L/s fed up to 75mm main to Mid-Tee Building |
| | | Total Well Capacity 6.4 L/s |
| Reservoir Storage | ( Volume, comment and High water level ) | |
| R-1 | Upper Tee Reservoir | 1,720 $m^3$ Rectangular Buried Concrete Reservoir, 4 cells HWL 1685.74 m |
| R-2 | Ridge Reservoir | 1,020 $m^3$, Trapezoidal shape Buried Concrete Reservoir, single cell HWL 1,731.70 m |
| | | Total Reservoir Storage = 2,720 $m^3$ |
| Booster Stations | hp, flow, description | |
| B-1 | Ridge Booster | 2 – 7.5 hp (5.36 L/s each @ 53m TDH) in line turbines, 3 phase 208V,<br>Centreline of piping elevation = 1631.6m<br>150mm diameter PRV valve |
| Transmission Main | | |
| T-1 | Paradise to Mid-tee | 2,800 m long C-900 150mm diameter Class 150 PVC Main<br>Capacity of flow to Upper Tee Reservoir HGL Estimated at 20 L/s |

Tied to Figure 1.1 which shows the location of the components as set out on the mountain. Wells 6-9 and 11 were not deemed sufficient to be incorporated in to the Utility. Well 13 has been drilled but not proven out yet.

## 1.3 WATER SUPPLY ISSUES

There are several issues related to water quality and quantity that were identified through the scope of this study. These issues include:

- ☐ Water quality variations in the late winter seasons during snowmelt when turbidities in Paradise Reservoir could rise to above 1.0 NTU for brief periods of time, thereby limiting year round use;
- ☐ Low pressure at the knoll area of the village where water pressures can be below 35 psi;
- ☐ Issue of watermain installation and the timing of when to install additional watermain capacity from the Paradise reservoir storage area of the mountain to the village;
- ☐ Attaining sufficient chlorine contact time for *Giardia* inactivation within the reservoirs and before the first point of contact;
- ☐ Addressing IHA concerns as set out in their January 17, 2007 memorandum and review letter;
- ☐ Watershed capacity and licensing concerns related to storage;
- ☐ Balancing the groundwater and surface water supplied to achieve the highest quality.

## 1.4 DESIGN OBJECTIVES

The water system design is to meet the following broad objectives:

- Develop a water treatment concept that meets the requirements of the IHA and the GCDWQ;
- The report must be suitable for submission to approving authorities including the Province of BC (for CPCN) and Interior Health Authority;
- Provide sufficient detail for water treatment options, direction and recommended process, based on collected water quality information; and
- To provide the basis for the pre-design of facilities including the footprint, preliminary piping layout for water treatment and disinfection equipment and watermain sizes.

## 1.5 REPORT PREPARATION

In accordance with the scope of work and the Terms of Reference, the following tasks were proposed and then carried out to complete this report:

Task 1 - Project Initiation and Data Collection
Task 2 - Water Demand Assessment
Task 3 - Water Quality Assessment
Task 4 - Regulations Review and Requirements
Task 5 - Water Treatment Options
Task 6 - Water Treatment Plant Siting Review
Task 7 - Draft Report
Task 8 - Final Report Submission (pending review of draft report)

Specific components of the works were a review of the Strategic plan by KWL (2005), a review of the Bell-MK report on WTP siting (2006), review of the distribution system and supply line hydraulics with the aid of the EPANET computer distribution system model, a site visit of the key facilities, meetings with all of the main stakeholders including the IHA, RDNO and Silver Star Mountain Resort. External information on hydrology and regional capacity to supply the mountain was also reviewed.

## 1.6 APPROVAL AGENCIES

There are several approval agencies that will be involved during the design and construction of the water supply system and water treatment facilities. A summary of the agencies and their involvement is set in Table 1.2.

**Table 1.2 Approving Agencies**

| | |
|---|---|
| **IHA** | Water Approval is required from the Public Health Engineer for all new domestic water supply works. The review by IHA focuses on potability of water and public health. Two sets of sealed engineering drawings are to be submitted to the Penticton Regional Health Office prior to any water system construction taking place. |
| **RDNO** | RDNO will review any future treatment or water infrastructure designs as part of their operations of the water utility. They will review water distribution and water treatment designs in conformance with their subdivision and engineering design bylaws.<br><br>In addition, the RDNO will also review any reservoir or building construction as part of the Building code review of requirements. Ultimately the system will become part of the RDNO water system. |
| **MOE** | Approval is required for any changes in water licensing applications for storage facilities or water for distribution.<br><br>Any reviews of the dam works must meet the provincial requirements for dam safety. |

# 2. CRITERIA

## 2.1 INTRODUCTION

This section provides the criteria used in the development of this report. The applicable regulations and bylaws that apply are listed within this section.

## 2.2 WATER QUANTITY CRITERIA

Water quantity criteria for mountain resorts are substantially different from that of typical residential development. The criteria is based on indoor water demands. All of the water utilized within the distribution system is used for domestic in the residence purposes and as a result, the water demand numbers are significantly lower than that of other bylaw criteria that exists in the Okanagan. The water quantity criteria used for this report are developed in Section 3.0. It is summarized below.

**Table 2.1 Water Quantity Criteria**

| Quantity Parameter | Criteria | Comments |
|---|---|---|
| **Water Demand (flow records)**<br>Maximum Day Demand<br>Peak Hour Demand<br>Maximum Monthly Demand<br>Average Day Demand (winter)<br>Average Day Demand<br>UFW | <br>1,035 $m^3$/day<br>11.98 L/s<br>16,200 $m^3$/month<br>500 $m^3$/day<br>315 $m^3$/day<br>65.5 $m^3$/day | <br>Correspondence, W.McKim<br>Flow Records<br>Flow Records<br>Agua Review and Est.<br>Agua Review and Est.<br>KWL Estimate of 2,000 $m^3$/mo. |
| **Water Demand (design)**<br>Peak Hour Demand<br>Design Daily Demand | <br>22.28 L/s (est. of 1.86 x MDD)<br>227 L / PU / day | 4 PU/ Hotel room<br>12 PU/ SF dwelling unit (chalet)<br>17 PU/ duplex dwelling unit<br>5 PU/ 1 BR condo<br>6 PU/ 2 BR condo<br>7 PU/ 3 BR condo<br>9 PU/ Grnd floor townhouse<br>17 PU/Duplex Lot<br>3 PU/ Hostel unit<br>1 PU/ 5 seats, pub, restraint<br>1 PU/ 500 sq. m Retail store |
| **Fire Demand / duration**<br>Silver Creek Hotel<br>(hotel is not sprinkler protected) | 9,750 L/min (162.5 L/s) for 2.0 hrs | Fire calculations for flow and duration based on Fire Underwriters Survey<br>Fire protection is based on either storage volume sited above or the combination of storage plus pumping capacity with backup power |
| **Reservoir Storage** | Sum of the following 3 items<br>• Balancing storage plus<br>• fire storage plus<br>• emergency storage of 25% of the sum (fire + balancing) | Standard industry criteria for reservoir sizing |

## 2.3 HYDRAULIC CRITERIA

Hydraulic criteria as set out in the RDNO Subdivision Servicing Bylaw No. 1769 were not considered applicable to Silver Star due to the vast range in the number of persons on the hill over the course of a year. Therefore the design demands were developed from flow records from Silver Star and Big White ski resorts as well as in accordance with good engineering practices.

The water distribution modeling program EPANET was used to analyze the water supply facilities and to determine watermain sizes to convey the required fireflow to the north and south development areas and the central multi-family development area.

## 2.4 WATER QUALITY CRITERIA

Drinking water quality in BC falls under the control of the Provincial Government under the Ministry of Health. The BC Drinking Water Protection Act, passed in 2001, forms the basis for legislation for water quality in BC. The act sets out the general policy for the supply of drinking water to the people of BC.
The BC Drinking Water Protection Regulation 200/2003, including BC Regulation 352/2005 and including amendments to Dec 9$^{th}$, 2005 is the current regulation that sets out the specific requirements for the protection of drinking water in the province. The regulation is interpreted by the Chief Medical Health Officer of each Health Authority region in the province and the details of what must be met by local water utilities are set at this level. For this region, the Interior Health Authority is the local regulator.

### IHA Treatment Criteria

The IHA has recently raised the standard of expectation of water treatment for new and existing water systems. IHA has stated that the standard for water supply is to meet the updated Guidelines for Canadian Drinking Water Quality and that the target for turbidity is to be 0.10 NTU. This target is only achievable with water treatment including filtration. Turbidity is a measurement of clarity of water. The IHA has stated that the following "43210" requirement, in accordance with the GCDWQ, is to be met for all new water systems in the IHA's area of jurisdiction;

| | |
|---|---|
| 4 | 4 log (99.99 %) inactivation of viruses |
| 3 | 3 log (99.9%) inactivation of *Cryptosporidium* and *Giardia Lamblia* (protozoa cysts) |
| 2 | 2 types of treatment including two barriers of treatment |
| 1 | Less than 1.0 NTU turbidity units at all times |
| 0 | 0 total and fecal coliforms in the water system |

The 43210 protocol was introduced several years ago and has been accepted as a good design standard by the water supply industry.

### Filtration Deferral

The concept of filtration is based on the premise that source water that is uncontaminated poses a lower risk of causing waterborne diseases that water which may be contaminated. A water utility must do what is can within it's controls to keep the raw source water in a state of high natural quality. Provided the raw water quality meets the parameters within the GCDWQ, and all of the known risks can be managed through enhanced disinfection processes, the requirements to treat may be reduced to where filtration may not be necessary.

The concept of water filtration deferral is currently being considered by the IHA as a viable means of achieving water quality improvements. The concept is considered to be viable in watersheds which have high source water quality and a low risk of contamination of wastes that can cause waterborne diseases. The basis for the deferral is in accordance with the GCDWQ which allow for high quality unfiltered sources to remain as-is through protection of the source. This would include the development of a *Watershed Control Program*. A similar concept has been formalized and enacted by the USEPA and is known as the "*Filtration Avoidance Criteria*" which is now part of their Surface Water Treatment Rule. The exclusion criteria as set out by the GCDWQ are included in Appendix A.

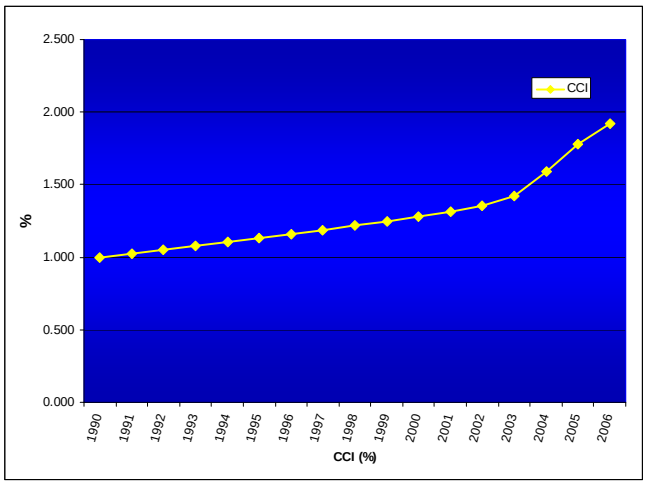
The cost to protect source water is typically a fraction of that of the water treatment processes. The revenue stream to protect those sources does not formally exist within our current regulatory regime. A solid principle for sustainability is to have the most committed stakeholder have a lead role in monitoring and protecting their water source. Numerous discussions have taken place with IHA staff and at this time, filtration deferral seems achievable for Silver Star Utility, however the final decision rests with the regulator.

#### Interior Health Authority (IHA) Construction Criteria

All drinking water infrastructure designs must be reviewed and approved by the Public Health Engineers. The IHA Public Health Engineers utilize the Ten States standards for review of municipal infrastructure. These standards form an excellent baseline from which the safety of infrastructure can be assessed.

## 2.5 COST ESTIMATE CRITERIA

Cost estimates are provided in year 2007 dollars and include a 10% allowance for engineering and a 15% allowance for project contingency.




In the past few years, construction costs and costs for building trades has significantly increased in the Okanagan. The construction cost index has historically risen at a rate of 2.75%. The cost increase in the Okanagan since 2004 has been estimated at 21%.

Taxes are in addition to the cost estimates provided.

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# 3. WATER DEMAND ASSESSMENT

## 3.1 INTRODUCTION

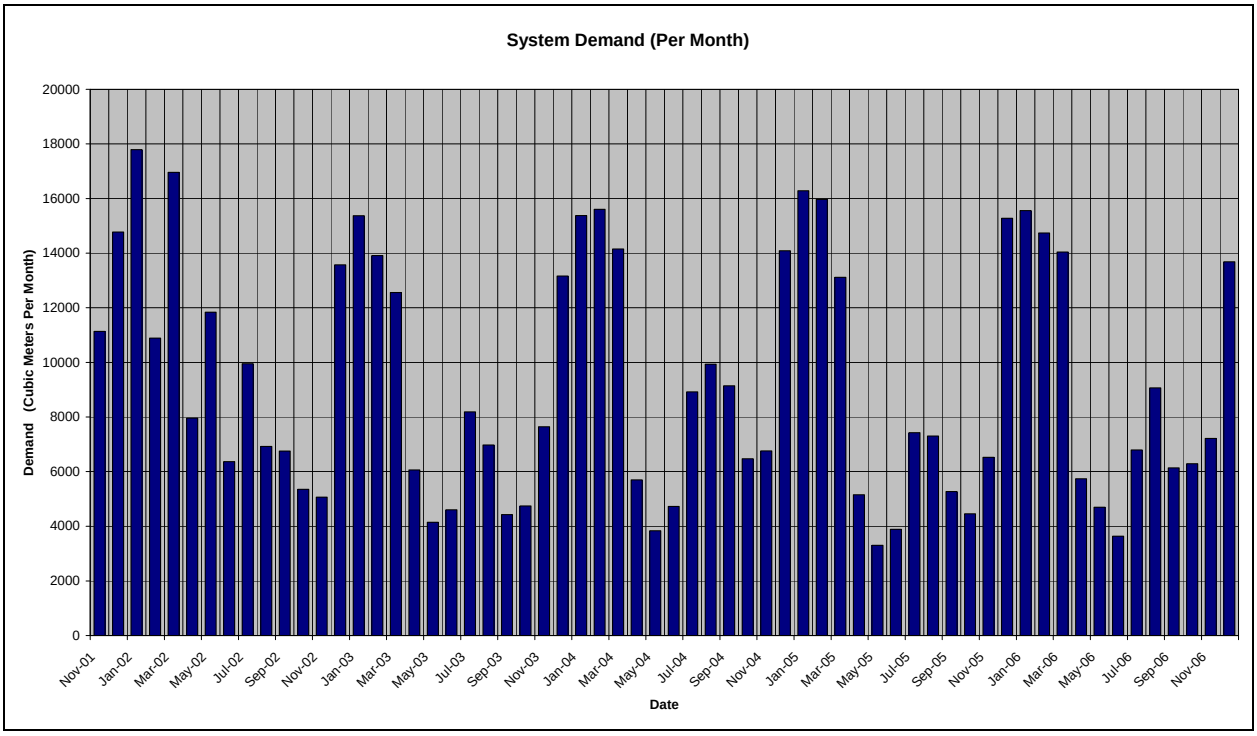
Water demands for various conditions and time horizons were developed and are presented in this section. The demands are based on existing measured flows and data from previous reports. The data and water demand information is extended forwards to provide future estimates.

