ANNUAL WATER REPORT

2022

grow with us
THE DISTRICT OF BARRIERE

TABLE OF CONTENTS

ATTACHMENTS:

ATTACHMENT 1

Groundwater Under Direct Influence of Surface Water Study
Groundwater At Risk Containing Pathogens Study

ATTACHMENT 2

Water Master Plan

ATTACHMENT 3

DW3 Well Report

ATTACHMENT 4

Bradford, Spruce and LCIP Full Spectrum Analysis Reports

INTRODUCTION

The District of Barriere is working to continually improve the water system and public awareness to meet the changing needs of our community.

Water safety is of the utmost importance to the District of Barriere. The supply of good, clean drinking water has been taken for granted by the general public in Canada until events such as the Walkerton E. Coli outbreak brought the safety of the water supply into the public eye.

This report has been submitted to Interior Health and is posted on the District of Barriere website: www.barriere.ca

We are dedicated to providing safe, clean water to the residents of Barriere as indicated in the following report.

WATER UTILITY OBJECTIVES

- To ensure adequate supply of high-quality water to the community.
- To effectively treat the raw water to provide potable water of integrity to the community.
- To ensure the adequate delivery of high-quality potable water to all points within the system for domestic and emergency purposes.
- To ensure effective management of all water system aspects and provide excellent customer service and information to the community.
- To manage water demand by effectively assessing and managing water losses from leakage in the system.
- To develop an effective water conservation program for operations and the wider community.
- To maintain water rates that encourage conservation and resource awareness while providing quality accessible water to consumers.

PROVINCIAL REQUIREMENTS

All drinking water in the water system must meet the Canadian Guidelines for Drinking Water Quality. In British Columbia, the Ministry of Health regulates water suppliers through the Drinking Water Protection Act. This legislation ensures safe drinking water in the Province. It requires that the water supplier monitor the drinking water source and distribution system to ensure compliance with the Drinking Water Protection regulations and report all results to the Health Authority. Water monitoring, inspection and testing, emergency response planning, cross connection control and security standards are all regulated for persons operating a water system.

Changes in water systems must be approved by the Interior Health Authority (IHA), and conform to the District's specifications.

Under the *BC Water Act*, the District must acquire licenses for withdrawal from water bodies.

Under the *Community Charter*, the District may, by bylaw, regulate, prohibit, and impose requirements in relation to municipal service and public health. The District must make reports available to the public on request regarding fees imposed under this section.

SUPPLY SOURCES

Photo by Ellen Monteith

The District of Barriere's potable water system is supplied by a system of three wells, one being constructed during the 1990s, the second in 2019 and the third most recently in 2022. All three wells are in the northeast quadrant of the community, adjacent to the Barriere River. Two deep wells are located at the north end of Spruce Crescent, and a third production well, is located on Bradford Road. The wells are summarized in Table 3.1 below. The location of these wells can be seen on the overall water system plan on the following page.

Table 3.1: Barriere's Supply Wells

Well	Year Built	Pumping Capacity (L/s)	Approximate Depth (m)	Known Issues Or Concerns
PW1 Bradford Park	2019	20	91	High Iron, Manganese
DW2 Spruce Crescent	1997	44	35	Increasing evidence of iron and manganese - limited lifespan
DW3 Spruce Crescent	2022	32	45	Manganese periodically found over the Aesthetic Objectives.

WATER TREATMENT

The well water is injected with a chlorine solution at the pump stations such that it contains an approximate free residual chlorine concentration of 1.0 mg/L adjacent to the pump stations and has been measured to 0.8 mg/L at the more remote parts of the system.
In terms of the Interior Health Authority requirements, this treatment is satisfactory in a ground water source that is not under the influence of surface water, as these types of supply are given credit for filtration. Referencing the 4-3-2-1-0 requirements, the chlorine addresses the 4 and the 0, while the fact that the Spruce Well supply is a non-GWUDI well appears to be protected by a confining layer and addresses points 3, 2, and 1.

RESERVOIR STORAGE

The North reservoir is a rectangular concrete tank with sloping sides and a capacity of 1,540m^3 (406,560 USG). It is located at the north end of the community adjacent to Barriere Lakes Road and has a free water level of 451 meters. A 350mm diameter supply main connects the reservoir with the rest of the system at the intersection of Lodgepole Road and Barriere Lakes Road.

The South reservoir is a rectangular concrete tank and has a capacity of 1,300m^3 (343,200 USG). It is located at the south end of the community near the top of Mountain Road and has a free water level of 451 meters. A 250mm diameter supply main connects the reservoir with the rest of the system at Mountain Road.

DISTRIBUTION SYSTEM

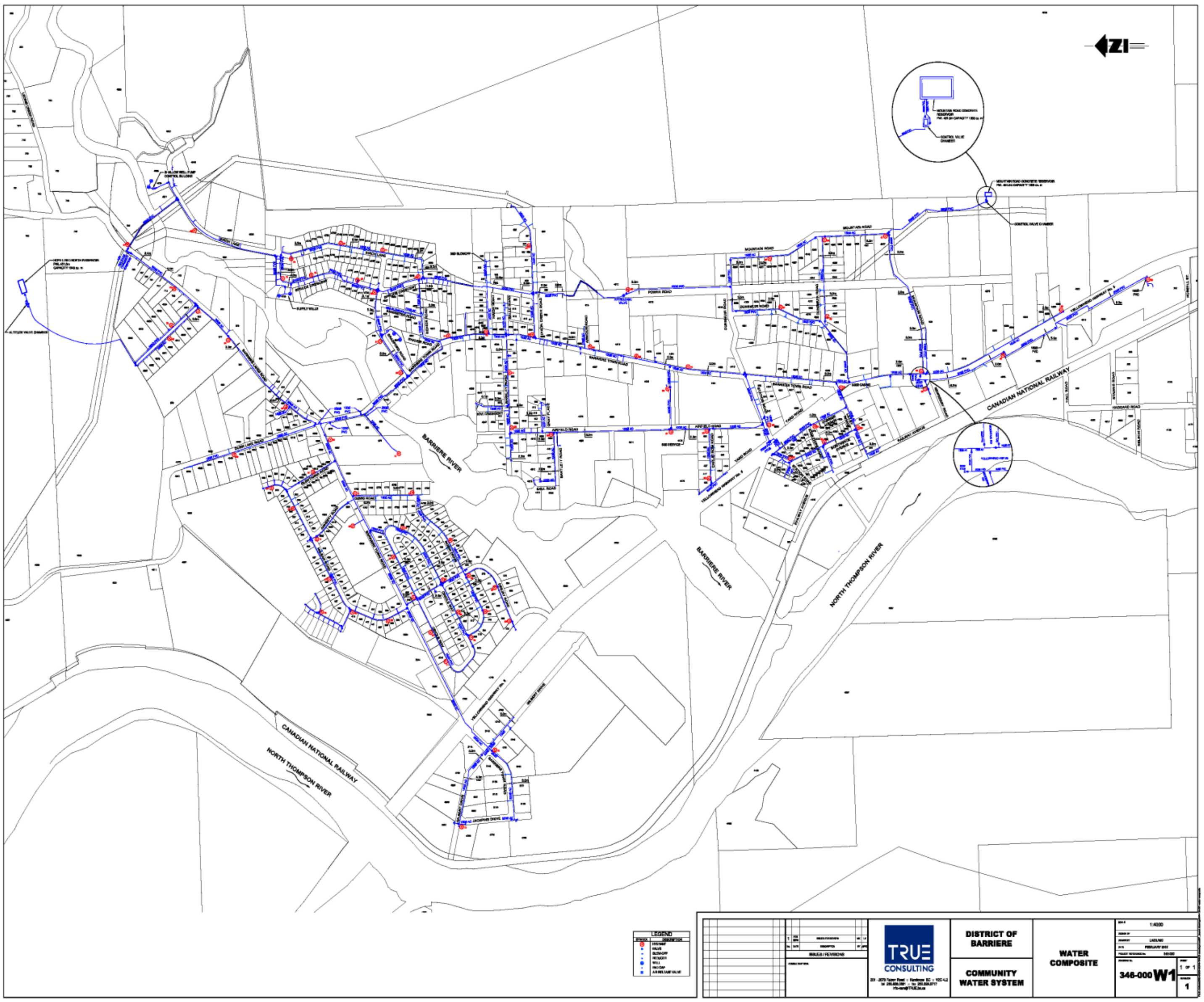
Approximately 24,750 meters of watermain are joined together to create the District of Barriere water system. The water system has been undergoing upgrades to ensure the water quality is safe for consumption. The first upgrades were from 1966 onwards when the pipes were asbestos cement. Beginning in the 1980's the pipes began to be upgraded to PVC due to the potential health risks of leakage from decaying asbestos/cement pipe. The PVC pipes range in diameter from 100 mm to 350 mm and provide potable water to approximately 783 residential and 75 commercial service connections in Barriere.

The District irrigates four public parks (Fadear, Bradford, Oriole, Gray Place), four baseball fields, two green spaces, and the cemetery, during off-peak demand times using a total of 77 irrigation zones with an average of 3 sprinkler heads per zone. In addition, the school district operates and maintains irrigation for the three school fields in Barriere.

Several sections of pipe within the District's water supply system are undersized, limiting flows and negatively impacting fire protection and pressures in certain parts of the network. Piping has been upgraded at the High School intersection along to Bradford Road, and from Barriere Town Road to Spruce Crescent.

In early 2021, the District began the process of drilling a new deep well alongside the current deep well (DW2) on Spruce Cres. This new well was given the moniker, "Deep Well 3 (DW3)" and as projected, completed in the spring of 2022.

WATER SUPPLY SYSTEM



WATER SAMPLING AND TESTING

Bacteriological:
As required by the Interior Health Authority (IHA), staff takes weekly water samples for bacteriological testing for total coliforms and e-Coli bacteria. There are 3 different sampling sites used throughout Barriere; North, Centre, and South.

Full Spectrum Analysis:
Water samples have been sent from the source water for a full spectrum analysis. Parameters such as alkalinity, metals, pH, turbidity, and hardness are tested. *SEE ATTACHMENT 4*

Summary:
In 2022 the District of Barriere had no positive bacteriological testing results pertaining to Total Coliforms or E.Coli and remained in compliance throughout the entire year of 2022. In 2022, the District began analyzing and tracking manganese levels on a more frequent basis to observe trends during different operating periods and times of the year.

EMERGENCY RESPONSE PLAN

The District of Barriere has an Emergency Response Plan for the water system. It identifies a number of potential emergencies that could occur and provides a systematic approach on how the District will deal with those emergencies. The plan is available for public viewing at the District Office, 4936 Barriere Town Road.

WATER QUALITY COMPLAINTS

The District of Barriere received few complaints in 2022 in respect to the quality of water being provided. Our community water wells, especially the Bradford wells have elevated iron and manganese levels, which once combined with chlorine create a brownish precipitate that showed up throughout the distribution system, therefore creating an aesthetically unpleasing water quality. Although the water was still safe for human consumption, the District of Barriere along with the Interior Health authority (IHA), continued maintaining the water quality advisory (WQA) that was implemented in 2019. However, with the onboarding of DW3, IHA removed the WQA in December of 2022 and therefore, is no longer in effect.

Most of the complaints received in 2022 were the result of this iron/manganese precipitate getting dislodged from the water mains during our annual hydrant flushing program. This is a temporary issue that clears upon running a household tap for a short period of time.

SYSTEM UPGRADES COMPLETED IN 2022

The new 300mm (12") production well (DW3) installed at a depth of 45.1m (148ft) was commissioned and put into production on March 1, 2022. The well was completed in a confined aquifer 23m thick, is at a low risk of containing pathogens (see Stage 2 GARP Assessment) and has a yield of 32 Litres/sec (500gpm). It follows all the Guidelines for Canadian Drinking Water Quality. Manganese was found at concentrations above the aesthetic objective of .02mg/l (see raw water sample analysis in Attachment 4) and is managed through a yearly flushing program. The well was installed to replace one of the existing production wells that provided water for the community for many years. Along with DW3 well casing, drop piping, pump and motor, some upgrades were made to the electrical controls. A new variable frequency drive, programmable logic controller, and alarm dialer were replaced. New piping, wiring and a flow meter were also needed to complete this project. The well produced 200,207m3 or 53,646,880 US gallons of potable water for the community in its first year.

Additional upgrades completed in 2022 include the installation of a new remote chlorine analyzer, and dual chlorine dosing pumps for redundancy at the Spruce Crescent pumphouse.

POTENTIAL SYSTEM UPGRADES

- Biological manganese removal Water Treatment Plant
- Additional Production Well (DW4) as the municipalities' population grows.
- Upgrading the asbestos cement water main on Barriere Town Road, installed in 1966, from Bradford Rd. to Mountain Rd. to remove the bottleneck and balance North and South reservoirs.

CROSS CONNECTION CONTROL PROGRAM

The District of Barriere maintains a Cross Connection Control Program to prevent the potential backflow of non-potable water into the District's water distribution system. The Program is based on premises isolation to ensure there is a reliable barrier between private and public water systems. The program uses a priority approach with higher hazard ICI (Industrial, Commercial, and Institutional) service connections being first in line for inspections and compliance mandates, as well as residential connections with auxiliary water. The District of Barriere Water System Bylaw # 189 gives the District authority to implement this program.

All new ICI developments are required to be inspected for Cross Connections as a condition of the provision of water service.

Backflow prevention devices are documented and tracked by the District to ensure they are tested annually and in good working order. This annual testing must be carried out by a certified Backflow Assembly Tester. It is also worth noting that all residential outside hose bibs were confirmed to have vacuum breakers installed (2012) and all new builds are required to have them.

The District also monitors potential backflow situations through its water meter program. All service connections in the District must be metered. Our water meters will detect and flag backflow occurrences and provide additional information on time of occurrence, duration, and volume. If the situation were to occur, it would prompt immediate investigation and may trigger our Water System Emergency Response Plan.

2022 Summary Report	
Total ICI Facilities/Premises (inc. District facilities and parks)	102
Total BFP's Tracked	45
Past Due Test Reports	21

Hazard (L/M/S)	Inspected Premises with CCs	Premises in Compliance
Sever	4	4
Moderate	16	14
Low	8	0
Total	28	18

The District will continue to improve and further implement its Cross Connection Control Program through inspections, tracking, program development and public education to eventually have all actual or potential cross connections identified and in compliance with our CCC Program.

OPERATOR CERTIFICATION

The District of Barriere currently employs three licensed operators, all in good standing with the EOCP. One Senior Utilities Specialist, who holds a Class 2 certification in Water Treatment and Water Distribution. One Water Technician 2, who holds a Class 2 certification in Water Treatment and a Class 1 certification in Water Distribution. One Water Technician 1, who holds a Class 2 certification in Water Distribution, Chlorine Handling Certification, and will be obtaining his Class 1 certification in Water Treatment soon. Our Water Technician 2 is also the District of Barriere's cross connection control inspector and certified backflow assembly tester.

SUMMARY OF SOURCE WATER PROTECTION EFFORTS

The District of Barriere is currently working towards completing a wellhead protection plan to ensure a consistent effort is being made to protect our groundwater production wells. The wellhead protection plan assesses risks and makes recommendations with respect to source water protection. The plan notes that risks to production wells from activities within and outside the capture zone are perceived to be low. Another measure the District of Barriere has implemented is a property covenant on all surrounding residential homes which prohibits the use of fertilizers and pesticides. Further to this the District undertook a GWUDI/GARP study of its deep wells at the Spruce Crescent site to determine potential influences of the adjacent Barriere River (see ATTACHMENT 1).

APPENDIX I

WATER CONSUMPTION (US GALLONS)

Month	2022 PW1	2022 DW2	2022 DW3	2021 DW2	2020 DW2
January	31,410	6,805,520	0	5,554,308	7,434,506
February	0	6,391,427	0	3,171,904	7,210,840
March	0	6,464,290	0	0	5,874,752
April	0	1,211,884	4,867,882	5,229,866	6,451,104
May	73,281	3,323,020	3,541,490	10,650,658	9,001,828
June	155,491	4,445,487	4,057,947	14,100,544	6,221,416
July	761,317	5,446,963	8,456,675	15,452,256	6,657,220
August	745,625	5,636,586	8,687,033	11,291,344	9,915,824
September	469,407	4,459,488	5,813,898	7,145,984	7,292,080
October	614,596	3,256,184	3,184,594	5,908,984	5,500,160
November	172,636	2,688,214	2,796,525	5,671,928	4,974,608
December	155,412	3,076,811	3,231,352	5,207,212	5,207,212

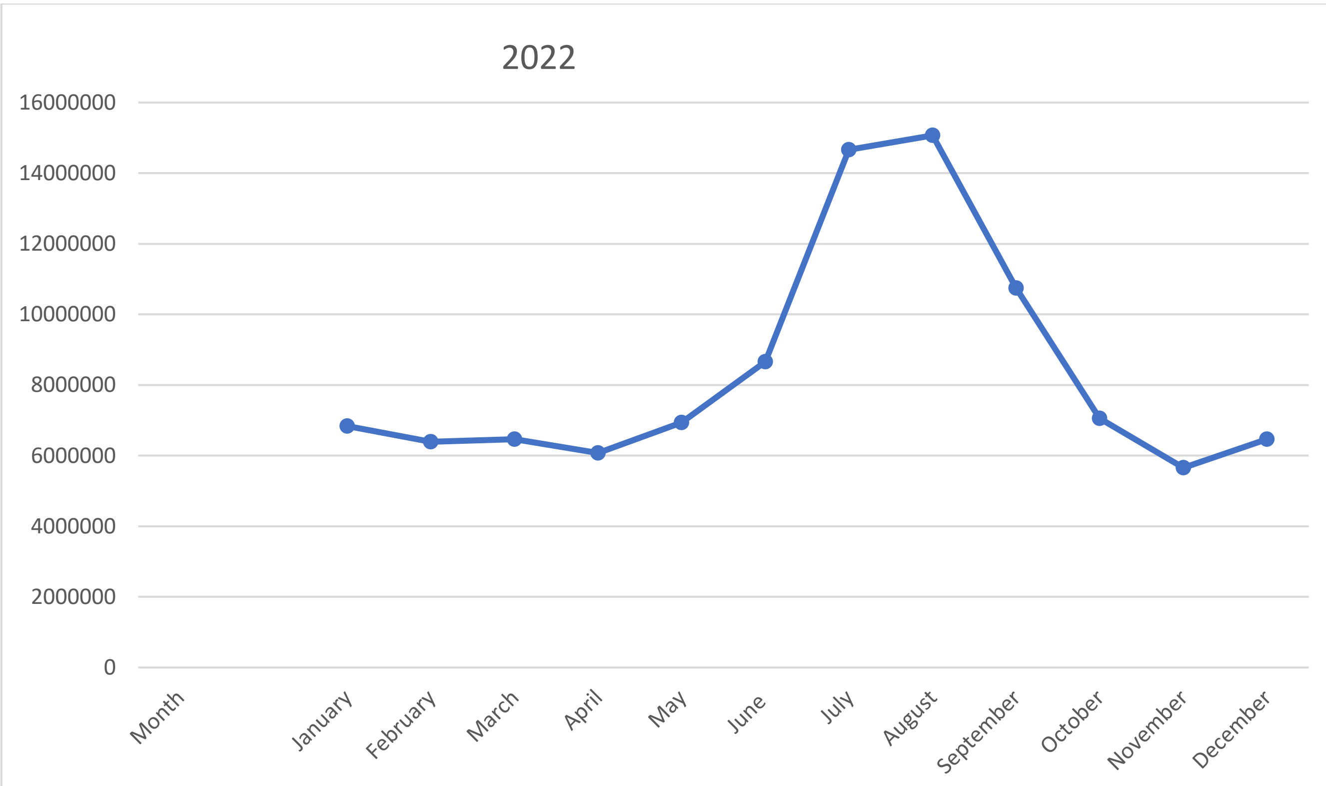
HISTORICAL ANNUAL WATER CONSUMPTION

Total Consumption for 2022: 101,022,445 US Gallons
Total Consumption for 2021: 102,128,334 US Gallons
Total Consumption for 2020: 82,478,189 US Gallons
Total Consumption for 2019: 119,537,215 US Gallons
Total Consumption for 2018: 145,826,200 US Gallons
Total Consumption for 2017: 158,865,845 US Gallons
Total Consumption for 2016: 122,206,199 US Gallons
Total Consumption for 2015: 142,223,460 US Gallons
Total Consumption for 2014: 141,532,585 US Gallons
Total Consumption for 2013: 172,664,965 US Gallons

APPENDIX II

WATER CONSUMPTION

2022 Total Water Consumption



APPENDIX III

LOUIS CREEK INDUSTRIAL PARK (LCIP)

The District of Barriere has a small water system in the Louis Creek Industrial Park (LCIP) which is located 4 kilometers south of the town of Barriere. This water system serves only the businesses which are in the industrial park, along with 1 residential homeowner. The LCIP water system started production on June 1, 2020.

The water system consists of a 50-gpm production well, and a pump house where disinfection occurs. There is a non-potable storage reservoir which is located on the east side of the industrial park. Backup power is scheduled to be installed in the summer of 2023.