Source availability is also presented in this section. The total annual withdrawal from groundwater versus surface water is provided along with where future surface waters may come from.

## 3.2 DESIGN WATER DEMAND

The water demand rates for Silver Star Utility were developed by reviewing past water study reports (KWL and Bell MK) as well as Silver Star Utility's own water use records. These past reports generated the water demands empirically from water meter records. Due to the large changes in water demand from summer to winter as well as the large changes in numbers of persons on the hill, the highest water demand period was used for design purposes (the week between Christmas and New Years).

**Figure 3.1 - Monthly Water Demand Pattern**



We have assumed that the most recent numbers provided to us (i.e. 2006/2007 ski year) represent the busiest time for the resort. We understand that December 30th, 2006 was the busiest day on the hill with 6,700 skiers. The corresponding water use record for that day (ie maximum daily demand) was approximately 230,000 Igal (1,035 $m^3$). Table 3.1 provides the rationale for developing the water demand criteria per pillow unit (PU).

Assumptions made in the generation of the base criteria in Table 3.1 are as follows;

- The 6,700 total skiers differs from the number of "day skiers". Day skiers are those that travel to the mountain from elsewhere and do not have on-hill accommodation;
- It was considered that the portion of the day skiers which were staying on the hill to be approximately 80% of the number of design PU;
- For design purposes it was considered that the mountain was at capacity, which took into consideration units which were empty and units which were over capacity.
- The use of 43 Igal/day per PU was considered to be conservative as future demands would assume 100% occupancy for the PUs;
- Day skiers (i.e. did not stay overnight) were calculated as 1,000 vehicles (2.5 passengers per vehicle) plus 10 buses of 40 passengers each equalling 2,900. This number was used through both future estimates at a growth rate of 3% per annum. The day skiers are considered to be "locals" and their number would only increase slightly (compared with the number of pillow units). This is due to the fact that although the local population is growing, a portion of the local skiers would also buy units on the hill..

**Table 3.1 – 2006 - Maximum Day Water Demand Estimate**

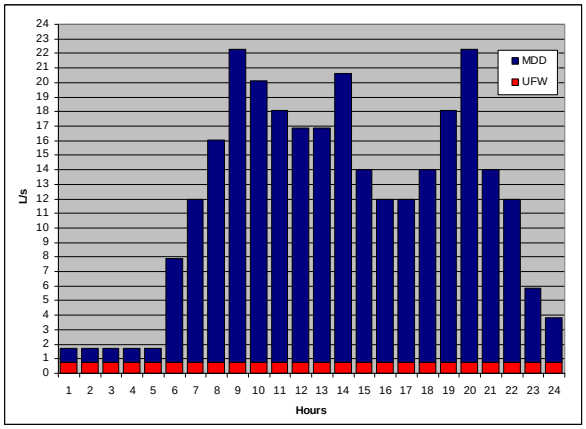
| | Units | | Estimate of Actual | | Design Criteria | |
|---|---|---|---|---|---|---|
| Demand Category | (No.) | (Igpd) | (Igpd) | (L/s) | (Igpd) | (L/s) |
| **UFW** | | | 14500 | 0.76 | 14500 | 0.76 |
| **Day Skiers** | | | | | | |
| Actual (best est.) | 2,900 | 10 | 29000 | 1.52 | | |
| Design No. | 2,900 | 10 | | | 29000 | 1.52 |
| **Pillow Units** | | | | | | |
| Actual (84% full of 5454 PU) | 4363 | 42.7 | 186500 | 9.71 | | |
| Design No. (100% full capacity) | 5454 | 43 | | | 234522 | 12.32 |
| **Total Actual MDD ( 1,035m3/day)** | | | 230000 | | | |
| **Total Design MDD** | | | | | **278022** | **14.6** |

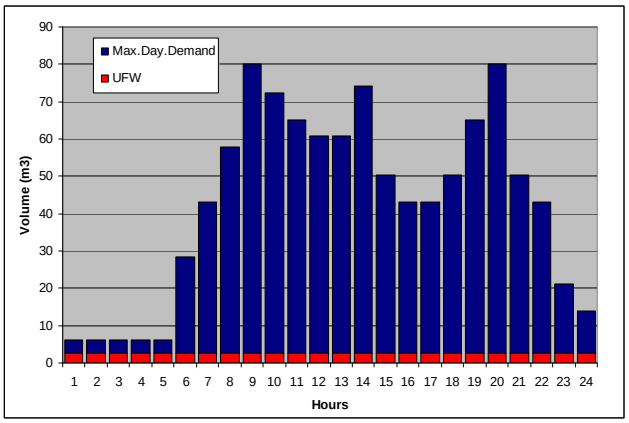
**Table 3.2 - MDD Water Demand Estimate (Diurnal Pattern Estimate)**

| Hour | UFW (L/s) | MDD Volume (L/s) | Total Volume (L/s) | Balancing (m3) | GDF Curve | MDD Flow (L/s) |
|---|---|---|---|---|---|---|
| 1 | 0.76 | 0.97 | 1.73 | | 0.14 | 1.73 |
| 2 | 0.76 | 0.97 | 1.73 | | 0.14 | 1.73 |
| 3 | 0.76 | 0.97 | 1.73 | | 0.14 | 1.73 |
| 4 | 0.76 | 0.97 | 1.73 | | 0.14 | 1.73 |
| 5 | 0.76 | 0.97 | 1.73 | | 0.14 | 1.73 |
| 6 | 0.76 | 7.15 | 7.91 | | 0.66 | 7.91 |
| 7 | 0.76 | 11.22 | 11.98 | | 1.00 | 11.98 |
| 8 | 0.76 | 15.29 | 16.05 | 14.66 | 1.34 | 16.05 |
| 9 | 0.76 | 21.52 | 22.28 | 37.09 | 1.86 | 22.28 |
| 10 | 0.76 | 19.37 | 20.13 | 29.33 | 1.68 | 20.13 |
| 11 | 0.76 | 17.33 | 18.09 | 22.00 | 1.51 | 18.09 |
| 12 | 0.76 | 16.13 | 16.89 | 17.68 | 1.41 | 16.89 |
| 13 | 0.76 | 16.13 | 16.89 | 17.68 | 1.41 | 16.89 |
| 14 | 0.76 | 19.85 | 20.61 | 31.05 | 1.72 | 20.61 |
| 15 | 0.76 | 13.26 | 14.02 | 7.33 | 1.17 | 14.02 |
| 16 | 0.76 | 11.22 | 11.98 | | 1.00 | 11.98 |
| 17 | 0.76 | 11.22 | 11.98 | | 1.00 | 11.98 |
| 18 | 0.76 | 13.26 | 14.02 | 7.33 | 1.17 | 14.02 |
| 19 | 0.76 | 17.33 | 18.09 | 22.00 | 1.51 | 18.09 |
| 20 | 0.76 | 21.52 | 22.28 | 37.09 | 1.86 | 22.28 |
| 21 | 0.76 | 13.26 | 14.02 | 7.33 | 1.17 | 14.02 |
| 22 | 0.76 | 11.22 | 11.98 | | 1.00 | 11.98 |
| 23 | 0.76 | 5.11 | 5.87 | | 0.49 | 5.87 |
| 24 | 0.76 | 3.08 | 3.83 | | 0.32 | 3.83 |
| **Totals** | **0.76** | **11.22** | **11.98** | **250.6** | **24.00** | **11.98** |

Table 3.2 provides an estimate of the maximum daily demand on an hourly basis throughout a single day. The information is based on residential use patterns for water systems without any external or outdoor uses.

**Figure 3.2 - Existing MDD – Daily Diurnal Water Demand Pattern by Flow and Volume**



The resort is growing with more residential and commercial building planed for construction, including Snowbird, Alpine Meadows and the Ridge. In the 2006-2007 season it was estimated that there were 4,500 PU on the hill. The growth projections identified by Silver Star Mountain Resort are as follows:

| Timing | Development Units | Growth Rate |
|---|---|---|
| ▪ Existing (2007) | 5,454 PU | |
| 2009 | 10,081 PU | 36% |
| ▪ 2017 | 14,200 PU | 4.5% |
| ▪ Ultimate build-out | 20,000 PU | n/a |

As a result, this document considers the implications on the water system for expansion up to 14,200 pillow units in the next 10 years and uses this number in projecting the water demands.

**Table 3.3 – Estimated Future Maximum Day Water Demand**

| Condition | PU (No.) | Day Trips (No.) | UFW (L/s) | PU (L/s) | Day Trip (L/s) | Total (L/s) |
|---|---|---|---|---|---|---|
| Existing | 5454 | 2900 | 0.76 | 12.32 | 1.52 | 14.61 |
| Year 2009 | 10081 | 3400 | 0.76 | 22.78 | 1.79 | 25.32 |
| Year 2017 | 14200 | 3900 | 0.76 | 32.08 | 2.05 | 34.89 |
| Ultimate | 20000 | 6300 | 0.76 | 45.19 | 3.31 | 49.26 |

| Criteria | | |
|---|---|---|
| | Pillow Units | 43 Igpd |
| | Day Trips | 10 Igpd |

Treatment facilities must be sized to expand to an ultimate maximum daily demand flow of 50 L/s.

## 3.3 SOURCE AVAILABILITY AND LICENSING

### Surface Water

Silver Star utility currently has 49.0 ML of effective surface water available to them in an average annual year. With the addition of Vance Creek Reservoir, there is expected to be three available storage reservoirs with storage volume as summarized below.

| | |
|---|---|
| Mid-Tee reservoir | 4.5 ML |
| Paradise Reservoir | 44.5 ML |
| Vance Creek Reservoir | 189.0 ML (pending approvals) |
| **Total Expected Surface Water Storage** | **238.0 ML** |

Construction is complete for another 224 ML/yr. of surface water storage at the Vance Creek Reservoir site. The conservative estimate for its useable volume (taking ice and evaporation into account) is 189 ML. Licensing and approvals are still being worked through with the regulator. Silver Star Utility currently has a submission to the MOE for technical assessment of a water license. The license application is for an additional 130,000,000 Imperial gallons (585 ML) annually requested from Vance Creek for potable use. The new reservoir is not on line at this time but is expected to be once repairs are complete and applicable permits and licensing is approved. This work is being carried out by others.

### Groundwater

In addition to the surface water sources, Silver Star Utility also relies on groundwater. Based on data presented in the Bell MK report the maximum annual volume of groundwater supplied to the system is 68.3 ML during the winter period and 59.3 ML for the remainder of the year for a total of 127.6 ML. The utility has not fully relied on groundwater as the peak runoff rates cannot be maintained during the peak demand days during the winter season.

The total water currently available is 176.6 ML of groundwater and surface water available annually. Table 3.4 provides a projection of future annual water demand requirements. One unknown factor that may have a significant impact on the annual water demand is the future level of activity on Silver Star Mountain during the summer season.

**Table 3.4 – Estimated Future Annual Water Demand**

| Condition | PU (No.) | Consumpt. (m3/day) | Day Trips (m3/day) | UFW (m3/day) | Total Demand (m3/day) | Annual (ML/yr) |
|---|---|---|---|---|---|---|
| Existing | 5454 | 225 | 25 | 65.5 | 315 | **115** |
| Year 2009 | 10081 | 416 | 46 | 66 | 528 | **193** |
| Year 2017 | 14200 | 586 | 65 | 66 | 716 | **261** |
| Ultimate | 20000 | 825 | 92 | 66 | 982 | **358** |

| | | | | | |
|---|---|---|---|---|---|
| Consumpt. Criteria | Pillow Units | 9.086 | Igpd / PU | 41.25 | L/d/PU |
| | Day Trips | 10% | Percentage | | |

# 4. WATER QUALITY

## 4.1 INTRODUCTION

Section 4 presents a summary of water quality available from the water sources, risks to water quality, and water treatment options that were considered. The direction provided in this section is intented to provide Silver Star Mountain with improved drinking water quality through methods of source protection and upgraded treatment.

## 4.2 WATER QUALITY CONSIDERATIONS

### Current Sampling Program

The current RDNO sampling program was reviewed with respect to compliance with the GCDWQ. Health Canada requires 1 sample per 1,000 population per month for bacteria in the treated water. The RDNO is exceeding this requirement for bacteria and $Cl_2$ residual levels. A review of the Silver Star Utility 2005 yearly sampling report indicates that 222 samples were taken from five different locations in the distribution system and no samples tested positive for total or fecal coliforms. Sampling has been adjusted to now test for *E.coli*.

There has been limited data collected on the raw water before treatment, and this information is key to determining the level of source water risk and potential bacteria or protozoa in the raw water.

Full parameters for all of the sources has not been collected at regular intervals. Due to the large number of sources, this may or may not provide useful information. It is recommended that full parameters be collected twice a year on June 1 and on December 1 annually. The June 1 time corresponds to the end of spring runoff and allows Silver Star Utility time to evaluate if there is a link between the source water and the groundwater activity on the mountain. The December 1 time corresponds to the start of ski season when higher water demand will be required by the resort. Time to adjust for any deviations or poorer quality sources can be determined from the December 1 water quality data.