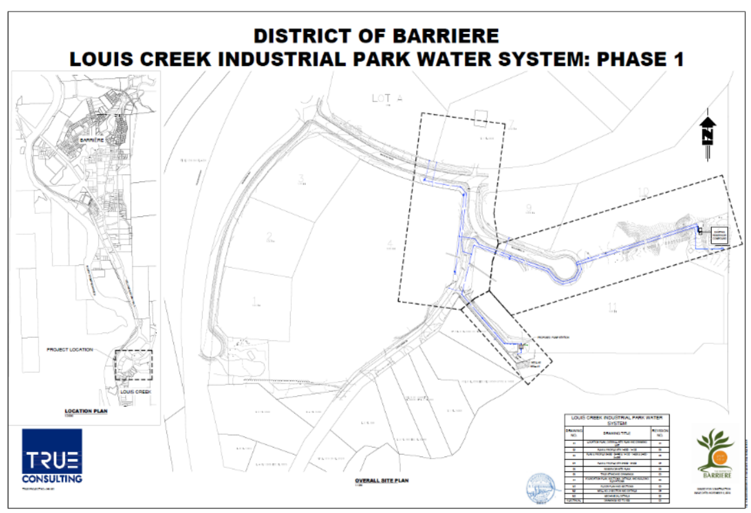
The district utility staff attends this site daily where chlorine levels and flows are monitored. Weekly bacteriological samples are collected for analysis from an outside independent laboratory. LCIP had no positive bacteriological testing results pertaining to Total Coliforms or E. Coli and remained in compliance throughout the entire year of 2022.

The District's grant funding application for constructing a new reservoir and water system upgrades was approved in late 2022. Work is expected to commence in early spring of 2023.

A full spectrum analysis of the raw water source was conducted in 2022 and can is shown in Attachment 4 of this document.

LCIP WATER CONSUMPTION (CUBIC METERS)

Month	2022 LCIP	2021 LCIP
January	307.6	266.1
February	292.0	219.6
March	304.0	241.9
April	279.3	148.6
May	307.6	190.2
June	168.9	170.7
July	170.4	651.9
August	143.7	262.7
September	107.6	140.7
October	140.1	141.9
November	149.3	135.9
December	124.9	253.5



Total Consumption for 2022: 2526.4 m3
Total Consumption for 2021: 2392.0 m3

Water Master Plan – Part I

District of Barriere

October 2020

Project No. 346-371

ENGINEERING ■ PLANNING ■ URBAN DESIGN ■ LAND SURVEYING

201-2079 Falcon Rd | Kamloops BC | V2C 4J2 | www.true.bc.ca | tel 250.828.0881 | fax 250.828.0717

Distribution List

# of Hard Copies	PDF Required	Association / Company Name

Revision Log

Revision #	Revised by	Date	Issue / Revision Description

Report Submission

Report Prepared By:

Sydney Emerson, EIT
Project Engineer

Report Reviewed By:

Dave Underwood, P. Eng.
Project Engineer

R:\Clients\300-399\346\346-371\05 Reports\Water Master Plan\346-371-Barriere-Water Master Plan-October 2020.docx

Table of Contents

APPENDICES

List of Tables

List of Figures

List of Acronyms

ADD	Average Day Demand
BCGWCS	BC Groundwater Consulting Services
District	District of Barriere
GARP	Groundwater at Risk of Containing Pathogens
GCDWQ	Guidelines for Canadian Drinking Water Quality
GUDI	Groundwater Under Direct Influence
IHA	Interior Health Authority
MAC	Maximum Allowable Concentration
MFLNRO	Ministry of Forests, Lands and Natural Resource Operations
MDD	Maximum Day Demand
MMCD	Master Municipal Construction Documents
MOE	Ministry of Environment
NTU	Nephlometric Turbidity Unit
TRUE	TRUE Consulting
UV	Ultra Violet

WTP	Water Treatment Plant

Units of Measure

ft	feet
Igpm	Imperial gallons per minute
km	kilometre
L/d	Litres per day
L/m	Litres per minute
L/s	Litres per second
lpcd	Litres per capita per day
m	metre
mg/L	milligrams per Litre
mm	millimetre
NTU	Nephelometric Turbidity Units
psi	pounds per square inch
USgpm	US gallons per minute

Referenced Reports

1	District of Barriere Official Community Plan, 2008
2	Golder, Well Head Protection Plan, January 24, 2008
3	District of Barriere Annual Report, 2019
4	District of Barriere Annual Water Report, 2018, 2016
5	Kala Geosciences, Wellhead Protection Assessment, September 8, 1997

Executive Summary

The purpose of Part I of the Water Master Plan is to identify water sources available to the District of Barriere (the District) and assess the associated water quality. The District has called for the preparation of this master plan to identify a sustainable, long term water source that will sufficiently provide the community with high quality water. The master plan is focused on development of the source and the associated treatment requirements.

Part II of the Water Master Plan will look at the water distribution system, fire-flow improvements, and looping opportunities to improve efficiency.

The District currently relies on Deep Well 2 (DW2) as its main source of drinking water and water quality to date has allowed for treatment using Chlorine only. The well was drilled in 1997 and is not capable of meeting maximum day demand (MDD) on its own. At times of high demand, the District must impose strict water restrictions. There is opportunity to supplement production with the Bradford Park Wells. The Bradford Park Wells cannot be operated at a high flow rate due to concerns regarding the stability of the sand filter pack, and though the water is safe to drink, it is aesthetically unpleasant. Deep Well 1 (DW1) could also be used to supplement supply, however DW1 does not meet the Guidelines for Canadian Drinking Water Quality (GCDWQ) criteria and a Boil Water Notice must be issued if the well is put into service. The DW1 source has been physically disconnected from the system.

The capacity and associated quality of the drinking water sources available to the District have been examined to identify a sustainable water supply for the District of Barriere. Treatment requirements for the water sources have been identified to determine order of magnitude costs associated with bringing those sources online for use by the District.

1.0 Background

1.1 Introduction

The District of Barriere has been successful in the ICIP infrastructure planning grant program and has called for the preparation of a Water Master Plan to assess available source and treatment options that will meet demand and water quality requirements. This document will also provide guidance regarding future capital expenditures.

The District of Barriere has had many challenges in acquiring a sustainable water source that will both meet Maximum Daily Demand (MDD) and satisfy the Guidelines for Canadian Drinking Water Quality (GCDWQ)

A Giardia outbreak in 1990 led the District to pursue a groundwater source. A brief overview of the District's existing groundwater infrastructure is as follows:

TABLE 1-1: DISTRICT OF BARRIERE WELL OVERVIEW

Shallow Wells (SW1, SW2)	▪ Incapable of meeting MDD ▪ High probability of being Groundwater at Risk of Containing Pathogens (GARP)
Deep Water Wells (DW1, DW2)	▪ DW2 is currently the main source ▪ DW1 contains manganese levels greater than the Maximum Allowable Concentration (MAC) ▪ May be GARP, assessment has not yet been completed
Bradford Park Production Wells (PW1, PW3)	▪ Incapable of meeting MDD ▪ Issues with the stability of the aquifer and quality of the water

A Groundwater Under the Direct Influence of Surface Water or Groundwater at Risk of Containing Pathogens Assessment (GUDI/GARP) has not been completed on any of the District's wells. The water quality of the sources has only been examined from previous testing.

An outline of the District's source water timeline is provided in Section 1.4.

1.2 Planning Documents

1.2.1 Official Community Plan

The District's planning in relation to water infrastructure is guided by the Official Community Plan.

Environment

3.2.1 To protect and enhance the quality of Barriere's rivers, streams and ground water sources in order to provide an integrity level that supports the ecological services of the North Thompson River and Barriere River and Watershed

a) Support and establish a Groundwater and Surface Water Protection Plan
b) Require the implementation of Barriere Riparian Area Regulations for all development occurring withing a Riparian Area
c) Require all new development to connect to the District Water system, except where physically or economically unfeasible, as determined by the District
d) Prohibit bulk water sales

3.2.2 To provide leadership to promote water conservation and further educational programs

a) Develop a Water Conservation Plan
b) Undertake a water metering program
g) Encourage requirements and incentives for low water use fixtures (e.g. low flow shower heads and toilets)
j) Promote water demand education, management and conservation as a component of a sustainable community

Infrastructure and Utility

3.5.6 To work towards connecting all of Barriere to the water and sewer systems

a) Promote responsible on-site water and septic system management for all existing systems
b) Review water use and encourage water metering for both residential and commercial sectors; and
c) Property owners and occupiers are encouraged to ensure that maintenance contracts for on-site septic systems are followed in accordance with the appropriate Provincial regulations.

1.2.2 2018 Annual Report

The District's Annual Report includes the objectives of the water utility.

Water Utility Objectives

- To ensure adequate supply of high-quality water to the community
- To effectively treat the raw water to provide potable water of integrity to the community
- To ensure the adequate delivery of high-quality potable water to all points within the system for domestic and emergency purposes
- To ensure effective management of all water system aspects and provide excellent customer service and information to the community
- To manage water demand by effectively assessing and managing water losses from leakage in the system.
- To develop an effective water conservation program for operations and the wider community
- To maintain water rates that encourage conservation and resource awareness while providing quality accessible water to consumers

1.3 Water Demand

The District of Barriere population was 1713 in 2016 (Census). The water supply has approximately 780 residential connections and 75 commercial connections (District of Barriere 2018 Annual Report).