Additional sampling to validate the use of UV disinfection is recommended. The low coliform levels that are expected from the watershed also require validation. To prove that the water source is protected and of high quality, the quality data must be collected and documented.

### Recent Sampling

As part of this report, four water samples were retrieved and delivered to Caro Environmental Services (analytical laboratory) of Kelowna BC. All samples were analyzed for the standard water testing parameters included in Caro's routine water potability analysis as well as total organic carbon (TOC) and UV transmissivity. The analytical results are summarized in Table 4.1. The laboratory certificates of analysis presented in Appendix A.

Two water samples were taken on May 8$^{th}$, 2007 in the mid-Tee chlorination building. Sample SS1 was taken from a "bleeder" line which was water from Paradise Reservoir pipeline. The Paradise Reservoir was off line at the time and is standard practice for the summer months. The bleeder line allows a small

continuous volume of water to pass from the pipeline. Sample SS2 was taken from the groundwater supply main. Groundwater is the main water supply for Silver Star Utility during the low demand periods (i.e. water is not being blended with surface water from the open raw water reservoirs). At the time the sample was taken groundwater wells #1, #2 and #3 were pumping.

Two additional samples were taken on May 23rd, 2007 from Paradise Reservoir. Sample "Spillway Paradise" was retrieved from the spillway out of Paradise reservoir. It could be considered as representative of the water in the reservoir from the snowmelt. Sample "Pipeline old" was taken from the outlet pipeline from the reservoir.

The sample "pipeline old" was compared to SS1 as it should be the same source water. With the exception of turbidity all parameters were also within the GCDWQ.

The sample "spillway-Paradise" exceeded the GCDWQ for turbidity, total iron and total coliforms. This water was spilling from the reservoir and the reservoir was offline at the time. We understand that the reservoir will not be on line until the late fall of 2007.

Table 4.1 provides a summary of four samples taken.

#### UV Disinfection Applicability

A review of the water quality results for samples SS1 and SS2 indicate all parameters were well within the GCDWQ. Parameters without guidelines were considered to be within what is considered as acceptable for drinking water. The UV transmissivity levels were very high and would be considered viable for UV treatment.

Total Organic Carbon (TOC) levels are also a very good indicator of UV transmissivity. The TOC levels are all below 3.0 mg/L. This is expected with the high elevation of the source water, the shorter growing season for plant life at this elevation, and the resulting lower levels of growth at this elevation. At TOC levels below 3.0 mg/L, the UV transmissivity through the water is expected to be reliably above 85%.

**Table 4.1 - Summary of Water Samples**

| | GCDWQ | Units | SS-1 | SS-2 | Spillway-Paradise | Pipeline-Old |
|---|---|---|---|---|---|---|
| General Inorganic Parameters | | | | | | |
| Chloride | AO<250 | mg/L | 3.2 | 0.28 | 0.26 | 0.56 |
| Flouride | MAC<1.5 | mg/L | <0.1 | <0.1 | <0.1 | <0.1 |
| Alkalinity (total as CaCO3) | ng | mg/L | 124 | 139 | 63 | 112 |
| Nitrate-N | MAC<10 | mg/L | 0.795 | 0.402 | 0.2 | 0.075 |
| Sulfate | AO<500 | mg/L | 27.7 | 40.4 | 18.8 | 24.1 |
| Nitrite-N | MAC<1 | mg/L | <0.01 | <0.01 | <0.01 | <0.01 |
| Hardness (CaCO3 equiv.) | ng | mg/L | 118 | 159 | 83.3 | 140 |
| Conductivity-EC | ng | uS/cm | 376 | 329 | 169 | 276 |
| Colour-true | AO<15 | colour units | <5 | <5 | <5 | <5 |
| pH | AO = 6.5-8.5 | pH units | 7.4 | 7.4 | 7.0 | 7.1 |
| Total Organic Carbon | ng | mg/L | 2.2 | 0.6 | 2.9 | 2.1 |
| Total Dissolved Solids | AO<500 | mg/L | 193 | 198 | 112 | 160 |
| Transmissivity @ 254nm | ng | % | 96.2 | 96.6 | 82.9 | 86.7 |
| Turbidity | MAC<1 | NTU | 0.1 | 0.1 | 15 | 2.1 |
| Microbiological Parameters | | | | | | |
| Coliforms-total | MAC<1 | CFU/100mL | <1 | <1 | 110 | ns |
| E.coli | MAC<1 | CFU/100mL | <1 | <1 | <1 | ns |
| Total Metals | | | | | | |
| Arsenic | MAC<0.025 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 |
| Calcium | ng | mg/L | 38.4 | 54.9 | 24.4 | 44.1 |
| Iron | AO<0.3 | mg/L | 0.13 | 0.15 | 1.02 | 0.29 |
| Magnesium | ng | mg/L | 5.37 | 5.44 | 5.4 | 7.19 |
| Manganese | AO<0.05 | mg/L | 0.011 | <0.001 | 0.033 | 0.042 |
| Potassium | ng | mg/L | 0.55 | 2.01 | 0.69 | 0.62 |
| Silicon | ng | mg/L | 2.3 | 4.7 | 3.1 | 2.7 |
| Sodium | AO<200 | mg/L | 0.96 | 2.08 | 0.67 | 1.34 |
| Uranium | MAC<0.02 | mg/L | 0.0005 | 0.0012 | 0.0002 | 0.0005 |

## 4.3 DRINKING WATER RISK ASSESSMENT

As part of the Drinking Water Protection Act, a Water System Assessment Plan must be developed for each water supplier. The purpose of an assessment is to identify, inventory and assess:

(a) the drinking water source for the water supply system, including land use and other activities and conditions that may affect that source,
(b) the water supply system, including treatment and operation,
(c) monitoring requirements for the drinking water source and water supply system, and
(d) threats to drinking water that is provided by the system

This section sets out threats facing the Silver Star Water Utility.

### Multi-Barrier Approach

*The key to ensuring clean, safe and reliable drinking water is to understand the drinking water supply from the source all the way to the consumer's tap. This knowledge includes understanding the general characteristics of the water and the land surrounding the water source, as well as mapping all the real and potential threats to the water quality. These threats can be natural, such as seasonal droughts or flooding, or created by human activity, such as agriculture, industrial practices, or recreational activities in the watershed. Threats can also arise in the treatment plant or distribution system thanks to operational breakdowns or aging infrastructure.*

*The multi-barrier approach takes all of these threats into account and makes sure there are "barriers" in place to either eliminate them or minimize their impact. It includes selecting the best available source (e.g., lake, river, aquifer) and protecting it from contamination, using effective water treatment, and preventing water quality deterioration in the distribution system.*

*The approach recognizes that while each individual barrier may be not be able to completely remove or prevent contamination, and therefore protect public health, together the barriers work to provide greater assurance that the water will be safe to drink over the long term.*

Source of text: Health Canada Website

The water system for Silver Star Utility utilizes both groundwater and surface water sources. Both sources have differing risks. Golder Associates Ltd. has been retained by RDNO to develop a Groundwater Protection Plan. We understand that the work is underway and that the report will assess drinking water risks that may impact on the existing groundwater wells.

A list of potential drinking water risks apparent to the mountain sources are listed in Table 4.2. The overall level of risk occurrence facing Silver Star Utility is considered to be low to moderate for all scenarios. The moderate risks are manageable and can be improved to low risks through simple and relatively low cost upgrades.

**Table 4.2 - Drinking Water Risk Summary**

| No. | RISK | IDENTIFICATION METHOD(S) | REVIEW COMMENTS | RISK* |
|---|---|---|---|---|
| 1.1 | Human Activity | Total/*E.Coli* monitoring of raw water. Positive E.Coli denotes that waste loading is present from warm blooded animals | Organic waste is possible in watershed. Risk exists if high E.Coli levels are found in combination with inadequate treatment/disinfection. There is no source of human sewage located above the sources. WWTP ponds are located well below water sources | Low |
| 1.2 | Natural Wildlife | Sitings of wildlife | High elevation, lower than average populations | Low |
| 1.3 | Cattle | Sitings of cattle at low reaches of ski hill. | Noted by Silver Star staff that cattle from local lower range leasees occasionally stray up to the higher elevations. Cattle are not allowed within watershed. They are removed immediately when noted | Low |
| 1.4 | Chemical Spill | Call-in by public or notification by road officials. Phone call. | A spill of fuel or some other substance could impact on groundwater wells below the roadway. The question should be addressed in the GW report. | Low |
| 1.5 | Algae Blooms in raw water reservoirs | Source water monitoring. Visible to the eye. Biological monitoring and testing required. | Risk exists. Preventative measures are key to avoiding this. Monitoring for algae bloom potential should be part of the source protection program to understand summer condition of the reservoir. Boil water is not a viable method of protection | Low due to low organic levels at high elevations |
| 1.6 | Distribution system regrowth | Customer complaints. Sampling and low residual levels. | Flushing and if necessary, pigging will help to alleviate regrowth issues. Fresh and low nutrient level waters is key to maintaining low regrowth. | Low |
| 1.7 | Cross Connection | Measurable loss in $Cl_2$ residual level. | Cross-connection-control is policy for all new construction. Premise isolation and backflow is in place. The number of commercial and high hazard installations on the mountain is low. | Low |
| 1,8 | Watermain Break | Either a contractor will phone or your customers will tell you. | Entrainment of silt, sediment and stirred up sediment from within the distribution system piping will create turbidity within the distribution system. Vacuum condition may result at highest elevations if break is at lower elevations. | Moderate. High elevation changes in area |
| 1.9 | Power Failure | Alarms to Operator of Communications failure or equipment failure | Emergency generators required for all chlorinators | Moderate |
| 1.10 | Remoteness of location | Remote locations require higher lead time, take longer to access and results in a smaller margin for error. | Location is already considered to be remote with access being weather dependant and operators not living on the hill. Remoteness increases if facilities are located on the far side of the mountain. | Moderate |

* The Risk Rating denotes risk of occurrence. Risk of occurrence is the assessment of whether or not the risk is present. If there is a risk of occurrence, then a risk of waterborne disease outbreak is possible.

The risk for *Cryptosporidium* and/or *Giardia* cysts in the raw water source is considered to be very low for the Silver Star Utility source water. There is also a low risk for viruses and bacteria is also considered low (a positive bacterial test for total coliforms is possible due to the presence of decaying organic matter).

No data was reviewed for fecal or *E.coli* in the raw water. Increased monitoring is required to ensure that Total and *E.coli* coliform levels are at and remain at low levels. As part of a *Watershed Control Program*, a raw water sampling program must be in place.

## 4.4 WATER TREATMENT OPTIONS

As per the Agua proposal, four options for water treatment are considered for this report. These four options include

1. Enhanced disinfection through the use of Ultra-violet light disinfection;
2. Pressure Filtration through multi-media or carbon filters;
3. Cartridge filtration through some form of replaceable cartridge filters; and
4. Membrane Filtration.

For all of the four options, a disinfection system is to be provided at the end of the water treatment process. Disinfection is required to achieve two objectives. Primary disinfection is to provide the initial kill of all bacteria, viruses and protozoa. Secondary disinfection is to provide a level of protection that bacteria or regrowth does not occur within the water distribution system. This results in a measurable chlorine residual level within the water distribution system at all times. For all options, either or a sodium or calcium hypo-chlorite system is recommended.

Table 4.3 at the end of this section sets out expected treated water quality for the various options. Costs are included in Table 4.3.

For the proposed treatment processes, the costs provided are to treat water demands to a flow of 30 L/s. This flow is approximately 60% of the ultimate flow that could be developed for the utility. Full redundancy is provided for the options. For example, the UV sizing to meet 30 L/s flow consists of three 15 L/s units of which one would be on standby.
The cost estimates are for treatment train (installed) only (i.e. does not include building, electrical, site grading) and are for comparisons purposes only.

## TREATMENT OPTION NO. 1 - ENHANCED DISINFECTION

The first option includes improved disinfection through the use of Ultraviolet (UV) light. It is the only option that does not include filtration. If this option is selected, it is expected that IHA will require a *Watershed Control Program* to show that the water utility is doing what they can to protect and manage the risks present in the source water. The key components of a *Watershed Control Program* are set out in Section 4.5 of this report.

The installation of UV light for primary disinfection followed by chlorine to provide secondary disinfection can provide a high level of disinfection of the water. There are no known side effects of transmitting UV light through water. UV light has been recognized as a useful method of disinfecting water with first US Patent issued in 1950. The technology did not catch on due to there being no measurable residual level to ensure that safety was maintained through the water distribution system. The technology was found in 1997 to be effective in sterilizing chlorine resistant protozoa for a very low cost. This has revitalized the importance of this disinfection in the application towards drinking water.

Major advantages of this option are that it does not have a "waste stream" of water treatment filter backwash, it has reduced power requirements and lower chemical addition costs when compared to the filtration options.

For this option, UV light is recommended to be used as the primary disinfectant as it has the ability to inactivate *Giardia* and *Cryptosporidium* in a cost effective manner. The primary disinfection system would be designed to meet the following criteria:

- Each large UV reactor sufficient capacity to treat an MDD flow (15 L/s). Larger units would require validation certification through one of the approved international methods;
- Three units would be required with two handling the design flow and one unit being redundant;
- Smaller units would be required for flows in the off-season range. A capacity of 1.5 L/s (20 Igpm) is recommended for the smaller units. Smaller units would require NSF 61 certification;
- Dosage rate of 40 milli joules/cm$^2$;
- Design transmissivity of the raw water 87%.

### Large Lamp System

The UV disinfection is proposed with staged capacity to be expandable as demands increase. The initial UV disinfection system would consist of two large lamps (capacity 15 L/s each) that allow for full redundancy should one fail. Large lamp section would be expandable to increase to a size of 5 – 15 L/s lamps. Four lamps would provide long term capacity of 60 L/s.

### Small Lamp System

The small lamps are required to handle the off-season flows below 15 L/s. Three lamps with a flow of 1.5 L/s each is initially recommended to provide the flows when the hill is not in full operation.