Existing Flows

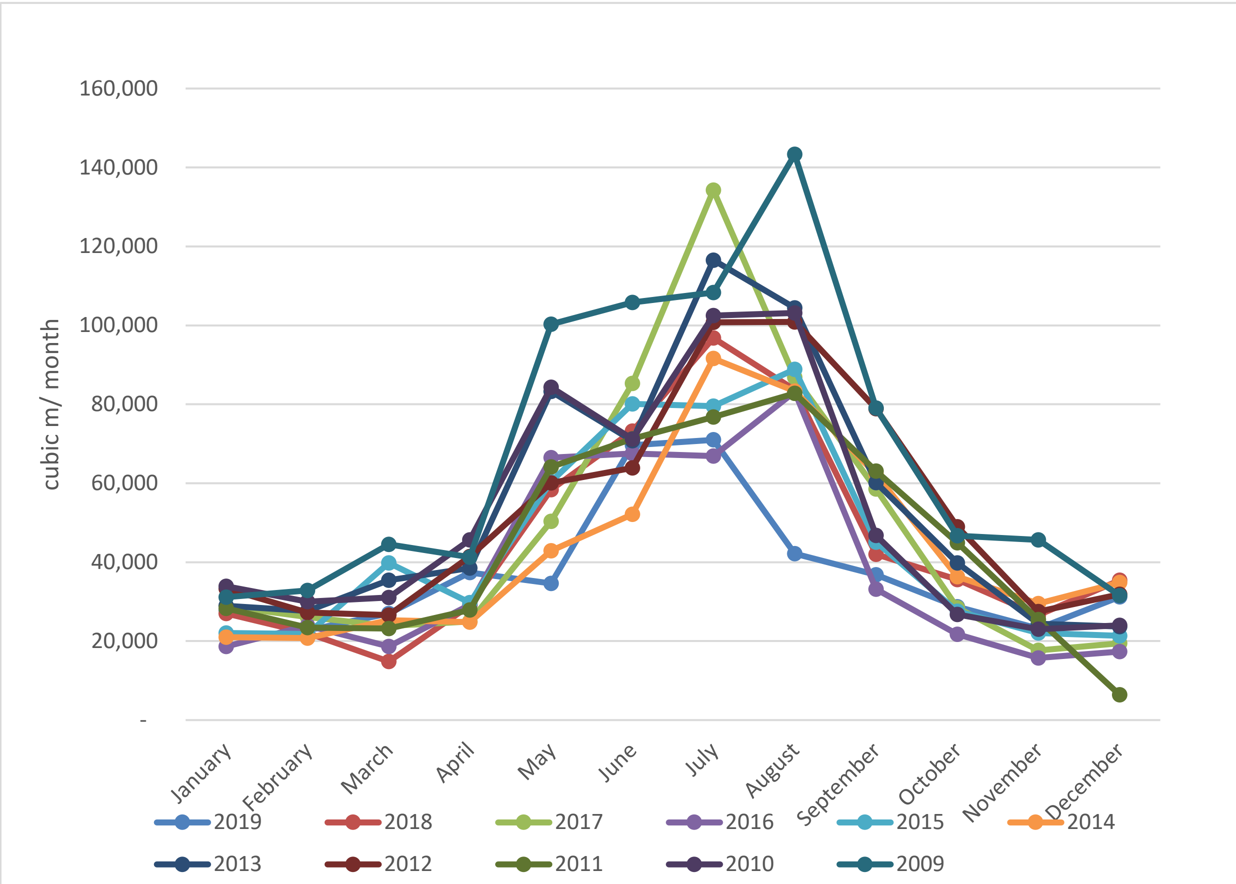


FIGURE 1-1: MONTHLY DEMAND

Future Growth Projection

Census population was 1773 in 2011 and 1713 in 2016. BC Stats have estimated significant growth in the years 2017, 2018 and 2019 as shown in Figure 1-2.

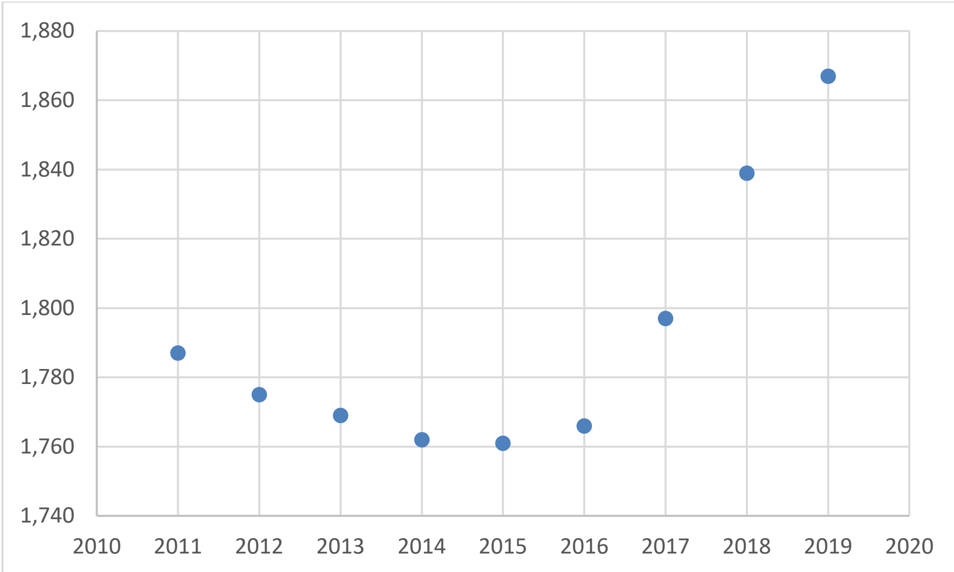


FIGURE 1-2: BARRIERE ESTIMATED POPULATION (BC STATS, 2020)

A range of growth scenarios have been calculated for use in estimating future water requirements (Table 1-3).

TABLE 1-2: FUTURE POPULATION GROWTH

	Growth Rate	2019	2025	2040	Difference (2019-2040)
Population	2%	1763	1985	2672	909
	0.5%	1763	1817	1958	195
	0.25%	1763	1790	1858	95

Design Demand

Based on past monthly flow data and population growth projections an MDD of 60L/s has been selected for water projects in Barriere.

1.4 District of Barriere Water Supply Timeline

Pre 1990 –	Barriere using surface water from Leonie Creek and Barriere River. The water is treated with chlorine in reservoir prior to distribution
1990 –	Up to 20 people in Barriere diagnosed with giardiasis
May – October 1990 –	MOE undertakes a sampling program, finding that Giardia is present in up to 90% of the surface water samples
February 1991 –	Pump testing of Shallow Water Wells. They were not capable of producing MDD.
April 1991 –	Slow sand filter pilot study (TRUE Consulting)
1991 –	TRUE memo recommends exploring treatment options for Leonie Creek, groundwater will not be sufficient for current or future demand
1994 –	DW1 Drilled
1997 –	DW2 Drilled
2009 –	Test wells drilled at Bradford Park under direction of BC Groundwater Consulting Services
2010 –	DW2 rehabilitated
April 2011-	Barriere applies for UBCM Gas Tax Grant for deep water well development
2012 –	Installation of universal water metering. Consumption reduced by 35 - 40%
2012 –	SCADA monitoring system installed
May 2012 –	District of Barriere using two deep water wells (DW1, DW2) as main water source, required to supplement in the summer with shallow water well under direct influence of surface water
May 2017 –	Drilling of PW2 fails due to heaving and sand lock of the drill string
July 2017 –	Breakthrough of fine sand into PW3 during pump testing
Fall 2017 –	Shallow water wells taken offline due to GUDI status
Winter 2018 –	Bradford Park Well development completed at lowest practical flow rate (12 L/s for each well)

February 2019 – The flow meter at DW2 fails, requiring the District to take DW2 offline. The District puts Bradford Park PW1 online under close monitoring, various complaints regarding water colour are received.

April 15, 2019 – District issues Water Quality Advisory

May 19, 2019 – Bradford Park PW3 is re-developed

July 11, 2019 – Bradford Park wells are put back on-line at a maximum of 50% of their individual maximum production rates (approx. 12 L/s per well).

2.0 Capacity and Condition of Current Water Supply

2.1 General

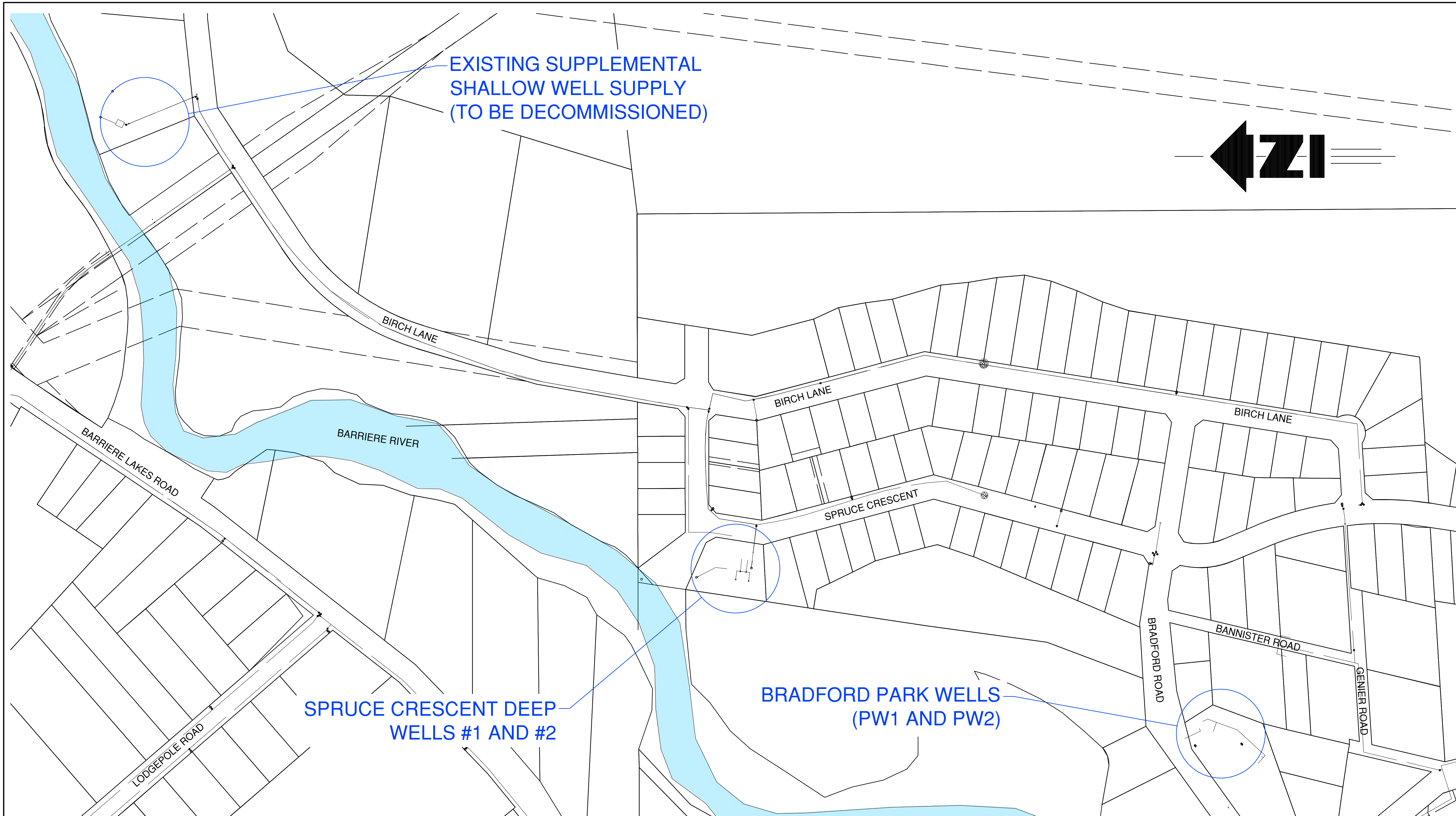
The District of Barriere's active water supply wells are on two sites, Spruce Crescent and Bradford Park. The Spruce Crescent wells were drilled in 1994 (DW1) and 1997 (DW2). DW2 is currently the District's main water source and is able to meet average day demand (ADD) of approximately 30 L/s. It is unable to meet maximum day demand (MDD). DW2 has reached the end of its useful life and as such, is not a sustainable source of water for the District. Each summer the District imposes severe seasonal watering restrictions to avoid bringing another well online. DW1 cannot supplement the system due to Manganese levels above the maximum allowable concentration (MAC), and the existing water treatment plant requires refurbishment to operate effectively. With refurbishment the existing filters would have a filtration capacity of approximately 38 L/s. DW1 has been disconnected from the system

The Bradford Park Wells (PW1 and PW3) were drilled in 2017. The District originally hoped to develop the twinned well system and remove the older Spruce Crescent wells from service. Unfortunately, the project has been unsuccessful. The Bradford Park wells have been difficult to develop. For example, the drilling of PW2 failed due to heaving conditions and sand-lock of the drill string and PW3 had sand breakthrough during pump testing that resulted in the well needing to be rescreened. Due to the challenging nature of the aquifer, it has been recommended that the wells are only operated at 50% of their capacity, meaning they are unable to meet demand requirements on their own.