**Figure 4.1 - UV Disinfection Sizing Chart (R-Can SUVAM – 6C/4 Lamp System Brochure)**

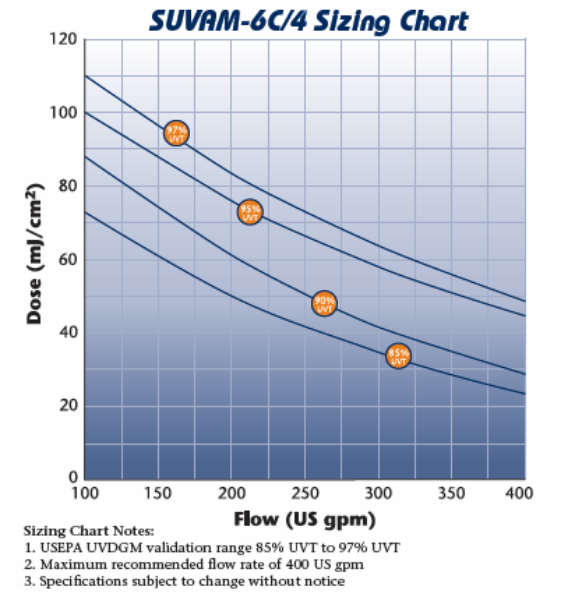
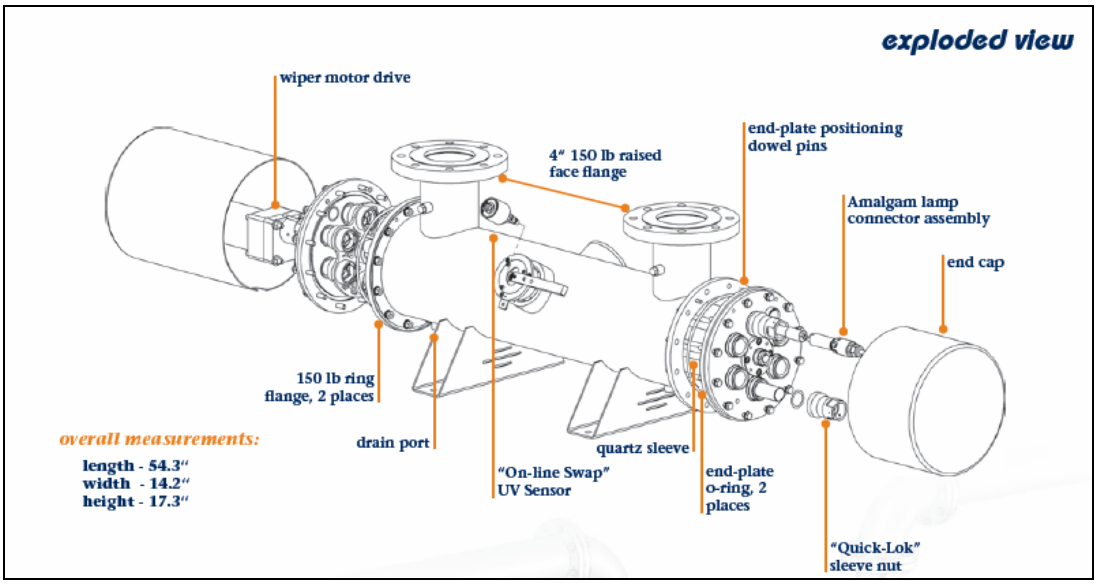



**Figure 4.2 - UV Lamp Cross Sectional View (R-Can SUVAM – 6C/4 System Brochure)**




The estimated cost for this 15 L/s UV reactor is $35,000 each. Three reactors are required to provide 30 L/s.

- ☐ The estimated Capital cost of the UV equipment installed is $250,000;
- ☐ The 2007 O & M cost is estimated to be $15,000 /year;
- ☐ The 20 year lifecycle cost including Capital and O & M costs is $ 486,000.

## TREATMENT OPTION NO. 2 – PRESSURE FILTRATION PLANT

A conventional package pressure filtration system was proposed by Silver Star Mountain Resort and was planned for installation at the building located near Vance Creek Reservoir. The filtration system is similar to the installation that has been in service at Big White Ski Resort.

The proposed process consists of running the raw water through pressure filters consisting of sand and multi-media. Water would then be disinfected through the use of chlorine. Typically the system designers for these types of systems state they will reliably meet effluent that is below 0.50 NTU turbidity units. The benefits of this system would be reduction of turbidity levels, protection against protozoa, and improved taste. The taste improvements are due to the absorption capacity of the carbon that would be part of a multi-media filter. Organic tastes are absorbed by the carbon. There would be a filter back wash effluent stream generated by this style of plant which would need to be disposed of, likely to the wastewater treatment plant in operation at the resort.

As part of the background research of this project and in conjunction with work for Big White Ski Resort, the filtration performance of the existing filters at Big White were reviewed with samples taken and bench scale tests conducted. The results of the bench scale work by Easy Treat is summarized in Appendix A, Section A.4. The bench scale tests showed that chemical addition was required to create enough charge in the raw water to allow particle removal to occur.

Photo - Big White Water Treatment Plant – Filter Media

For the development of a package filtration system, the proposal by Silver Star was reviewed in the costing of system components (scaled up to meet 30 L/s).

- The estimated Capital cost of the direct filtration system is $1,259,000;
- The 2007 O & M cost is estimated to be $28,000 /year;
- The 20 year lifecycle cost including Capital and O & M costs is $ 1,706,000.

### TREATMENT OPTION NO. 3 – CARTRIDGE FILTER SYSTEM

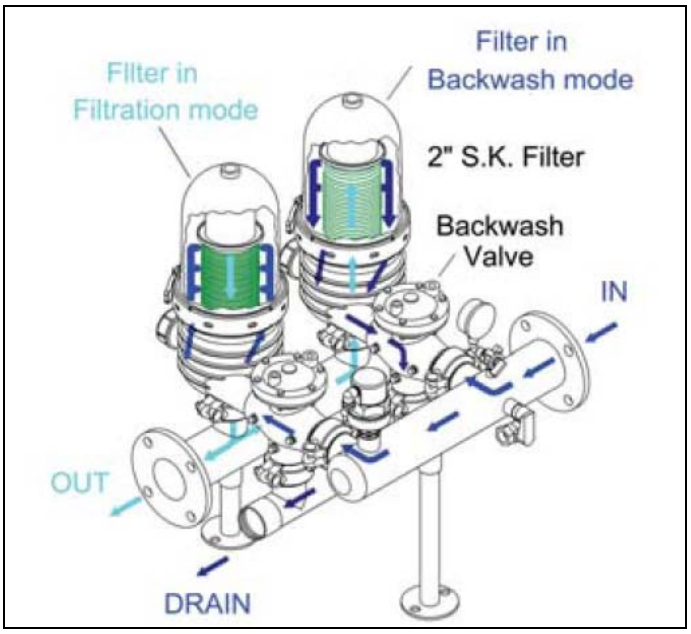
A cartridge filtration system would consist of a combination filtration system that involves a 20 micron backwashable filter to remove the larger particulate matter. The pre-filtered water would then be filtered through 5 micron and 1 micron cartridge filters. Presently two Harmsco Filter cartridges exist at the Mid-Tee building at Silver Star. The filters are under capacity and were considered to be expensive to maintain. They are presently off-line and are not being used.

Photo - Silver Star Mid-Tee Building – Cartridge Filter System

Part of the problem with the system as it exists is that there is no pre-filter to remove the larger particulate matter. One of the methods in reducing the potential for filter binding is to install an automated backwashable filter as shown in the Figure 4.1 below. The Arkal 5 model is a 20 micron filter that is a self-cleaning spinning filter that is triggered by a pressure differential switch which is set with a differential of between 5 and 7 psi.

For this option,the Opal style spinning pre-filters are recommended followed by finer cartridge filters as illustrated in the photograph above.

**Figure 4.3 - Opal Filtration Batteries (Arkal Filtration Systems Brochure)**




If taste and odour issues are encountered, a carbon filter cartridge can be added to the pressure filtration system to provide tastes and odour control, if required. Chlorination would be in place to protect the users from bacteria and/or viruses. This option will generate a filter backwash stream which will need to be treated/disposed of via the existing wastewater treatment process. In addition the cartridge filters with the smallest pore sizes will like need to be disposed of as particulate builds up on them and replaced with new ones.

This option would meet the requirements of IHA for filtration.

- The estimated Capital cost of the cartridge filtration system is $735,000;
- The 2007 O & M cost is estimated to be $45,000 /year;
- The 20 year lifecycle cost including Capital and O & M costs is $ 1,450,000.

### TREATMENT OPTION NO. 4 - MEMBRANE FILTRATION PLANT

An alternative to media/cartridge filtration is a membrane filtration plant. This style of plant can be provided along with chlorine disinfection. This would result in very high quality of water supplied by the Silver Star Water Utility.

The proposed membrane filtration process would typically consists of cartridge filtration, ultrafiltration (UF) and chlorination. The cartridge filter will remove suspended solids from raw water while chlorination provides primary and secondary disinfection. The UF membrane system will be operated automatically via signals from the level switches in the finished water tank. The membrane flushing cycle would be automatically activated at a preset time interval to clean the membrane filter surfaces.

The process would remove the majority of particulate matter. This option would meet all requirements of IHA. This option generates a backwash stream which will need to be treated/disposed of through the existing wastewater treatment process on the mountain. Capacity for the waste stream is required within the WWTP.

- The estimated Capital cost of the membrane filtration system is $1,500,000;
- The 2007 O & M cost is estimated to be $23,000 /year;
- The 20 year lifecycle cost including Capital and O & M costs is $ 1,860,000.

**Table 4.3 Expected Treated Water Quality**

| Water Quality Parameter | GCDWQ (Guideline) | 1.0 Enhanced Disinfection | 2.0 Pressure Filter System | 3.0 Cartridge Filtration | 4.0 Membrane Filtration |
|---|---|---|---|---|---|
| Algae Levels | No standard | Presently low | 3 log removal | 3 log removal | 3 log removal |
| Alkalinity | No standard | No change | No change | No change | No change |
| Coliforms | < 1.0 Total<br>< 1.0 Fecal | < 1.0 Total<br>< 1.0 *E.Coli* | < 1.0 Total<br>< 1.0 *E.Coli* | < 1.0 Total<br>< 1.0 *E.Coli* | < 1.0 Total<br>< 1.0 *E.Coli* |
| Colour | < 15 TCU (AO) | < 5 | < 5 | < 5 | < 5 |
| Hardness | 80 – 120 mg/L of $CaCO_3$ (AO) | 135 | 135 | 135 | 135 |
| Neurotoxins Blue-grn algae | No standard | No protection | No protection | No protection | No protection |
| pH | 6.5 – 8.0 range | 7.4 | 7.4 | 7.4 | 7.4 |
| Taste & Odour | | Good | Very good | Good** | Very good** |
| Temperature | < 15°C (AO) | No change | No change | No change | No change |
| THM | < 100 ug/L | 0.040 mg/L (est.) | 0.025 mg/L (est.) | 0.040 mg/L (est.) | 0.025 mg/L (est.) |
| TOC (in mg/L of $CaCO_3$) | No standard | 0.6 – 2.2 mg/L | 0.3 – 1.0 mg/L | 0.6 – 2.2 mg/L (est.) | 0.3 – 1.0 mg/L (est.) |
| Turbidity | < 1.0 NTU (MAC) | 0.10 – 1.0 | 0.10 – 0.50 | 0.10 – 0.50 | 0.05 – 0.15 |
| UV Transmissivity | > 85% | 87% | 90% | 87% | 92% |
| Waste Stream | No regulation | No waste stream | Significant waste stream | expended cartridge filters | Moderate waste stream |
| *Capital Cost | | $ 250,000 | $ 1,260,000 | $ 735,000 | $ 1,500,000 |
| Annual O &M | | $ 15,000 | $ 28,000 | $ 45,000 | $ 23,000 |

* Capital costs are based on purchase of process equipment and installation cost of process equipment. Cost excludes building structure, civil, electrical and mechanical works.

** Taste and odour is subjective to the consumer. By passing the water through a deep bed anthracite or carbon filter, the taste impacts from organic based materials is reduced significantly.

For comparative purposes, all equipment is sized to provide a maximum day flow of 30 L/s

Table 4.3 shows that the variances in water quality are very small for the options. The safety to the public is basically the same for all options given this raw water source. The decision on which option to proceed with should be based on meeting the regulatory requirements and on costs.

**Long Term Risks and Recommendation**

In the view of the longer term risks that may face Silver Star Utility in the future, the water is being obtained from a limited access area with minimal human activity other than downhill skiers or cross country skiers. The impacts of mining, agriculture, livestock, forestry, wastewater processes and other contamination generating activities is limited at this location. The chances of drifting of pesticides or groundwater movement of contamination is low.

The unresolved issue facing utilities with uncontaminated sources such as Silver Star Utility is whether or not filtration will be required in the future. Emerging contaminants and new treatment processes continue to be developed and the new technology will dictate the direction for the future.

For Silver Star Utility source water, all of the criteria for filtration exclusion appear to be achievable as the raw water quality of the sources is very high. The water quality monitoring results from recent data meet the GCDWQ however, there are data gaps that must be filled. The clarity of the source water is very good and the transmissivity of UV light through the water ranging from 87 to 97%.

For the above reasons, the lower cost option of Enhanced Disinfection is recommended along with the development of a *Watershed Control Program*.

## 4.5 WATERSHED CONTROL PROGRAM

A *Watershed Control Program* is recommended for the Silver Star Water Utility source waters. The control program must encompass the contributing watershed areas and recharge areas of the groundwater aquifers for the wells.

The program must be set up with the following components:

- Defined raw and treated water monitoring;
- Watershed and groundwater recharge area surveillance and proof of such;
- Procedures for water monitoring, recording and reporting;
- Deviation reporting and actions to be taken to ensure that the source water quality feeding reservoirs and aquifers is not compromised during the year;
- Auditable report for easy review and inspection by the regulator (IHA);
- Reporting and corrective actions when several regulatory agencies are involved in a conflict that compromises drinking water;
- Annual plan for source water quality monitoring and source water improvements.

Recommendations have not specifically been made with respect to the Groundwater Protection Plan as it is assumed that Golder Associates will identify these areas of concerns.

# 5. INTEGRATION OF WATER TREATMENT

## 5.1 INTRODUCTION

This section provides the basis for how the proposed water treatment process should be integrated into the existing water system at Silver Star Utility. The integration of infrastructure must consider efficient and effective servicing of existing and future connections on the mountain.

The recommended water treatment approach as set out in Section 4 is to use enhanced disinfection, through the addition of Ultraviolet light, and have sufficient room for further treatment process upgrades for a water treatment process yet to be determined. A site selection exercise is carried out in this section.

Key issues to address are the location of the water treatment plant, whether or not the construction of the 300mm transmission main from Vance Creek Reservoir is warranted at this time.

## 5.2 CURRENT WATER SUPPLY PROPOSAL

In 2006, Silver Star Mountain Resort carried out expansion of the water supply system. The proposed project included the following components:

- Construction of 225 ML Vance Creek Reservoir;
- Installation of a WTP above Vance Creek reservoir in a new WTP building;
- Pumping capacity to lift water from the Reservoir to the WTP and again from the WTP to a new reservoir;
- New bolted steel reservoir located at elevation 1730 metres above Paradise Reservoir;
- A large 300mm diameter feed from the steel tank to the village.

The works completed so far consist of a new HDPE lined reservoir as shown in the photo below. Three phase power has also been extended to the site.

Issues related to costs, access for operations and maintenance, long term cost effectiveness and pumping efficiencies were raised as concerns and further development of the concept is awaiting location of the water treatment process and facilities. The Vance Creek Reservoir site building is one of the options for siting of the Water Treatment Building.

## 5.3 WTP SITING OPTIONS

The proposed water treatment process set out in Section 4 was considered for implementation at several sites. The process is to included UV light as a primary disinfection and utilizing chlorination as secondary disinfection. Developing a site for the water treatment plant included review of several factors:

**Access:** The site must be accessible year round by vehicle. For the initial water treatment technology, it may not be that critical, however, for any future water treatment process, the level of attention and need to have readily available tools and equipment would increase;

**Expandability:** The location of the site must have sufficient room for building and water treatment process expansion. Locations with more space would be preferable;

**Power:** Three phase power is required for the site to power the UV lamps and if necessary, pumping equipment;

**Distribution Modifications:** Distribution system modifications are required for all options. The options with lesser modifications and resulting costs are preferred. System modifications that will allow correction of low pressures in the existing distribution system are preferred.

**Hydraulics:** Having the water treatment plant site at a higher elevation is preferred as the water can be fed by gravity to more of the service area. Sufficient hydraulic capacity must be in place to feed water up to the existing upper tee reservoir at elevation 1,684m.

**UV Limitations:** The WTP site cannot be located at too low an elevation. This would result in pressures on the UV equipment that are too high for the lamps to operate without being exposed to pressures beyond their lamp rating. A maximum pressure of 100 psi is recommended for much of the equipment on the market, but operating pressures in the range of 75 psi or lower are preferred. Some suppliers of smaller equipment have ratings that will go as high as 125 psi.

**Operating Efficiencies:** Less pumping and operations by gravity is preferred as this will reduce the long term electrical costs.

The entire mountain was considered to determine where feasible sites might exist for the water treatment facility. Four sites were selected as having potential for development. Three of the four sites are illustrated on Figure 5.1. All sites are discussed below.

## SITE NO. 1 - VANCE CREEK RESERVOIR SITE

### Siting

The Vance Creek reservoir site would consist of a water treatment facility located within the steel building shown in the photograph in Section 5.2.

Photo - Vance Creek Reservoir and Building

### Water Flow

All water from Paradise Reservoir would have to be directed to flow down to Vance Creek Reservoir at times when the reservoir can handle the capacity. Low head pumps would lift the water from Vance Creek Reservoir through the treatment facility and then water would have to be pumped up again to elevation 1715 metres from where it can flow to town by gravity through the existing 150mm watermain. This system is the least efficient of the four options with respect to long term electrical costs as dual pumping is required.

A positive aspect of this option is that the pumps can add additional hydraulic grade line to force more water through the existing 150mm diameter watermain when needed.

### Constraints

The site is remote and the RDNO may have future operations staff that may limited means of getting to the site year round. Having the water system operations staff crossing ski-runs and activity areas of the ski hill is also not desired by the Resort.

### Distribution System Works

The water would be routed from the Vance Creek treatment site through the 150mm transmission main to the Village to the mid-tee location from where the water would be routed to the Upper Tee Reservoir, to the Ridge Pump Station and reservoir and to the village. Contact times would not be an issue, however reservoir storage would be necessary at some date in the future to provide balancing storage for the additional development.

### Disadvantage

Groundwater would not be treated with this option. There are limited options for discharge of filter backwash effluent.

## SITE NO. 2 - MID TEE FACILITY

### Siting

Photo - Mid-Tee Building and surrounding area – looking northeast

A plan view of development at the Mid-Tee site is illustrated in Figure 5.2. The site redevelopment would consist of a water treatment facility located just uphill of the existing concrete block building.

### Water Flow

All water from Vance Creek Reservoir would be pumped slowly up to Paradise Reservoir. From Paradise Reservoir, all flow would initially be conveyed through the 150mm main to the Mid-Tee site. There would be sufficient flow to convey water through the facility and then up to the Upper Tee Concrete Reservoir. This system results in the least amount of water distribution system piping works of any of the options as most of the groundwater is currently routed through this location.

### Constraints

The site does not have year round road access. Three phase power is required for the site to power the UV, future treatment process and lift pumps.

### Distribution System Works

The water would be routed from the Mid-Tee facility treatment site to the Upper Tee Reservoir and to the distribution system simultaneously. Hydraulics work well for this scenario.

### Disadvantage

Vehicle access is possible for only 8 months per year. However, access from the SW end of Alpine Meadows may make this site more acceptable as the walking distance is less than 100m.

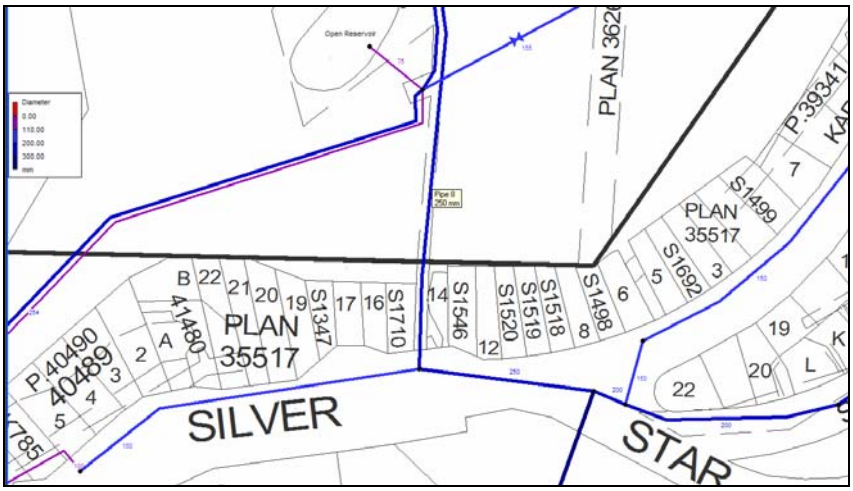
## SITE NO. 3 - NORTH OF SKI-BRIDGE

### Siting

A plan view of development at the Ski-Bridge site is illustrated in Figure 5.3. The site development is constrained by the slopes, ski-bridge and surrounding roads. There is an existing ditch that flow through this site that would have to be filled in with continuation of the drainage pipe and surface catch basins to deal with local surface runoff. The water treatment facility would be located immediately north of the existing ski-bridge berm.

All water from Vance Creek Reservoir would be pumped slowly up to Paradise Reservoir. From Paradise Reservoir, all flow would initially be conveyed by gravity through the 150mm main to the Mid-Tee site. From here, there are two options to extend water to the site, one is via the 250mm diameter watermain shown in Figure 5.4, and the second is through the installation of a new 300mm watermain along the same alignment. This system would allow for treatment for the majority of the well water on the site.

**Figure 5.4 - Watermains from Mid Tee to Ski-Bridge Site**




### Distribution System Works

The water would be routed from the Ski-Bridge treatment site directly to the distribution system and to the Upper Tee Reservoir . Hydraulics work well for this scenario.

### Constraints / Disadvantage

The site is of adequate size, but not overly large and real estate at the ski hill has high value. Three phase power is required for the site to power the UV, future treatment process and potential lift pumps. The hydraulic head on the UV lamps is a concern that may result in high pressures against the lamp.

## SITE NO. 4 - NORTH END OF ALPINE MEADOWS

### Siting

This site is located at the end of the switchback at the northeast limits of Alpine Meadows near to where the watermains from Paradise come down to the village. The location is illustrated in Figure 5.4.

### Water Flow

All water from Vance Creek Reservoir would be pumped slowly up to Paradise Reservoir. From Paradise Reservoir, all flow would initially be conveyed by gravity through the 150mm main to this site. From here, water would be directed through the existing 300mm main to the Upper Tee Reservoir and to the Mid-Tee building for further distribution. Groundwater from the Mid-tee building would be directed through the 150mm Paradise supply line to this site where the groundwater can also be disinfected to a high level.

Photo - Looking southwest at site towards Mid-Tee

### Distribution System Works

Once treated at this site, water distribution to the village is relatively straightforward. With UV and chlorination, contact times are minimal. The USEPA Table for contact times to achieve 4 log viruses is included in Appendix A.

### Constraints / Disadvantages

The site area will be limited due to the value of land. Power must be extended to the site as must watermains from Mid-Tee to treat groundwater.

**Table 5.1 - Site Selection Summary**

| Site Selection Factor | SITE 1 Vance Reservoir | SITE 2 Mid Tee Building | SITE 3 North of Ski-Bridge | SITE 4 N.of Alpine Meadows |
|---|---|---|---|---|
| Site Elevation in metres | 1660 m | 1638 m | 1613 m | 1643 m |
| Static HGL 1715 m | 58m (82 psi) | 80m (114 psi) | 111 m (158 psi) | 72 m (102 psi) |
| Static HGL 1685 m | 58m (82 psi) | 48m (68 psi) | 73m (104 psi) | 42 m (60 psi) |
| Vehicle Access | 6 months per year, poor | 8 months per year, fair | Year Round, very good | Year Round, very good |
| Expandability | OK – Lots of Room | OK – sufficient Room | Limited room but adequate | Limited room but adequate |
| Hydraulics related to WD system | No impact. Location is furthest away from centre of Village which is a constraint | Best location as all water is routed to this location now. Central location | Additional piping required but is feasible. All location is very central for future distribution | All well water must be routed here. Location is relatively central |
| Site Construction | Easy, low cost | Easy, low cost | Moderate cost | Higher cost due to slope and limited space |
| Well integration to site | Poor | Moderately well | Good intregration | Very good integration |
| UV constraints | No issues | System pressures are moderately high | System pressures are very high | System pressures are moderately high |
| Ranking | 4 | 2 | 3 | 1 |

Upon lengthy review, the critical reasons for ranking the sites are as follows:

- System hydraulic grade line (HGL) is a critical issue. Any changes to the operating system HGL must not deviate significantly from the current operating HGL of 1686m. If any significant changes are developed, such as changing the operating head to elevation 1715m (TWL of Paradise Reservoir), then many of the wells will have substantially lower capacity or will require larger pumps as the HGL will have increased by 30 metres. Keeping the HGL in the range of 1690 metres is an objective for siting;
- Maximum operating pressure for UV equipment on the market is 100 psi with some suppliers allowing pressures up to 125 psi.
- Long term access is a key issue as development will continue to grow at Silver Star. Flow and capacity from the treatment location must be centrally located and road accessible. A site closer to the village centre is a huge advantage and is how the system should be set out. A central location is more secure than a remote location and is not as weather dependant for access. Repairs are much easier in the event of an emergency;
- Integration into the water distribution system through water distribution system re-routing and minor modifications is a key issue for consideration;

- Simplicity in operations and controls is a key issue for consideration. A simpler system operating by gravity is preferred to a system with variable speed operated pumps. Controls should be set out on the simplest of set points and water levels;
- Capacity of the existing 150mm diameter was not an issue in the WTP site selection process as this capacity is a function of flow and development driven.

## 5.4 WATERMAIN HYDRAULIC CAPACITY

Eventually a decision must be made on how and when the flow capacity from Paradise Reservoir to the Village is to be upgraded. There are two options to upgrade the capacity.

- One is to install a larger 300mm diameter parallel watermain;
- Alternately, a new pump station can be utilized to increase the hydraulic capacity of the main at times of high demand.

This section provides some insight into the decisions of timing and approach to this issue.

### Existing Pipeline Capacity

An assessment of the hydraulic capacity of the existing 150mm main from Paradise Reservoir was estimated at various levels of residual pressure. The capacity was estimated using the Hazen William formula. The results are asummarized in Table 5.2.

**Table 5.2 - Capacity of Paradise Reservoir 150mm Transmission Main**

| Condition | Residual HGL (m) | Head (m) | Pressure ( psi ) | Slope ( m/m ) | Flow ( L/s ) |
|---|---|---|---|---|---|
| Static ( No flow) | 1717 | 0 | 105 | 0.000000 | 0.0 |
| moderate flow | 1707 | 10 | 91 | 0.004348 | 13.1 |
| high flow | 1697 | 20 | 77 | 0.008696 | 19.0 |
| Maximum Gravity flow | 1687 | 30 | 63 | 0.013043 | 23.7 |
| Pumped condition | **1655** | **62** | 17 | **0.026957** | **35.0** |

* assumed ground elevation at 1643m

The maximum gravity flow to the village from this watermain is estimated to be 23.7 L/s. With the addition of the wells, the wells that were not tied to the 150mm main would also be able to add to the overall system capacity. The wells that are tied into the 150mm main are Wells No. 10 and the proposed well No. 13.

The remaining wells could add another 6.0 L/s of capacity to the pipeline flow for a total capacity of 29.7 L/s. This is sufficient for approximately 10,000 PU or based on the current growth projections, good to the year 2009.

**In-Line Pump Option**

If a pump were installed, the pipeline flow could be increased to 35 L/s. The pump sizing is based on a flow of 21.5 L/s @ 33m TDH. Two 15 hp pumps would be of sufficient size to meet this requirement. This would result in suction pressures at the station in the range of only 12m of head or 18 psi. Proper pump selection would be required to ensure that this is feasible.