In addition to difficult well development, the water supplied by the Bradford Park wells is aesthetically unpleasant. The District had to take DW2 offline for repairs in 2019 when a flow meter failed. Bradford Park PW1 was brought online with close monitoring and the District received numerous complaints about the aesthetic quality of the water. The Bradford Park well system has not proven to be a sustainable long-term drinking water source as planned.

Interior Health is currently completing their annual inspection of the drinking water system and has requested that GUDI/GARP assessments be completed for all the District's wells that are connected to the system. If it is determined that the wells are GUDI/GARP they will need to meet the Interior Health 4-3-2-1-0 treatment objective for surface water and groundwater at risk of containing pathogens as follows:

- 4 log (99.99%) removal or inactivation of viruses
- 3 log (99.9%) removal or inactivation of Giardia Lamblia and Cryptosporidium
- 2 treatment processes for all surface drinking water systems
- 1 NTU of turbidity with a target of 0.1 NTU
- 0 E. Coli



EXISTING WELL LOCATIONS

TRUE CONSULTING

DESIGN BY: SE	
SCALE: 1:5000	
DWG NO.:	REV:
FIG: 2-1	-
DRAWN BY: DJF	
DATE: OCT 2020	

FILE:r:\clients\300-399\346\346-371\03 drawings\cad\03 base drawings\346-371-base.dwg

The District's current source water supply is not capable of adequately supplying the needs of the community. DW2 can provide ADD, however the age and condition of DW2 is such that it is not a sustainable source for the District. Bradford Park wells PW1 and PW3 can supplement DW2, however these wells are sensitive to over-pumping, can only provide a fraction of the water requirements of the District, and the water is aesthetically displeasing. DW1 contains manganese that is elevated relative to the GCDWQ and this well has been disconnected from the system. The water source is the most critical component of the District's water system, and its current water source (DW2) is at high risk due to the age and condition of the well. The District does not have a redundant source of water in the event of mechanical failure at DW2.

2.2 Shallow Water Wells

The two shallow water wells were drilled in 1991 to a depth of approximately 12m. The shallow wells are categorized as being under the direct influence of surface water due to their proximity to the Barriere River and a history of measurable total coliform concentrations (Golder, 2008). Testing in February of 1991 showed that the wells were unable to support the demand of the community, Shallow Well 1 (SW1) is capable of producing 4 L/s and Shallow Well 2 (SW2) is capable of producing 10 L/s. The wells were disconnected from the water system in the Fall of 2017.

Due to the treatment required and the low production of the existing shallow wells, a shallow well water source is not recommended for long term servicing requirements.

FIGURE 2-2: SHALLOW WELL SITE

2.3 Spruce Crescent Wells – (DW1, DW2)

The Spruce Crescent site has two existing wells. As discussed in Section 2.1 DW2 is the District of Barriere's primary water source. This source can meet an average demand of approximately 30 L/s and has aesthetically acceptable water quality. DW1 remains disconnected from the system due to manganese levels above the MAC of 0.12 mg/L. Table 2-1 summarizes previously completed water quality testing.

Golder Associates compared the Barriere wells to the prevailing GUDI standard in the Well Head Protection Plan completed in 2008. Golder has assessed that DW1 and DW2 are likely not GUDI wells because they are located approximately 100m from the Barriere River in a confined aquifer. The wells have not been assessed against the current Ministry of Health GARP Standard (2015). It is expected that DW1 and DW2 would be classified as GARP or GARP-virus only.

The Spruce Crescent Wells have supplied consistent water quantity and quality for 25 years. However, the age of the wells and lack of redundancy puts the District in a vulnerable position. If DW2 fails, the District will be unable to meet demand. In particular, the District cannot put DW1 online without a boil water advisory.

If the Spruce Crescent wells were replaced, it could be reasonably expected that the new wells would have water quality and production rates similar to the existing wells. With refurbishment and expansion of the existing treatment plant, the wells would be able to sufficiently meet forecasted demand.

TABLE 2-1: DEEP WATER WELLS - MANGANESE AND TURBIDITY

	Date	Total Manganese* (mg/L)	Turbidity
Deep Well 1 DW1	October 8, 2013	0.12	5.22
	October 13, 2015	0.14	4.35
Deep Well 2 DW2	October 8, 2013	0.0058	0.23
	October 13, 2015	0.0052	0.18

* Manganese MAC =0.12 mg/L, AO = 0.02 mg/L

2.4 Bradford Park Production Wells (PW1, PW3)

The District has had a variety of issues associated with the development of the Bradford Park Wells. As discussed in Section 2.0 the wells are unable to meet demand requirements, they are vulnerable to sand breakthrough, and the water is aesthetically unpleasant. BCGWCS has recommended that the Bradford Park wells are operated at a maximum of 12 L/s each and monitored closely. Analytical testing results have been summarized in Table 2-2 below. All total Manganese results are above the aesthetic objective (AO) of 0.02 mg/L, and nearing the MAC of 0.12 mg/L.

The yield of the Bradford Park Wells is unable to meet demand requirements and they are not considered to be a sustainable long-term drinking water source. Nevertheless, it is recommended that they remain connected to the system for emergency back up purposes. The licensing application for the Bradford Park Wells is currently pending review.

TABLE 2-2: BRADFORD PARK WELLS – MANGANESE AND TURBIDITY

	Date	Total Manganese* (mg/L)	Turbidity
Bradford Park PW1	April 27, 2017	0.083	0.75
	May 30, 2019	0.0985	0.27
	April 22, 2020	0.104	-
Bradford Park PW3	August 17, 2017	0.106	2.61
	May 30, 2019	0.0713	0.48
	October 6, 2019	0.0615	0.46
	July 21, 2020	0.0755	-

* Manganese MAC = 0.12 mg/L, AO = 0.02 mg/L

2.5 Surface Water Sources

The District of Barriere utilized water licences on Barriere River and Leonie Creek as their primary water source prior to 1990. The District diverted water from Leonie Creek and chlorinated the water directly in the reservoir. Water from the Barriere river was pumped to a high lift pump station where it was chlorinated before entering the distribution system. In 1990 the community had several diagnosed cases of giardiasis. The Ministry of Environment undertook a 6-month sampling program and found that Giardia was present in approximately 90% of the surface water samples.

There are no readily available water quality results for these surface water sources. Drinking water treatment requirements for surface water must meet the Interior Health 4-3-2-1-0 treatment objectives.

The District continues to hold licenses over both sources. The existing surface water licenses would be sufficient to meet forecasted demands. Cost associated with the construction of a river intake and surface water treatment plant will be much greater than the development of a groundwater source. The development of a surface water treatment plant is seen as a potential future upgrade to the District's water system and would add additional redundancy and reliability to the water system.

Table 2-3: Summary of Water Sources

Source Name	Description	Water License No.	Estimated Yield	Water Quality Concerns	Treatment Requirements	Comments
Leonie Creek	Surface Water	C050374 497796 m³/year (15.8 L/s) average		Surface Water Source Limited Data	Subject to 4-3-2-1-0 treatment objectives	Recommend a sampling program to better understand water quality and come up with a treatment strategy Would require the construction of of new inlet structures, pipelines, and treatment
Barriere River	Surface Water	C032392 (1966) 248898 m³/year (7.89 L/s) average C046787 (1974) 2488984 m³/year (78 L/s) average		Surface Water Source Limited Data	Subject to 4-3-2-1-0 treatment objectives	
Shallow Well 1 (SW1) PW90-1	Drilled in 1991 Depth: 9.6 m		5.34 L/s (Hardy BBT. 1991)	Directly recharged by Barriere River Assumed to be GARP	Subject to 4-3-2-1-0 treatment objectives	Formal GARP assessment not completed, wells assumed to be under direct influence of surface water Yield not capable of meeting MDD
Shallow Well 2 (SW2) PW 91-1	Drilled in 1991 Depth: 11.6 m		15.26 L/s (Hardy BBT, 1991)	Directly recharged by Barriere River Assumed to be GARP	Subject to 4-3-2-1-0 treatment objectives	
Deep Well 1 (DW1) PW93-2	Drilled in 1994 Depth: 59.3 m Diameter: 300 mm		Approximately 44 L/s	May be GARP or GARP-virus only. Manganese levels above MAC. Deep Wells have elevated nitrate, close proximity to on-site sewage systems.	Requires Manganese removal filtration	GUDI/GARP assessment not completed Aged wells at risk of failure Capable of providing MDD if treatment system is updated
Deep Well 2 (DW2) PW97-1	Drilled in 1997 – currently districts main water source Depth:42.1m Diameter: 250mm		Approximately 50 L/s	May be GARP or GARP-virus only. Deep Wells have elevated nitrate, close proximity to on-site sewage systems.	No treatment required apart from disinfection	
Bradford Park Production Well 1 (PW1) PW17-1 Well ID: 48866	Well Tag #114383 Depth: 91.4 m Diameter: 250 mm	Temporary Licence for 25 L/s	A maximum of 12 L/s per well until recharge is determined	May be GARP or GARP-virus only. Manganese results above AO of 0.02 mg/L. Approaching MAC of 0.12 mg/L.	Manganese and Iron Removal may be required	GARP assessment not completed Will not meet ADD at current yield Aquifer vulnerable due to overpumping failure
Bradford Park Production Well 3 (PW3) PW17-3 Well ID: 48898	Well Tag #114384 Depth: 121.9 m Diameter: 250 mm	Temporary Licence for 25 L/s	A maximum of 12 L/s until recharge is determined			

3.0 Water Supply and Treatment Plant Upgrade Plan

The District of Barriere's highest priority for its water system is to establish a reliable high quality potable water supply for the community. It is important that the solution is cost effective, sustainable, and efficient. The District plans to apply for funding under the 3rd intake of the Investing in Canada Infrastructure - Rural and Northern Communities Grant Program for funding to increase the community's access to potable water and complete the first phase of water upgrades.

The proposed scope of work includes the following:

- Drill two additional wells at Spruce Crescent and decommission DW1 and retain DW2 as mechanical backup if possible
- Convert existing greensand filtration units to biological manganese removal filtration units for a total flow capacity of 38 L/s
- Expansion of the treatment plant including:
    - Additional biological manganese removal units for an additional flow capacity of 38 L/s
    - A chlorination room
    - A backup generator

The proposed upgrade plan is detailed in the attached cost estimate in Appendix A. Preliminary Design Drawings are located in Appendix C.

Phase 1 focuses on establishing a sustainable water source and sufficient water treatment for reliable service delivery. The first phase will ensure redundancy and provide sufficient potable water for demand requirements.

3.1 New Wells

The existing Deep wells have been found to require urgent replacement due to their age, condition and the extent to which Barriere relies on them as their main water source. The District recognized this urgency in 2009 when it initiated a groundwater assessment study. Unfortunately, the replacement wells drilled at Bradford Park did not meet the intended project objectives.

The new wells will be located close to the Barriere River. As such, the top of the well casings will be set at least 300mm above the local 200-year flood elevation.

The new wells at Spruce Crescent would be drilled and tested prior to finalizing the design of the water treatment systems. As such, this work would be scheduled for at least one year before the design and construction of the WTP improvements.

3.2 Treatment Plant

3.2.1 Design Parameters

Design Flow

The 20-year flow projection undertaken for this Master Plan report has an estimated Maximum Daily Demand of 5,200m^3/d (60 L/s).

The future MDD flow is expected to remain stable based on the following factors:

- The community has universal water metering.
- There is a history of relatively stable or declining population in the BC Interior.
- The District is not expecting to approve additional expansion of the system within the design period (to 2040).

Design Raw Water Quality

The treatment system will treat a blend of water from the existing wells, along with water from new wells on the Spruce Crescent site. The water quality from the new wells is expected to be similar to the existing deep wells. As such, the raw water quality is summarized as follows:

- Total manganese and iron at or exceeding aesthetic objective values
- Manganese exceeding maximum acceptable concentration
- Turbidity < 1.0 NTU
- Fecal coliforms and E coli < 1 CFU / 100ml

No concerns have been noted in relation to other parameters.

3.2.2 Manganese Removal

Manganese and iron removal is most commonly undertaken using greensand filters, such as the filters already installed at Spruce Crescent. These rely on the use of an oxidant to cause the manganese to be adsorbed onto the sand media.

The existing treatment system is no longer being used, but it could be refurbished for future use. The filters have been visually assessed and appear to be structurally sound. However, the mechanical and electrical systems are obsolete and need to be replaced. This is expected to include the replacement of pipework, media and the filter underdrains.

TABLE 3-1: EXISTING GREEN SAND FILTRATION UNITS

The refurbished filters can be used for manganese removal by processes other than greensand filtration. A range of treatment methods are available including sequestration, ion exchange, adsorption / filtration and biological filtration.

Sequestration: When manganese levels are less than the MAC, one potential method for addressing it is simply to mask its effects through sequestration. Sequestering manganese involves adding sodium phosphate to the water to effectively hide the presence of the dissolved metal for a short period of time. Sequestering is typically inexpensive but to be effective it is recommended that the water not have a maximum dissolved manganese concentration exceeding 0.1 mg/L.

Ion Exchange: In an ion exchange process, dissolved manganese ions are exchanged for sodium ions with an exchange resin. This is the very same process used for softening hard water. Therefore, an ion exchange process would be capable of softening the water in addition to removing the dissolved manganese. However, the sodium concentration of the treated water will increase substantially as the exchange resin indiscriminately replaces virtually all positively charged ions such as calcium, magnesium, iron and manganese with sodium ions. This increased sodium concentration could create health issues for those on the salt restricted diets.

Oxidation and Filtration: Manganese removal may also be achieved through the conventional chemical-physical process of oxidizing the dissolved manganese and removing the resulting insoluble manganic manganese with filtration. Oxidation can be performed through chlorination of the water, which has the added benefit of providing disinfection while removing the manganese.

Aeration with pure oxygen or potassium permanganate may be also used for oxidation in combination or potentially as an alternative to chlorination. Oxidation with potassium permanganate is particularly useful because it also regenerates the filter media but comes with complex handling requirements because of its hazardous nature. Sufficient contact time is required for the oxidation process to thoroughly precipitate the dissolved manganese. Filtration media can be greensand or proprietary media such as Filox. Filox can be used without an oxidant but the performance of the media is affected.

Biological Filtration: Another technology that is being used more in BC in recent times is biological filtration. Biological filtration makes use of innocuous bacteria already present in the groundwater that naturally feed on dissolved manganese. Within the filter vessel, the bacteria form a biofilm on the surface of the filter media that effectively consumes manganese. In addition to removing manganese, the removal of other dissolved metals such as iron and ammonia can be achieved.

Biological removal system has advantages that are relevant to the Barriere WTP, such as reduced waste volumes, reduced chemical requirements and a backwash waste that is free of oxidants and easier to dispose of.

The preferred treatment option for Barriere is biological manganese removal. Based on the dimensions of the existing filters, they will have a treatment capacity of 38 L/s. A further 38 L/s of treatment capacity is proposed in order to achieve the design MDD. This can be achieved by installing two additional filter units as shown on the drawings (Appendix C).

3.2.3 Disinfection

Chlorination will be required for primary disinfection, targeting bacteria, viruses. The chlorine will also provide a residual in the distribution system to preserve the quality of water and protect against contamination.

Space will be set aside for ultraviolet disinfection to ensure compliance with Interior Health Authority requirements in case the wells be classified as GARP in the future.

3.2.4 Backwash System

The proposed water treatment plant process will periodically backwash, producing biological suspended solids removed from the filters that must be disposed of. The backwash flow becomes a waste or process residual that has to be managed. The proposed site means that the waste can be allowed to settle, with the clear supernatant disposed of to the existing rock trap. The remaining concentrated solids will then flow to the Birch Lane WWTP for treatment.

It will be important to backwash the biological filters with unchlorinated water so a clean backwash water storage tank will be needed.

3.3 Building Design

3.3.1 Building Energy Efficiency

It has been confirmed by the Investing in Canada Infrastructure Program that in order to meeting the project funding criteria, the building design must target the BC Building Code values. Therefore the 2018 version of the BCBC applies to this funding application. There is no requirement to exceed these energy standards.

Barriere is assumed to be in the same climate zone as Kamloops. The BCBC (2018) assesses Kamloops as having 3,450 degree-days below 18˚C. The building will include other energy efficiency features such as;

- LED lighting
- High R rated overhead doors (e.g. Wayne Dalton Thermospan 150 Insulated Sectional Steel Door)
- High R value translucent wall panels in place of windows (e.g. Kalwall® window replacement panels)

3.3.2 Emerging Technologies, Environmental Considerations and Societal Impacts

Emerging Technologies: Given that this system provides drinking water to residents of the Barriere community and must be approved by Interior Health, the water treatment system will use proven technology. The proposed biological manganese removal process has been in use in Europe since the 1980s and is marketed by the Suez Corporation as the Mangazur process. Despite this, the process is relatively new to British Columbia. There are Mangazur plants working successfully at 100 Mile and 108 Mile. A biological manganese removal plant is also currently under construction in Burns Lake. This plant will be the first in BC to retrofit existing filters to the biological treatment method.

As far as possible, new building technologies aimed at energy efficiency will be implemented as part of the design.

Environmental Considerations: Apart from making use of energy efficient building features, the site selection makes use of existing disturbed land, minimizing impact on natural areas.

Societal Impacts: Access to clean drinking water will benefit members of the Barriere community. Residents will be affected by an increase in operating charges related to the new infrastructure.

4.0 Cost Summary

4.1 Capital Costs

The overall estimated capital cost of the new wells and treatment improvements is $3,870,360 with no opportunities for phasing. A preliminary capital cost estimate for the project is presented in Table 4-1 and more detailed cost estimates are included in Appendix A.

TABLE 4-1: WATER TREATMENT PLANT CAPITAL COST ESTIMATE

Item	Description	Estimate
General	Insurance, Bonding, Mobilization, Demobilization, Commissioning	$80, 000
Well Improvements	Wells, pumps, electrical	$795,000
Water Treatment Plant – Existing Manganese Removal System Modifications	Filtration Equipment and Services	$290,000
Manganese Removal System – Supply	Filtration Equipment	$500,000
Water Treatment Plant Foundation	Excavation, Backfill, Subbase, Foundation	$100,650
Water Treatment Plant Building	Pre-cast concrete structure, doors, windows, roof modifications	$306,750
Chlorination Room	Chemical Feed, Storage Tank	$83, 500
Emergency Diesel Generator	Generator, testing and commissioning	$150,000
Manganese Removal System - Installation	Installation	$85,000
Electrical, SCADA and Controls	Electrical, SCADA, Controls, Instrumentation	$318,000
Supply Piping	Site Piping	$62,500
Backwash Water Seepage Ponds – Supply Piping	Supply Piping, manholes	$55,8000
Chlorine Contact Piping	Piping, appurtenances	$150,000

Cost Estimate Summary

Subtotal	$2,977,200
Engineering – Allow (15%)	$446,580
Contingencies – Allow (15%)	$446,580
TOTAL PROJECT	**$3,870,360**

4.2 Annual Operating Costs

Annual operating costs for the new water treatment system have been calculated at approximately $77,450 per annum. The calculated annual operating costs relate primarily to the following items:

- Staff time
- Electricity
- Treatment chemicals

The detailed cost breakdown is as follows:

TABLE 4-2: POWER CONSUMPTION COSTS

Item	hp	kW	No. Connected	No. Duty 1	Runtime (hr/day)	kW-hr/d
Well Pump	150	111.9	2	1	8	895.2
Manganese Filtration System	10.0	7.5	2	1	20	149.2
Backwash Pump	30	22.4	2	1	0.67	14.99
General equipment		1			24	24.0
Lighting		0.06		10	1	0.6
Heating						25.2

Total Electricity	1109.2
Assumed Electrical Cost	$0.10
Total Daily Power Costs	$110.92
Total Annual Power Costs	**$40,484**

TABLE 4-3: OTHER CONSUMPTION COSTS

Type	Consumption (L/d)	Estimated Unit Cost ($/L)	Daily Cost
Sodium hypochlorite (disinfection)	28	$0.87	$24.36

Total Daily Consumption Costs	$24.36
Total Annual Consumption Costs	**$8,891**

TABLE 4-4: LABOUR COSTS

Type	Description	Hours/wk	Daily Cost
Weekly	Visual check of equipment, top up chemicals	8	$68.38
Annual	Recommended cleaning, oil changes, filter replacements	1	$8.55

Total Daily Labour Costs	$77
Total Annual Labour Costs	**$28,080**

Annual O&M Costs Summary

Total Annual Power Cost	$40,484
Total Annual Consumption Cost	$8,891
Total Annual Labour Costs	$28,080
Total Estimated Annual O&M Costs	**$77,455**

4.3 Lifecycle Costs

The annual cost of facility ownership for the upgrade has been calculated, taking into account the costs of constructing and operating the system. These costs are summarized in this section. The life cycle cost is broken down as follows:

Life cycle cost = Ownership Cost + Operating Cost

Ownership cost has been calculated based on the following formula:

Ownership Cost = Initial Cost / AP

Where,

AP = [(i(1+i)N)/((1+i)N -1]

i = 5% (inflation 2% and discount rate 3%)

N = The number of years of expected life

TABLE 4-5: EXPECTED OWNERSHIP COST FOR WATER TREATMENT PLANT

	Civil	Mechanical	Electrical
Facility Capital Cost	$702,367	$1,780,167	$494,667
Expected Life (years)	80	20	20
Factor	0.05	0.08	0.08
Annual Value of Replacement Cost	**$36,000**	**$143,000**	**$40,000**

The water treatment plant Life Cycle Cost is summarized as follows;

Ownership cost $219,000 per annum

Operating cost $77,000 per annum

Life cycle cost $296,000 per annum

It is proposed that a capital asset replacement fund would set aside funds to cover the ownership of the new assets.