With the wells and booster pump, a total available flow of 41.0 L/s could be provided. This is sufficient to service 15,000 PU which meet the water demands to the year 2025.

The pump size is estimated based on lifting the water to the elevation of the existing Upper Tee Reservoir (1686m). The estimated size of pumps and controls is estimated to be in the range of $200,000. A genset would also be recommended in conjunction with the disinfection system equipment to provide reliable power to the facilities.

**Expanded Pipeline Capacity**

A 300mm diameter pipeline is being considered by the resort as a viable option for expanding water system capacity. The concern raised is that the existing 150mm watermain is a bottleneck and fire protection can be improved with the installation of a new 300mm diameter watermain. Both statements are true. The issue of the bottleneck caused by the existing 150mm watermain may not be as large an issue as first thought. The timing shown above indicates there are many years and much expansion that can occur before the watermain is necessary.

The expenditure of the new watermain will be in the range of $500,000 (Charles Contracting quote). The issue of expanding the capacity of water flow to the village and fire protection directly from the upper open surface reservoirs complicates the treatment equipment as the equipment must be sized accordingly to treat the greater flow. The cost for treatment capacity upgrades in conjunction with the cost of the installation of the watermain is substantial.

## 5.5 WATER TREATMENT PLANT BUILDING LAYOUT

The recommended site is selected for the reasons of access, hydraulic grade line and ease of integration. It is not selected for the reasons of ease of construction. Figure 5.5 provides a recommended layout for the building.

Because of the no-build line on the adjacent property, the space at the site is restricted. It is recommended that either a two story structure be utilized or that expansion take place below grade out into the ski run where it will not be notices. At grade level access is recommended at the south site.

Additional investigation is required at this site including a topographic plan and a site survey to tie in all surface features.

Table 5.3 provides a cost estimate for the building including electrical, mechanical and structural considerations. Also included are costs for system modifications that must take place to implement a water treatment structure at the recommended location.

**Table 5.3 - Cost Estimate**

| Item | No. | Unit | Unit Price | Cost | Eng. 10.00% | Conting. 15.00% | TOTAL $ |
|---|---|---|---|---|---|---|---|
| General Requirements, commissioning | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Site Grading, Rock Excavation | 1 | LS | $ 20,000 | $ 20,000 | $ 2,000 | $ 3,000 | $ 25,000 |
| Building Concrete | 1 | LS | $ 100,000 | $ 100,000 | $ 10,000 | $ 15,000 | $ 125,000 |
| Building Woodwork, framing, doors, interior | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Building Miscellaneous Components | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Process Mechanical within Building incl. valves | 1 | LS | $ 50,000 | $ 50,000 | $ 5,000 | $ 7,500 | $ 62,500 |
| Pumps and Motors 15 hp | 0 | ea | $ 7,500 | $ - | $ - | $ - | $ - |
| UV Lamps Large Lamps ( 15 L/s ) | 3 | ea | $ 35,000 | $ 105,000 | $ 10,500 | $ 15,750 | $ 131,250 |
| UV Lamps Small lamp system (3 @ 1.5 L/s ) | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Building HVAC | 1 | LS | $ 12,000 | $ 12,000 | $ 1,200 | $ 1,800 | $ 15,000 |
| Building Electrical | 1 | LS | $ 50,000 | $ 50,000 | $ 5,000 | $ 7,500 | $ 62,500 |
| Building Instrumentation | 1 | LS | $ 25,000 | $ 25,000 | $ 2,500 | $ 3,750 | $ 31,250 |
| Electrical Service Connection - transformer | 1 | LS | $ 35,000 | $ 35,000 | $ 3,500 | $ 5,250 | $ 43,750 |
| Genset (75 kw) optional | 1 | LS | $ 50,000 | $ 50,000 | $ 5,000 | $ 7,500 | $ 62,500 |
| Tie-in to Existing Watermains | 2 | LS | $ 5,000 | $ 10,000 | $ 1,000 | $ 1,500 | $ 12,500 |
| Chlorination System | 1 | LS | $ 25,000 | $ 25,000 | $ 2,500 | $ 3,750 | $ 31,250 |
| | | | | | | | |
| Decommission works at Mid Tee | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Watermain Modifications at Mid Tee Reservoir | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| Watermain Modifications at Upper Tee Reservoir | 1 | LS | $ 15,000 | $ 15,000 | $ 1,500 | $ 2,250 | $ 18,750 |
| **SUBTOTAL - WATER TREATMENT PLANT** | | | | | | | **$ 733,750** |

# 6. SUMMARY

The major conclusions and recommendations of our investigation are presented in this section. Based on our review, we conclude the following.

- Currently there are 5,454 pillow units (PU) available on Silver Star Mountain Resort;
- There are commitments for an additional 4,627 PU through to 2009;
- On the busiest day of the past ski season (Dec. 29, 2006) there were 6,700 skiers on the hill and over 1,035$m^3$ (228,000 Imperial gallons) of water used;
- The growth projections (provided by RDNO) are;
  - 10,081 PU by 2009,
  - 14,200 PU by 2017 and
  - an ultimate build out of 20,000 PU
- Current water demands have been calculated as 315$m^3$/day (average day demand), 500$m^3$/day (average winter demand) and 1,035$m^3$/day (maximum day demand). These demands have been used for future demand calculations;
- The total potential storage, including the new 224 ML Vance Creek Reservoir, is estimated to be 273 ML;
- The newly constructed 224 ML reservoir must be properly certified by the MOE. Corresponding water licenses must also be obtained for both domestic use and storage. Once surface water evaporation and a reduction due to ice are accounted for, the useable volume is conservatively estimated to be approximately 189 ML;
- There is potentially 201 ML/yr of groundwater available annually (based on 6.4 L/s capacity), however the capacity is currently lower as the full groundwater capacity cannot be drawn into the distribution system on a year round basis;
- The current annual water demand based on existing flow records is 115 ML/yr;
- Based on the demand calculations it appears that there will be enough water available on the hill to meet future demands. The future water demands are as follows;
  - 195 ML/yr for 10,000 PU
  - 267 ML/yr for 14,200 PU
  - 361 ML/yr for 20,000 PU
- The existing 150 mm diameter raw water pipeline has sufficient capacity to provide water by gravity for flows up to 23.7 L/s;
- If two 15 hp pumps are added at the proposed Water Treatment Plant site, then the pipeline has capacity to provide for 35.0 L/s;
- In order to meet future demands greater than 35 L/s, an additional pipeline must be constructed from Paradise Reservoir to the site of the new water treatment facility, or additional capacity can be added in the form of increased pumping capacity from Vance Creek reservoir;

- Due to the low risk of waterborne disease from the watershed (including groundwater) and the high quality of raw water, there is a high likelihood of not requiring filtration of the raw water (utilizing the filtration avoidance criteria);
- In discussions with IHA, a *Watershed Control Program* will be required to meet the filtration avoidance criteria;
- As part of the *Watershed Control Program* it is recommended that the cattle (occasional presence) should be excluded from the catchments;
- Components to be included in a *Watershed Control Program* are set out in Section 4.5 of this report;
- Based on the outcome of the *Watershed Control Program* the routine bacteriological water sampling program for the raw water may need to be expanded. In addition, full parameters should be tested for the reservoirs in June and December each year;
- The current form of raw water disinfection is chlorination using sodium hypochlorite. In order to enhance the disinfection process it is recommended to install an ultraviolet light disinfection system. This will provide an additional barrier and a high quality, safer water supply for Silver Star Utility;
- The preferred location of the new UV disinfection system is Site No. 4 at the north end of Alpine Meadows as illustrated on Figure 5.4;
- Site No. 2 is the second best location based on hydraulics and its central location. It does not however have year round vehicle access;
- Based on meeting a flow rate of 30 L/s, the estimated cost for a UV system including the building and water distribution system modifications is estimated to be $ 737,500;
- With a UV system for primary disinfection, a chlorination system is still necessary to provide secondary disinfection to prevent bacterial regrowth within the water distribution system;
- The WTP building should be designed on a site with an available footprint for expansion for a filtration plant if required at some point in the future;
- In order to reduce demands on the potable water system and also loads on the waste water treatment system water conservation methods are encouraged and should include (but not be limited to), dual flush toilets, low flow shower heads and front loading clothes washing machines;
- Accurate water use records should be compared to current estimates of PU and day skiers on an annual basis to verify water use trends;
- Due to the high growth expected for Silver Star, the Water Master Plan should be revisited every two years for the next decade;

# APPENDIX A - WATER TREATMENT CONSIDERATIONS

Appendix A provides a summary of specific issues related to water treatment. These include:

A.1 Exclusion Criteria for Filtration by Health Canada

A.2 USEPA – Filtration Avoidance Criteria

A.3 USEPA – Virus and Protozoa Inactivation Tables

A.4 USEPA – Comprehensive Surface Water Treatment Rules, Quick Reference Guide: Unfiltered Systems

A.5 Laboratory Certificates of Analysis – Caro Environmental

A.6 Easy Treat Environmental – Water Treatment Study – Silver Star Mountain Resort

## A.1 EXCLUSION CRITERIA FOR FILTRATION BY HEALTH CANADA

Water quality criteria of the regulator, IHA is provided in Section 2.1 of this report.

### IHA and Health Canada Criteria

There has been significant discussion related to water treatment and water treatment direction in the Okanagan Valley. The issue of filtration being the end objective is in question as the capital costs are very high and the additional safety provided may not warrant the expenditure of a full water filtration plant.

Because of the high quality source water that is available in some parts of the Okanagan, the IHA is considering issuing filtration deferrals, based on the water utility protecting the source water and meeting the *Criteria for Exclusion of Filtration in Waterworks systems* as set out by Health Canada.

Current Health Canada guidelines set out criteria for the avoidance for filtration if the raw water quality is high. The avoidance for filtration criteria by Health Canada is set out as follows.

### HEALTH CANADA - CRITERIA FOR EXCLUSION OF FILTRATION IN WATERWORKS SYSTEMS

Filtration of a surface water source or a groundwater source under the direct influence of surface water may not be necessary if *all* of the following conditions are met:

1. Overall inactivation is met using a minimum of two disinfectants:
   - ultraviolet irradiation or ozone to inactivate cysts/oocysts;
   - chlorine (free chlorine) to inactivate viruses; and
   - chlorine or chloramines to maintain a residual in the distribution system.

   Disinfection should reliably achieve at least a 99% (2-log) reduction of *Cryptosporidium* oocysts,* a 99.9% (3-log) reduction of *Giardia* cysts and a 99.99% (4-log) reduction of viruses. If mean source water cyst/oocyst levels are greater than 10/1000 L, more than 99% (2-log) reduction of *Cryptosporidium* oocysts and 99.9% (3-log) reduction of *Giardia* cysts should be achieved. Background levels for *Giardia* cysts and *Cryptosporidium* oocysts in the source water should be established by monitoring as described in the most recent Health Canada "Protozoa" guideline document, or more frequently during periods of expected highest levels (e.g., during spring runoff or after heavy rainfall).
2. Prior to the point where the disinfectant is applied, the number of *Escherichia coli* bacteria in the source water does not exceed 20/100 mL (or, if *E. coli* data are not available, the number of total coliform bacteria does not exceed 100/100 mL) in at least 90% of the weekly samples from the previous 6 months.
3. Average daily source water turbidity levels measured at equal intervals (at least every 4 hours), immediately prior to where the disinfectant is applied, are around 1.0 NTU but do not exceed 5.0 NTU for more than 2 days in a 12-month period. Source water turbidity also does not show evidence of protecting microbiological contaminants.
4. A ***Watershed Control Program*** (e.g., protected watershed, controlled discharges, etc.) is maintained that minimizes the potential for faecal contamination in the source water.

## A.2 - USEPA FILTRATION AVOIDANCE CRITERIA

Although the USEPA criteria is not applicable in Canada, it has been included in this document to provide additional understanding on the rational for avoiding filtration on a water system. The USEPA has been using the filtration avoidance criteria since December 1991. A water system must meet source water quality and site specific conditions to remain unfiltered. The following table outlines the criteria established by the USEPA.

| | Requirement | Frequency |
|---|---|---|
| **Source Water Quality Considerations** | Microbial Quantity<br>Monitor fecal coliform or total coliform density in representative samples of source water immediately prior to the first point of disinfection application:<br>☐ Fecal coliform density concentrations must be less than 20/100 mL: or<br>☐ Total coliform density concentrations must be less than 100 / 100mL.<br>Sample results must satisfy the criteria above in at least 90% of the measurements from the previous 6 months. | 1 to 5 samples per week depending on the system size and every day the turbidity of the source water exceeds 1.0 NTU. |
| | Turbidity<br>Prior to the first point of disinfection application, turbidity levels cannot exceed 5 NTU. | Performed on representative grab samples of source water every 4 hours ( or more frequently) |
| **Site Specific Conditions** | System must:<br>Calculate total inactivation ratio daily and provide 3 log Giarida Lamblia and 4-log virus inactivation daily (except any one day each month) in 11 of 12 months (on an on-going basis). | Take daily measurements before or at the first customer at each residual disinfectant concentration sampling point:<br>☐ Temperature;<br>☐ pH; |
| | System must comply with:<br>☐ MCL for total coliforms in 11 of 12 previous months (as per total coliform rule)<br>☐ Stage 1 Disinfection Byproducts Rule requirements<br>System must have:<br>☐ Adequate point of residual disinfectant concentration;<br>☐ Detectable residual disinfectant concentration in the distribution system;<br>☐ Redundant disinfection components or automatic shut-off whenever residual disinfectant concentration is < 0.2 mg/L;<br>☐ Watershed control program minimizing potential contamination by viruses and protozoa in the source water;<br>☐ An annual on-site inspection by sate or approved third party with reported findings;<br>☐ Not been identified as a source of a waterborne disease outbreak. | ☐ Disinfectant contact time (at peak hourly flow)<br>☐ Residual disinfectant concentration measurements (at peak hourly flow) |