4.4 Investing in Canada Infrastructure Program – Rural and Northern Communities

It is expected that a grant will be sought under the Investing in Canada Infrastructure Program – Rural and Northern Communities Fund. The grant funding includes the following design requirements:

- A construction completion date of no later than March 31, 2026.
- Drinking water quality must meet or exceed provincial standards.
- Building to meet or exceed any applicable energy efficiency standards for buildings outlined in the Pan-Canadian Framework on Clean Growth and Climate Change.

The following requirements listed in the grant criteria will not be allowed for in estimating costs, as they do not appear to be applicable to this project.

- Federal environmental assessment requirements applying to the project including a requirement to consult with Indigenous Groups (project not on Federal land and environmental effects not expected to trigger assessment)
- A climate lens - greenhouse gas emissions assessment that includes a cost-per-tonne calculation as required by Canada (Total estimated eligible expenditures < $10 million).
- A climate lens - climate change resilience assessment (Total estimated eligible expenditures < $10 million).
- A climate change resilience assessment (only required for projects that seek funding under the Adaptation, Resilience and Disaster Mitigation Outcome).
- A Value Engineering assessment (Total estimated eligible expenditures < $15 million).

5.0 Required Licenses, Permits and Approvals

5.1 Interior Health Authority

Interior Health supports the installation of a manganese filtration process for Barriere. On the basis of a GARP-virus only source, the unfulfilled requirements of the Interior Health treatment objectives would be:

- Reduce manganese levels to be consistently below the MAC of 0.12 mg/L, and
- Provide 4 log inactivation of viruses

Construction permits are required under the Drinking Water Protection Act and must be obtained before the construction, installation, alteration, or extension of a water supply system. The application for a Water Supply System Approval must be submitted along with sufficient design information to allow a health risk assessment of the proposed works. This includes how the design for the proposed water supply system or infrastructure upgrades complies with industry standards and water quality objectives.

For complex systems, or systems with advanced treatment processes, preliminary or pre-design discussions with the Public Health Engineer will assist in the application process.

Source water approval will also be needed for the proposed new wells. This should be received prior to commencing the design and construction of treatment systems.

5.2 Water Sustainability Act

Among other things, the *Water Sustainability Act (*2016) regulates the construction, maintenance, deactivation and decommissioning of wells. Generally, all wells apart from private single-home domestic wells are subject to the licensing provisions in the Act and enabling regulations (Water Sustainability Regulation, 2016). A licensed well is a well that is associated with a water licence to divert water for a specified purpose as per the terms of the water license.

The District of Barriere is considered to be an existing non-domestic groundwater user under the Act. Existing users are those who used groundwater for non-domestic purposes before February 29, 2016. The three-year transition period to licence non-domestic groundwater sources (including municipal wells) under the Water Sustainability Act and Regulation expired in 2019 but was then extended until March 2022. As of the date of this report, we understand applications have been submitted to FrontCounterBC for licensing of the Deep wells.

A separate application was submitted in 2017 for the licensing of the Bradford Park Wells. A temporary use license, valid for one year was granted on October 19, 2018 with the option to extend the term an additional year to October 18, 2020. The full license is still pending and a temporary use license extension has been requested.

Separately to the licensing requirements, wells are required to be registered in the Ministry database. It appears that the Deep wells and Shallow wells are not currently in the government's GWELLS database of registered wells. Well log information for these wells will be submitted to the Ministry if such information was not already submitted with the existing use licence application.

The proposed Spruce Crescent replacement wells will require registration and either an amendment to the licence (if the existing use licence is issued in the next 1-2 years) or possibly, an amendment to the existing use licence application (in either case, the change would involve adding the new wells as "additional works" replacing the capacity of the old wells). If the plan is to decommission DW1 and DW2 once the new wells are commissioned, then the District need not apply for a new licence and as such there should be no delays associated with licensing.

5.3 Heritage Conservation Act

The Barriere area is within the traditional territory of the Simpcw First Nation and has been historically occupied by indigenous peoples.

The site of the Deep Wells has not been studied for its historical context. As such, an Archaeological Overview Assessment should be considered to be completed as part of this project phase. This assessment compiles existing knowledge about recorded archaeological site locations, historical First Nations' land use, and cultural and environmental context at the site location.

If it is found that there is a high potential for encountering protected archaeological sites and materials during construction then an Archaeological Impact Assessment (AIA) may be recommended prior to construction. The AIA would have the following objectives:

1. Identify (locate and map) general location and character of precontact cultural materials and deposits located in proposed development area
2. Assess existing disturbances to any identified archaeological sites
3. Determine the nature, extent, and intensity of proposed land-altering activities and evaluate their likelihood of adversely affecting any identified archaeological sites (or portions thereof); and
4. Provide recommendations for the further work required to effectively manage and protect any archaeological sites likely to be impacted by the project.

A Heritage Inspection Permit will be required for the AIA. A Heritage Investigation Permit may be required if significant intact archaeological deposits are identified during the AIA. Further work is then required to remove those deposits in a way that maximizes preservation of information (ie: detailed archaeological excavations). This permit and the work it authorizes may be required by the MFLNRORD Archaeology Branch following the review of the AIA results and recommendations. A Site Alteration Permit is required if any archaeological sites or materials are identified during the AIA and the proponent wishes to proceed with construction that overlaps the site in whole or in part. All Heritage Conservation Act Permits (listed above) carry regulatory requirements for the consulting archaeologist and proponent. These include:

- an AIA report (including mapping),
- submission of Site Inventory Forms and site spatial data, analysis, cataloguing, and curation of artifacts, and
- distribution of study results to any interested First Nations.

Acquiring permits from the Archaeology Branch is known to be a time-consuming process and applicants should allow at least 5 months from the time of application to the permit issuance.

The next phase will consist of mitigative work required to manage identified archaeological deposits including acquiring a site alteration permit, conducting the work, and complete regulatory reporting and analysis. This is only required if an archaeological site or sites are encountered. This may require:

- archaeologist-directed monitoring of construction excavation:
- hand-excavation of any intact features or cultural horizons identified during the AIA:
- sampling (through screening and/or raking) of a sample of disturbed site sediments displaced by mechanical excavation:
- detailed mapping of project-related impacts and sampling:
- laboratory analysis, cataloguing, and curation of all artifacts and other cultural materials:
- Regulatory paperwork including a permit report and site information form updates to be submitted to Archaeology Branch.

5.4 Canadian Impact Assessment Act

The Canadian Impact Assessment Act 2019 outlines a process for assessing the impacts of major projects and projects carried out on federal lands or lands outside of Canada. An Impact Assessment is a planning and decision making tool used to assess positive and negative environmental, economic, health, and social effect of proposed projects and impacts to indigenous groups and the rights of indigenous peoples.

This project does not require a legislated Environmental Assessment because it does not result in physical activities associated with a designated project under the Act.

5.5 Riparian Areas Regulation

The BC Riparian Area Regulation applies to commercial, residential or industrial development (or their ancillary activities) within 30 m of the average annual high-water mark of a lake or stream. As the proposed work is an institutional development, the Regulation does not apply to this project.

5.6 Zoning Bylaw

The treatment building works will need to be in compliance with the District's Zoning Bylaw No. 111.

5.7 BC Building Code

The District will require this project to obtain a building permit under the BC Building Code. The BC Building Code sets minimum standards for health, safety, fire and structural protection, accessibility and energy and water efficiency. The Building Code requires Letters of Assurance in specific instances to document the parties responsible for design and field review of construction, and to obtain their professional assurances that the work substantially complies with the requirements of the Building Code, and that the requisite field reviews have been completed.

The following must be submitted to the authority having jurisdiction (District of Barriere) at the relevant stages of the project.

Schedule	**Registered Professionals of Record**
Schedule A – Confirmation of Commitment by Owner and Coordinating Registered Professional	Coordinating Registered Professional
Schedule B – Assurance of Professional Design and Commitment for Field Review & Summary of Design and Field Review Requirements	Geotechnical Engineer Structural Engineer Civil Engineer Electrical Engineer
Schedule C-A – Assurance of Coordination of Professional Field Review	Coordinating Registered Professional
Schedule C-B – Assurance of Professional Field Review and Compliance	Geotechnical Engineer Structural Engineer Civil Engineer Electrical Engineer

6.0 Long Term Water Supply and Treatment Upgrades

A membrane filtration system is proposed for the future surface water treatment system. A membrane system uses a synthetic membrane with pores designed to exclude particles down to a given size. The membranes are housed in modules or may be submerged in tanks. Membrane technology is recommended for the following reasons:

- Protozoa removal is not dependent on achieving optimal raw chemistry.
- Relatively compact size.
- Relative ease of operation (systems can be classified EOCP level 2)
- Often fully automated for unattended operation.
- Membrane integrity can be tested automatically.
- UV disinfection post treatment is not normally required by IHA with membrane systems

The treatment system would comprise parallel independent "trains". The precise capacity depends on the make and model of the individual system and the number of modules fitted.

Because this is a river source without a strong influence from upstream lakes, it may be necessary to pre-treat the water by clarification. Alternatively, a submerged membrane system may be appropriate for the water quality.

Coagulants would be used to allow the filter to remove dissolved materials such as organics. Other related systems inside the water treatment plant building include backwash chemical storage and feed systems, blowers for airwash during the backwash cycle, and backwash pumps.

There is sufficient space available at the shallow well site for the water treatment plant (see Figure 346-141-G1 in Appendix C). Figure 346-141-G1 (Appendix C) illustrates a membrane filtration system package system enclosed in a pre-engineered steel building. Pre-engineered steel buildings are relatively cost effective and functional and are best suited to locations where aesthetics is not a primary design requirement. The proposed site is not a location where a steel building would be out of place aesthetically.

If an additional water source is found to be needed in the future, the District should undertake regular river water sampling and testing in order to establish the specific characteristics of this water source. Pilot testing may also be required to determine the performance of the system.