## A.3 USEPA – GIARDIA AND VIRUS INACTIVATION TABLES

### Table A.1 CT Values for 3-Log Inactivation of Giardia by Free Chlorine (source USEPA)

| Chlorine Concentration (mg/L) | Temperature <=0.5°C | | | | | | | Temperature =5°C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH | | | | | | | pH | | | | | | |
| | <=6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | <=6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 |
| <=0.4 | 137 | 163 | 195 | 237 | 277 | 329 | 390 | 97 | 117 | 139 | 166 | 198 | 236 | 279 |
| 0.6 | 141 | 168 | 200 | 239 | 286 | 342 | 407 | 100 | 120 | 143 | 171 | 204 | 244 | 291 |
| 0.8 | 145 | 172 | 205 | 246 | 295 | 354 | 422 | 103 | 122 | 146 | 175 | 210 | 252 | 301 |
| 1.0 | 148 | 176 | 210 | 253 | 304 | 365 | 437 | 105 | 125 | 149 | 179 | 216 | 260 | 312 |
| 1.2 | 152 | 180 | 215 | 259 | 313 | 376 | 451 | 107 | 127 | 152 | 183 | 221 | 267 | 320 |
| 1.4 | 155 | 184 | 221 | 266 | 321 | 387 | 464 | 109 | 130 | 155 | 187 | 227 | 274 | 329 |
| 1.6 | 157 | 189 | 226 | 273 | 329 | 397 | 477 | 111 | 132 | 158 | 192 | 232 | 281 | 337 |
| 1.8 | 162 | 193 | 231 | 279 | 338 | 407 | 489 | 114 | 135 | 162 | 196 | 238 | 287 | 345 |
| 2.0 | 165 | 197 | 236 | 286 | 346 | 417 | 500 | 116 | 138 | 165 | 200 | 243 | 294 | 353 |
| 2.2 | 169 | 201 | 242 | 297 | 353 | 426 | 511 | 118 | 140 | 169 | 204 | 248 | 300 | 361 |
| 2.4 | 172 | 205 | 247 | 298 | 361 | 435 | 522 | 120 | 143 | 172 | 209 | 253 | 306 | 368 |
| 2.6 | 175 | 209 | 252 | 304 | 368 | 444 | 533 | 122 | 146 | 175 | 213 | 258 | 312 | 375 |
| 2.8 | 178 | 213 | 257 | 310 | 375 | 452 | 543 | 124 | 148 | 178 | 217 | 263 | 318 | 382 |
| 3.0 | 181 | 217 | 261 | 316 | 382 | 460 | 552 | 126 | 151 | 182 | 221 | 268 | 324 | 389 |

### Table A.2 CT Values for 4 Log Inactivation of Viruses by Free Chlorine (source USEPA)

| | pH | |
|---|---|---|
| Temperature (°C) | 6-9 | 10 |
| 0.5 | 12 | 90 |
| 5 | 8 | 60 |
| 10 | 6 | 45 |
| 15 | 4 | 30 |
| 20 | 3 | 22 |
| 25 | 2 | 15 |

*Although units did not appear in the original tables, units are min-mg/L.

## A.4 USEPA QUICK REFERENCE GUIDE: UNFILTERED SYSTEMS

EPA United States Environmental Protection Agency

# Comprehensive Surface Water Treatment Rules Quick Reference Guide: Unfiltered Systems

## Overview of the Rules

| | |
|---|---|
| **Title** | **Surface Water Treatment Rule** (SWTR) - 40 CFR 141.70-141.75<br>**Interim Enhanced Surface Water Treatment Rule** (IESWTR) - 40 CFR 141.170-141.175<br>**Long Term 1 Enhanced Surface Water Treatment Rule** (LT1ESWTR) - 40 CFR 141.500-141.571 |
| **Purpose** | Improve public health protection through the control of microbial contaminants, particularly viruses, *Giardia*, and *Cryptosporidium*. |
| **General Description** | The **Surface Water Treatment Rules**:<br>▸ Applies to all public water systems (PWSs) using surface water or ground water under the direct influence of surface water (GWUDI), otherwise known as "**Subpart H systems.**"<br>▸ Requires all Subpart H systems to disinfect.<br>▸ Requires Subpart H systems to filter unless specific filter avoidance criteria are met.<br>▸ Requires unfiltered systems to perform source water monitoring and meet site specific conditions for control of microbials. |

## Overview of Requirements

**The purpose of this table is show how the requirements for the IESWTR and LT1ESWTR build on the existing requirements established in the original SWTR.**

| **APPLICABILITY: PWSs that use surface water or ground water under the direct influence of surface water (Subpart H) that do not provide filtration.** | | **Final Rule Dates** | | |
|---|---|---|---|---|
| | | **SWTR 1989** | **IESWTR 1998** | **LT1ESWTR 2002** |
| Population Served | ≥ 10,000 | ✓ | ✓ | |
| | < 10,000 | ✓ | N/A (except for sanitary survey provisions) | ✓ |
| Regulated Pathogens | 99.99% (4-log) inactivation of viruses | ✓ | Regulated under SWTR | Regulated under SWTR |
| | 99.9% (3-log) inactivation of *Giardia lamblia* | ✓ | Regulated under SWTR | Regulated under SWTR |
| | 99% (2-log) removal of *Cryptosporidium* (through watershed control) | | ✓ | ✓ |
| Residual Disinfectant Requirements | Entrance to distribution system (≥ 0.2 mg/L) | ✓ | Regulated under SWTR | Regulated under SWTR |
| | Detectable in the distribution system | ✓ | Regulated under SWTR | Regulated under SWTR |
| Unfiltered System Requirements | Avoidance Criteria | ✓ | ✓ | ✓ |
| Disinfection Profiling & Benchmarking | Systems must profile inactivation levels and generate benchmark, if required | | ✓ | ✓ |
| Sanitary Surveys (state requirement) | CWS: Every 3 years<br>NCWS: Every 5 years | | ✓ | Regulated under IESWTR |
| Covered Finished Reservoirs/Water Storage Facilities (new construction only) | | | ✓ | ✓ |
| Operated by Qualified Personnel as Specified by State | | ✓ | Regulated under SWTR | Regulated under SWTR |

(CWS) Community Water System (NCWS) Non-community Water System

## Filtration Avoidance Criteria

Since December 30, 1991, systems must meet source water quality and site specific conditions to remain unfiltered. If any of the following criteria to avoid filtration are not met, systems must install filtration treatment within 18 months of the failure. The following table outlines the avoidance criteria established by the SWTR and later enhanced by the IESWTR and LT1ESWTR.

**Filtration Avoidance Criteria**

| | | Requirement | Frequency |
|---|---|---|---|
| **SOURCE WATER QUALITY CONDITIONS** | **Microbial Quality** | Monitor fecal coliform or total coliform density in representative samples of source water immediately prior to the first point of disinfectant application:<br>▸ **Fecal coliform density** concentrations must be ≤ 20/100 mL; **OR**<br>▸ **Total coliform density** concentrations must be ≤ 100/100 mL.<br>Sample results must satisfy the criteria listed above in at least 90% of the measurements from previous 6 months. | 1 to 5 samples per week depending on system size and every day the turbidity of the source water exceeds 1 NTU. |
| | **Turbidity** | Prior to the first point of disinfectant application, turbidity levels cannot exceed 5 NTU. | Performed on representative grab samples of source water every four hours (or more frequently). |
| **SITE SPECIFIC CONDITIONS** | **Systems must:** | Calculate total inactivation ratio daily and provide 3-log *Giardia lamblia* and 4-log virus inactivation daily (except any one day each month) in 11 of 12 previous months (on an ongoing basis). | Take daily measurements before or at the first customer at each residual disinfectant concentration sampling point:<br>▸ Temperature<br>▸ pH (if chlorine used)<br>▸ Disinfectant contact time (at peak hourly flow)<br>▸ Residual disinfectant concentration measurements (at peak hourly flow) |
| | **System must comply with:** | ▸ MCL for total coliforms in 11 of 12 previous months (as per Total Coliform Rule).<br>▸ Stage 1 Disinfection Byproducts Rule requirements (as of January 1, 2002, for systems serving ≥ 10,000 or January 1, 2004, for systems serving < 10,000). | |
| | **Systems must have:** | ▸ Adequate entry point residual disinfectant concentration (see disinfection requirements).<br>▸ Detectable residual disinfectant concentration in the distribution system (see disinfection requirements).<br>▸ Redundant disinfection components or automatic shut-off whenever residual disinfectant concentration < 0.2 mg/L.<br>▸ A watershed control program minimizing potential for contamination by *Giardia lamblia* cysts and viruses in source water; IESWTR and LT1ESWTR update this requirement by adding *Cryptosporidium* control measures.<br>▸ An annual on-site inspection by state or approved third party with reported findings.<br>▸ Not been identified as a source of a waterborne disease outbreak. | |

## Disinfection

Disinfection must be sufficient to ensure that the total treatment process of the system achieves at least:

- 99.9% (3-log) inactivation of *Giardia lamblia*.
- 99.99% (4-log) inactivation of viruses.

Currently, *Cryptosporidium* must be controlled through the watershed control program and no inactivation credits are currently given for disinfection. Systems must also comply with the maximum residual disinfectant level (MRDL) requirements specified in the Stage 1 Disinfectants/Disinfection Byproducts Rule (Stage 1 DBPR).

**Residual Disinfectant Monitoring and Reporting Requirements**

| Location | Concentration | Monitoring Frequency | Reporting (Reports due 10th of the following month) |
|---|---|---|---|
| Entry to distribution system. | Residual disinfectant concentration cannot be < 0.2 mg/L for more than 4 hours. | Continuous, but states may allow systems serving 3,300 or fewer persons to take grab samples from 1 to 4 times per day, depending on system size. | Lowest daily value for each day, the date and duration when residual disinfectant was < 0.2 mg/L, and when state was notified of events where residual disinfectant was < 0.2 mg/L. |
| Distribution system - same location as total coliform sample location(s). | Residual disinfectant concentration cannot be undetectable in greater than 5% of samples in a month, for any 2 consecutive months. Heterotrophic plate count (HPC) # 500/mL is deemed to have detectable residual disinfectant. | Same time as total coliform samples. | Number of residual disinfectant or HPC measurements taken in the month resulting in no more than 5% of the measurements as being undetectable in any 2 consecutive months. |

**System Reporting Requirements**

| Report to State: | What to report: |
|---|---|
| Within 10 days after the end of the month: | ▸ Source water quality information (microbial quality and turbidity measurements).<br>▸ In addition to the disinfection information above, systems must report the daily residual disinfectant concentration(s) and disinfectant contact time(s) used for calculating the CT value(s). |
| By October 10 each year: | ▸ Report compliance with all watershed control program requirements.<br>▸ Report on the on-site inspection unless conducted by state in which the state must provide the system a copy of the report. |
| Within 24 hours: | ▸ Turbidity exceedances of 5 NTU and waterborne disease outbreaks. |
| As soon as possible but no later than the end of the next business day: | ▸ Instance where the residual disinfectant level entering the distribution system was less than 0.2 mg/L. |

## Disinfection Profiling and Benchmarking Requirements

A **disinfection profile** is the graphical representation of a system's microbial inactivation over 12 consecutive months.

A **disinfection benchmark** is the lowest monthly average microbial inactivation value. The disinfection benchmark is used as a baseline of inactivation when considering changes in the disinfection process.

### Disinfection Profiling and Benchmarking Requirements Under IESWTR & LT1ESWTR

The purpose of disinfection profiling and benchmarking is to allow systems and states to assess whether a change in disinfection practices creates a microbial risk. Systems should develop a disinfection profile that reflects *Giardia lamblia* inactivation (systems using ozone or chloramines must also calculate inactivation of viruses), calculate a benchmark (lowest monthly inactivation) based on the profile, and consult with the state prior to making a significant change to disinfection practices.

| REQUIREMENT | IESWTR | LT1ESWTR |
|---|---|---|
| **AFFECTED SYSTEMS:** | Community, non-transient non-community, and transient systems. | Community and non-transient non-community systems only. |
| **BEGIN PROFILING BY:** | April 1, 2000 | ➤ July 1, 2003 for systems serving 500-9,999 people.<br>➤ January 1, 2004 for systems serving fewer than 500 people. |
| **FREQUENCY & DURATION:** | **Daily** monitoring for 12 consecutive calendar months to determine the total logs of *Giardia lamblia* inactivation (and viruses, if necessary) for each day in operation. | **Weekly** inactivation of *Giardia lamblia* (and viruses, if necessary), on the same calendar day each week over 12 consecutive months. |
| **STATES MAY WAIVE DISINFECTION PROFILING REQUIREMENTS IF:** | TTHM annual average <0.064 mg/L and HAA5 annual average <0.048 mg/L:<br>➤ Collected during the same period.<br>➤ Annual average is arithmetic average of the quarterly averages of four consecutive quarters of monitoring.<br>➤ At least 25% of samples at the maximum residence time in the distribution system.<br>➤ Remaining 75% of samples at representative locations in the distribution system. | One TTHM sample <0.064 mg/L and one HAA5 sample <0.048 mg/L:<br>➤ Collected during the month of warmest water temperature; **AND**<br>➤ At the maximum residence time in the distribution system.<br><br>Samples must have been collected after January 1, 1998. |
| **DISINFECTION BENCHMARK MUST BE CALCULATED IF:** | Systems required to develop a disinfection profile and are considering any of the following:<br>➤ Changes to the point of disinfection.<br>➤ Changes to the disinfectant(s) used.<br>➤ Changes to the disinfection process.<br>➤ Any other modification identified by the state.<br><br>Systems must consult the state prior to making any modifications to disinfection practices. | Same as IESWTR, and systems must obtain state approval prior to making any modifications to disinfection practices. |

Office of Water (4606) EPA 816-F-04-001 www.epa.gov/safewater August 2004

## A.5 LABORATORY CERTIFICATES OF ANALYSIS (TWO SETS OF DATA) – CARO ENVIRONMENTAL

**CARO Environmental Services**

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**ANALYSIS REPORT**

| | | | |
|---|---|---|---|
| **CLIENT** | Agua Consulting Inc. | **WORK ORDER #** | K705259 |
| **PROJECT NAME** | Silver Star Water | **DATE REPORTED** | 18-May-07 |

**SS1 (K705259-01) Matrix: Water** Sampled: 08-May-07

| Parameter | Result | Can. Guidelines for Drinking Water (Mar 06) | RDL | Units | Analyzed | Notes |
|---|---|---|---|---|---|---|
| **General Inorganic Parameters** | | | | | | |
| Chloride | **3.20** | AO < 250 | 0.10 | mg/L | 10-May-07 | |
| Fluoride | **< 0.10** | MAC < 1.5 | 0.10 | " | 10-May-07 | |
| Alkalinity, Total as CaCO3 | **124** | No Guideline | 1.0 | " | 10-May-07 | |
| Nitrate as N | **0.795** | MAC < 10 | 0.010 | " | 09-May-07 | |
| Sulfate | **27.7** | AO < 500 | 1.0 | " | 11-May-07 | |
| Nitrite as N | **< 0.010** | MAC < 1 | 0.010 | " | 09-May-07 | |
| Hardness (CaCO3 equiv) | **118** | No Guideline | 1.45 | " | 14-May-07 | |
| Conductivity (EC) | **376** | No Guideline | 5 | uS/cm | 09-May-07 | |
| Colour, True | **< 5** | AO < 15 | 5 | Colour Units | 09-May-07 | |
| pH | **7.4** | AO = 6.5 - 8.5 | 0.1 | pH Units | 10-May-07 | |
| Total Organic Carbon | **2.2** | No Guideline | 0.5 | mg/L | 09-May-07 | |
| Total Dissolved Solids | **193** | AO < 500 | 5 | " | 10-May-07 | |
| Transmissivity @ 254nm | **96.2** | No Guideline | 0.1 | % | 09-May-07 | |
| Turbidity | **0.1** | Varies | 0.1 | NTU | 09-May-07 | |
| **Microbiological Parameters** | | | | | | |
| Coliforms, Total | **< 1** | MAC < 1 | 1 | CFU/100mL | 08-May-07 | |
| E. Coli | **< 1** | MAC < 1 | 1 | " | " | |
| **Total Recoverable Metals by ICPMS** | | | | | | |
| Arsenic | **< 0.001** | MAC < 0.025 | 0.001 | mg/L | 14-May-07 | |
| Calcium | **38.4** | No Guideline | 0.50 | " | 14-May-07 | |
| Iron | **0.13** | AO < 0.3 | 0.03 | " | 14-May-07 | |
| Magnesium | **5.37** | No Guideline | 0.05 | " | " | |
| Manganese | **0.011** | AO < 0.05 | 0.001 | " | " | |
| Potassium | **0.55** | No Guideline | 0.05 | " | " | |
| Silicon | **2.3** | No Guideline | 0.1 | " | " | |
| Sodium | **0.96** | AO < 200 | 0.05 | " | " | |
| Uranium | **0.0005** | MAC < 0.02 | 0.0001 | " | " | |

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## ANALYSIS REPORT

| | | | |
|---|---|---|---|
| **CLIENT** | Agua Consulting Inc. | **WORK ORDER #** | K705259 |
| **PROJECT NAME** | Silver Star Water | **DATE REPORTED** | 18-May-07 |

**SS2 (K705259-02) Matrix: Water** Sampled: 08-May-07

| Parameter | Result | Can. Guidelines for Drinking Water (Mar 06) | RDL | Units | Analyzed | Notes |
|---|---|---|---|---|---|---|
| **General Inorganic Parameters** | | | | | | |
| Chloride | **0.28** | AO < 250 | 0.10 | mg/L | 10-May-07 | |
| Fluoride | **< 0.10** | MAC < 1.5 | 0.10 | " | 10-May-07 | |
| Alkalinity, Total as CaCO3 | **139** | No Guideline | 1.0 | " | 10-May-07 | |
| Nitrate as N | **0.402** | MAC < 10 | 0.010 | " | 09-May-07 | |
| Sulfate | **40.4** | AO < 500 | 1.0 | " | 11-May-07 | |
| Nitrite as N | **< 0.010** | MAC < 1 | 0.010 | " | 09-May-07 | |
| Hardness (CaCO3 equiv) | **159** | No Guideline | 1.45 | " | 14-May-07 | |
| Conductivity (EC) | **329** | No Guideline | 5 | uS/cm | 09-May-07 | |
| Colour, True | **< 5** | AO < 15 | 5 | Colour Units | 09-May-07 | |
| pH | **7.4** | AO = 6.5 - 8.5 | 0.1 | pH Units | 10-May-07 | |
| Total Organic Carbon | **0.6** | No Guideline | 0.5 | mg/L | 09-May-07 | |
| Total Dissolved Solids | **198** | AO < 500 | 5 | " | 10-May-07 | |
| Transmissivity @ 254nm | **96.6** | No Guideline | 0.1 | % | 09-May-07 | |
| Turbidity | **0.1** | Varies | 0.1 | NTU | 09-May-07 | |
| **Microbiological Parameters** | | | | | | |
| Coliforms, Total | **< 1** | MAC < 1 | 1 | CFU/100mL | 08-May-07 | |
| E. Coli | **< 1** | MAC < 1 | 1 | " | " | |
| **Total Recoverable Metals by ICPMS** | | | | | | |
| Arsenic | **< 0.001** | MAC < 0.025 | 0.001 | mg/L | 14-May-07 | |
| Calcium | **54.9** | No Guideline | 0.50 | " | 14-May-07 | |
| Iron | **0.15** | AO < 0.3 | 0.03 | " | 14-May-07 | |
| Magnesium | **5.44** | No Guideline | 0.05 | " | " | |
| Manganese | **< 0.001** | AO < 0.05 | 0.001 | " | " | |
| Potassium | **2.01** | No Guideline | 0.05 | " | " | |
| Silicon | **4.7** | No Guideline | 0.1 | " | " | |
| Sodium | **2.08** | AO < 200 | 0.05 | " | " | |
| Uranium | **0.0012** | MAC < 0.02 | 0.0001 | " | " | |

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## ANALYSIS REPORT

| | | | |
|---|---|---|---|
| **CLIENT** | Agua Consulting Inc. | **WORK ORDER #** | K705733 |
| **PROJECT NAME** | Silver Star Water | **DATE REPORTED** | 04-Jun-07 |

**Star - (Spillway) Paradise (K705733-01) Matrix: Water** Sampled: 23-May-07

| Parameter | Result | Can. Guidelines for Drinking Water (Mar 06) | RDL | Units | Analyzed | Notes |
|---|---|---|---|---|---|---|
| **General Inorganic Parameters** | | | | | | |
| Alkalinity, Total as CaCO3 | **63.0** | No Guideline | 1.0 | mg/L | 25-May-07 | |
| Hardness (as CaCO3) | **83.3** | AO < 500 | 1.45 | " | 30-May-07 | |
| Chloride | **0.26** | AO < 250 | 0.10 | " | 28-May-07 | |
| Conductivity (EC) | **169** | No Guideline | 5 | uS/cm | 29-May-07 | |
| Colour, True | **< 5** | AO < 15 | 5 | Colour Units | 25-May-07 | |
| Fluoride | **< 0.10** | MAC < 1.5 | 0.10 | mg/L | 26-May-07 | |
| Nitrite as N | **< 0.010** | MAC < 1 | 0.010 | " | 24-May-07 | |
| Nitrate as N | **0.200** | MAC < 10 | 0.010 | " | " | |
| pH | **7.0** | AO = 6.5 - 8.5 | 0.1 | pH Units | 25-May-07 | |
| Sulfate | **18.8** | AO < 500 | 1.0 | mg/L | 28-May-07 | |
| Total Organic Carbon | **2.9** | No Guideline | 0.5 | " | 29-May-07 | |
| Total Dissolved Solids | **112** | No Guideline | 5 | " | 29-May-07 | |
| Transmissivity @ 254nm | **82.9** | No Guideline | 0.1 | % | 30-May-07 | |
| Turbidity | **15** | Varies | 0.1 | NTU | 24-May-07 | |
| **Microbiological Parameters** | | | | | | |
| Coliforms, Total | **110** | MAC < 1 | 1 | CFU/100mL | 24-May-07 | |
| Background Colonies | **>200** | No Guideline | 200 | " | " | |
| E. Coli | **< 1** | MAC < 1 | 1 | " | " | |
| **Total Recoverable Metals by ICPMS** | | | | | | |
| Arsenic | **< 0.001** | MAC < 0.025 | 0.001 | mg/L | 30-May-07 | |
| Calcium | **24.4** | No Guideline | 0.50 | " | 30-May-07 | |
| Iron | **1.02** | AO < 0.3 | 0.03 | " | 30-May-07 | |
| Magnesium | **5.40** | BCDW < 100 | 0.05 | " | " | |
| Manganese | **0.033** | AO < 0.05 | 0.001 | " | " | |
| Potassium | **0.69** | No Guideline | 0.05 | " | " | |
| Silicon | **3.1** | No Guideline | 0.1 | " | " | |
| Sodium | **0.67** | AO < 200 | 0.05 | " | " | |
| Uranium | **0.0002** | MAC < 0.02 | 0.0001 | " | " | |

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## ANALYSIS REPORT

| | | | |
|---|---|---|---|
| **CLIENT** | Agua Consulting Inc. | **WORK ORDER #** | K705733 |
| **PROJECT NAME** | Silver Star Water | **DATE REPORTED** | 04-Jun-07 |

**Star - Pipeline - Old (K705733-02) Matrix: Water** Sampled: 23-May-07

| Parameter | Result | Can. Guidelines for Drinking Water (Mar 06) | RDL | Units | Analyzed | Notes |
|---|---|---|---|---|---|---|
| **General Inorganic Parameters** | | | | | | |
| Alkalinity, Total as CaCO3 | **112** | No Guideline | 1.0 | mg/L | 25-May-07 | |
| Hardness (as CaCO3) | **140** | AO < 500 | 1.45 | " | 30-May-07 | |
| Chloride | **0.56** | AO < 250 | 0.10 | " | 28-May-07 | |
| Conductivity (EC) | **276** | No Guideline | 5 | uS/cm | 29-May-07 | |
| Colour, True | **< 5** | AO < 15 | 5 | Colour Units | 30-May-07 | |
| Fluoride | **< 0.10** | MAC < 1.5 | 0.10 | mg/L | 26-May-07 | |
| Nitrite as N | **< 0.010** | MAC < 1 | 0.010 | " | 26-May-07 | HT |
| Nitrate as N | **0.075** | MAC < 10 | 0.010 | " | " | HT |
| pH | **7.1** | AO = 6.5 - 8.5 | 0.1 | pH Units | 25-May-07 | |
| Sulfate | **24.1** | AO < 500 | 1.0 | mg/L | 28-May-07 | |
| Total Organic Carbon | **2.1** | No Guideline | 0.5 | " | 29-May-07 | |
| Total Dissolved Solids | **160** | No Guideline | 5 | " | 29-May-07 | |
| Transmissivity @ 254nm | **86.7** | No Guideline | 0.1 | % | 30-May-07 | |
| Turbidity | **2.1** | Varies | 0.1 | NTU | 28-May-07 | |
| **Total Recoverable Metals by ICPMS** | | | | | | |
| Arsenic | **< 0.001** | MAC < 0.025 | 0.001 | mg/L | 30-May-07 | |
| Calcium | **44.1** | No Guideline | 0.50 | " | 30-May-07 | |
| Iron | **0.29** | AO < 0.3 | 0.03 | " | 30-May-07 | |
| Magnesium | **7.19** | BCDW < 100 | 0.05 | " | " | |
| Manganese | **0.042** | AO < 0.05 | 0.001 | " | " | |
| Potassium | **0.62** | No Guideline | 0.05 | " | " | |
| Silicon | **2.7** | No Guideline | 0.1 | " | " | |
| Sodium | **1.34** | AO < 200 | 0.05 | " | " | |
| Uranium | **0.0005** | MAC < 0.02 | 0.0001 | " | " | |

HT Parameter(s) analyzed outside of the EPA/BCMOE/APHA recommended holding time.

## A.6 KLEARWATER TECHNOLOGIES EVALUATION OF FILTRATION EFFECTIVENESS

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# APPENDIX B - REFERENCE DOCUMENTATION

Reference documentation utilized in the preparation of this report includes:

- Kerr Wood Leidal Ltd. Computer water model, Silver Star Water Utility water distribution system, EPANET software;
- RDNO Silver Star Water Utility Annual Report, 2005.
- RDNO, Silver Star Monthly Log of Flow Records, 2002-06;
- Silver Star Water Utility Strategic Plan. Kerr Wood Leidal, January 2005.
- Silver Star Water Supply, Integration with RDNO Water System (Silver Star Water Utility), Draft #2. Bell MK Engineering Ltd. January 2007.
- RDNO Subdivision Servicing Bylaw 1769.
- Master Municipal Specifications:
- Interior Health correspondence received January 1, 2007. Application for a Construction Permit for Silver Star Ski Resort.
- www.silverstar.com
- Fire Underwriters Survey, Water Supply for Fire Protection, 1999;
- Health Canada, Guidelines for Canadian Drinking Water Quality (GCDWQ), Sixth Edition, 1996;
- Province of BC, Drinking Water Protection Act, Chapter 9, Order in Council No. 664, Approved and Ordered, June 30th, 2004;
- Province of BC, Drinking Water Protection Regulation 200/2003 including BC Regulation 352/2005 including amendments December 9th, 2005;
- USEPA, LT1ESWTR Disinfection Profiling and Benchmarking, Technical Guidance Manual, May, 2003;
- UV Guidance Manual
- Alpine Meadows Design Drawings. Don Ponto
- Site Plan Proposed Reservoir – Option B. Design Drawing June 30, 2006.
- Hay and Company Consultants Memorandum, Hydrotechnical Assessment of Reservoir B, Silver Star Mountain, October 12, 2006;
- IHA Correspondence to Earth Tech Canada Inc. regarding WTP, C. Dingman, P.Eng. to J.Bassett-Smith, Dec, 2006;
- Charles Contracting quote to Silver Star Mountain Resort, Watermain Installation, Vance Creek Reservoir to Village, September 18th, 2006;
- EBA Engineering Ltd., Silver Star Open Water Storage Reservoir Site Plan – Proposed Reservoir, Option B;

- Personal Correspondence, W. McKim, Water Operator on Contract to RDNO;
- Urban Systems Ltd., Design drawings, Carrington Resort Ltd., Water Supply and Storage System Completion costs, March 6, 2007;
- Earth Tech Canada Inc. Water treatment plant – P & ID Water Treatment and Pumping , August 29th, 2006;