APPENDIX A

Cost Estimates

BARRIERE WATER TREATMENT PLANT EXPANSION AND GROUND WATER SUPPLY WELLS
COST ESTIMATE - CLASS "D"

	DESIGN CRITERIA					
	Design Flow:				L/s	USgpm
	Well#3 (Assumed)				60	951
	Well#4 (assumed)				60	951
ITEM		**UNIT**	**EST.**		**UNIT**	**ESTIMATE**
NO.	**DESCRIPTION**		**QUANT.**		**PRICE**	
1.0	**General**					
	Insurance and Bonding	allow				$35,000
	Mobilization	allow				$20,000
	Restoration and Demobilization	allow				$15,000
	Treatment Plant Commissioning	allow				$10,000
	Subtotal Part 1.0					**$80,000**
2.0	**Production Well#3 (Assumed 250mm Well x 50m)**					
	Well Drilling and Flow Test c/w Steel Casing and Well Screen	allow				$250,000
	Assumed 150HP Submersible Pump and Motor	allow				$45,000
	Stainless Steel SCH40, 304 L Riser Pipe & Check Valve	allow				$35,000
	Pitless Adapter Unit (NSF-61)	allow				$40,000
	Power Cable and Junction Box	allow				$10,000
	Level Sensor and Signal Cable	allow				$5,000
	Reinstall Surface Seal	allow				$5,000
	Subtotal Part 2.0					**$390,000**
3.0	**Production Well#4 (Assumed 250mm Well x 70m)**					
	Well Drilling and Flow Test c/w Steel Casing and Well Screen	allow				$265,000
	Assumed 150HP Submersible Pump	allow				$45,000
	Stainless Steel SCH40, 304 Riser Pipe & Check Valve	allow				$35,000
	Pitless Adapter Unit (NSF-61)	allow				$40,000
	Power Cables and Junction Box	allow				$10,000
	Level Sensor and Signal Cable	allow				$5,000
	Reinstall Surface Seal	allow				$5,000
	Subtotal Part 3.0					**$405,000**
4.0	**Existing Manganese Removal System Modifications**					
	Total Filtration Flow Capacity: 600 USgpm, 150 USgpm per Filter					
	Backwash Supply with Non-Chlorinated Well Water					
	Convert Four (4) Steel Pressure Filters to Biological Filtration,					
	Filter Media, Underdrains, Air Actuators For Existing Filter Valves,					
	Instrumentation, Dual Air Compressors, Receiving Tank, Refrigerant					
	Dryer, PLC Control Panel, Programming and Controls, Site Installation					
	Supervision, Start-up and Training, Process Guarantees and Support					
	Transportation of Equipment to Site (FOB)					**$250,000**
	Modify Existing WTP Inlet and Outlet Piping and Valves					**$40,000**
	Subtotal Part 4.0					**$290,000**

BARRIERE WATER TREATMENT PLANT EXPANSION AND GROUND WATER SUPPLY WELLS COST ESTIMATE - CLASS "D"

5.0	**Manganese Removal System**				
	Total Filtration Flow Capacity: 600 USgpm, 300 USgpm per Filter				
	Backwash Supply with Non-Chlorinated Well Water				
	Two Biological Manganese Steel Pressure Filters, Filter Media,				
	Underdrains, PLC, Controls, Valves, Instrumentation,				
	O&M Manuals, Air Scour Blower and (2) Air Compressor, Flowmeter,				
	Sample Sink, Stainless Steel Interconnect Piping, Static Mixers,				
	Site Installation Supervision, Start-up and Training, Process				
	Guarantees and Support, Transportation of Equipment to Site (FOB)				
	Subtotal Part 5.0				**$500,000**
6.0	**Water Treatment Plant Expansion Foundation (Post-Disaster Design)**				
	Foundation Excavation	m³	325	$25	$8,125
	Foundation Backfill	m³	245	$25	$6,125
	Foundation Subbase Crush	m³	20	$100	$2,000
	Excavation Disposal	m³	80	$30	$2,400
	Cast-in-Place Concrete Building Foundation and Door Pads	m³	40	$2,000	$80,000
	Roll-up Door Bollards	ea	2	$1,000	$2,000
	Subtotal Part 6.0				**$100,650**
7.0	**Water Treatment Plant Expansion Building Structure (Post-Disaster Design)**				
	Precast Concrete Building Structure	allow			$150,000
	Wall and Ceiling Panels Painting	m²	350	$25	$8,750
	Epoxy Paint on Floor slab	m²	100	$100	$10,000
	Overhead Roll Up Door (10ft wide x 12ft high)	allow			$25,000
	Exterior Hollow Metal Insulated Door (3ft x 7ft)	ea	1	$3,500	$3,500
	Exterior Double Hollow Metal Insulated Door (6ft x 7ft)	ea	1	$5,000	$5,000
	Interior Metal Door /w window (3ft x 7ft)	ea	1	$3,000	$3,000
	Chemical Room Windows (8ft x 4ft)	ea	1	$1,500	$1,500
	Building Heating, Ventilation, Fans, Louvers and Dampers	allow			$50,000
	Building Plumbing c/w hot water tank, PRV, BFP, etc	allow			$30,000
	Chlorination Room Drainage Sump Grating	allow			$5,000
	Existing Building Roof Modifications	allow			$15,000
	Subtotal Part 7.0				**$306,750**
8.0	**Chlorination Room**				
	Chemical feed Pump Skid - 12.5% Sodium Hypochlorite c/w	LS	1	$50,000	$50,000
	Storage Tank, Level Transmitter, Float Switch				
	Chemical Transfer Pump	ea	1	$3,500	$3,500
	SCH80 PVC Process Piping, Valves, Fittings and Pipe Supports	allow			$6,000
	Safety Shower, Tempered Valve and Alarm with Flashing Light	allow			$15,000
	Dual Containment Piping w/ pipe supports	m			$5,000
	Static Mixer and Chemical Injection Quill	allow			$2,500
	Chemical Sump High Level Float Switch	ea	1	$1,500	$1,500
	Subtotal Part 8.0				**$83,500**

BARRIERE WATER TREATMENT PLANT EXPANSION AND GROUND WATER SUPPLY WELLS COST ESTIMATE - CLASS "D"

9.0	**Emergency Diesel Generator**		
	350kW Standby Power Rating at 1800 RPM, 600V, 3PH, 60HZ		
	Air Inlet System, Control System, Sound Enclosure, Cooling/Heating		
	System, Exhaust System, Fuel System (24 hours/900 Gallon fuel tank),		
	Generator, Circuit Breaker, Governing System, Lube System, Monitoring		
	System, Starting/Charging System, Testing and Commmissioing	allow	$150,000
	Subtotal Part 9.0		**$150,000**
10.0	**Manganese Removal System (Off-loading and Installation)**		
	TREATMENT PRESSURE FILTERS - INSTALL ONLY		
	Off-loading with Crane, Place 2 Filters, Anchor and Grout	allow	$10,000
	8 filter support pads		
	TREATMENT PROCESS PIPING & EQUIPMENT - INSTALL ONLY		$30,000
	Raw Water - Sch10 / 40, 304L SS, Filter Water - Sch10, 304LSS		
	BWS, BWW, FTW, DD, DR, V Piping - Sch10 / 40, 304L SS		
	Air Scour Piping - Sch10, 304L SS, Instrument & Process		
	Air SS Tubing, Pipe Couplings, Pipe Supports, etc…		
	TREATMENT PROCESS EQUIPMENT - INSTALLATION ONLY	allow	$30,000
	Butterfly Isolation Valves, Pneumatic Butterfly Valves		
	Flowmeter, Pressure Transmitters, Pressure Gauges, Static Mixer,		
	Sample Lines and Valves, Sample Sink, Air Valves, Pressure		
	Safety Valve, Check Valves, Ball Valves, Pipe Supports etc..		
	AIR SCOUR SYSTEM - INSTALLATION ONLY	allow	$5,000
	Install blower on concrete pad		
	Butterfly Valve, Flow Switch Low		
	AIR COMPRESSOR SYSTEM - INSTALLATION ONLY		
	Two vertical air compressors on concrete pad	allow	$10,000
	Refrigerant Dryer w/ isolation valves and wall supports, SS Isolation		
	Ball Valves, Flow Indicator, Solenoid Ball Valves, Check Valve		
	Subtotal Part 10.0		**$85,000**
11.0	**Electrical, SCADA and Controls**		
	BC Hydro Charges	allow	$50,000
	Electrical Service (600V, 3 ph, new secondary from existing pole)	allow	$15,000
	Remove and dispose existing electrical	allow	$20,000
	MCP c/w 150hp VFD drives, control panel, ltg panel, transformer	allow	$120,000
	Antenna Mast and Radio	allow	$5,000
	Treatment Plant / Building Electrical	allow	$35,000
	Building Electrical (Lights/Power)	allow	$15,000
	SCADA Hardware and Programming	allow	$25,000
	Supply Wells Electrical and Instrumentation	allow	$10,000
	Automatic Transfer Switch	allow	$20,000
	Water Treatment Plant Computer System	allow	$3,000
	Subtotal Part 11.0		**$318,000**

BARRIERE WATER TREATMENT PLANT EXPANSION AND GROUND WATER SUPPLY WELLS COST ESTIMATE - CLASS "D"

12.0	**Well#3 Supply Piping**					
	250mm (DR18) C900 PVC	l.m.	48		$500	$24,000
	250mm Gate Valves	ea.	1		$3,000	$3,000
	250mm Bends	ea.	2		$1,000	$2,000
	250mm Pipe Coupling and Uni-flange Restraint w/ Tie-rods	ea.	3		$500	$1,500
	Pressure Test	ea.	1		$1,000	$1,000
	Subtotal Part 12.0					**$31,500**
13.0	**Well#4 Supply Piping**					
	250mm (DR18) C900 PVC	l.m.	48		$500	$24,000
	250mm Gate Valves	ea.	1		$3,000	$3,000
	250mm Bends	ea.	2		$1,000	$2,000
	250mm Pipe Coupling and Uni-flange Restraint w/ Tie-rods	ea.	2		$500	$1,000
	Pressure Test	ea.	1		$1,000	$1,000
	Subtotal Part 13.0					**$31,000**
14.0	**Backwash Water Seepage Ponds - Supply Piping**					
	150mm (DR25) C900 PVC	l.m.	18		$350	$6,300
	1050mm Drainage Manhole	ea.	3		$7,500	$22,500
	150mm SCH40 Steel Pipe (underslab drain)	ea.	2		$5,000	$10,000
	Tie-in to existing Distribution Manholes	ea.	2		$3,500	$7,000
	150mm SCH40 Steel Pipe (distribution manhole connection)	ea.	2		$5,000	$10,000
	Subtotal Part 14.0					**$55,800**
15.0	**Chlorine Contact Piping**					
	600mm (DR18) C905 PVC					
	250mm Gate Valves					
	600mm Bends and Reducers					
	Pipe Coupling and Uni-flange Restraint w/ Tie-rods					
	Disinfect, Pressure Test, and Sample	allow				$150,000
	Subtotal Part 15.0					**$150,000**
	Cost Estimate Summary					
					Subtotal	**$2,977,200**
		Engineering - Allow (15%)				$446,580
		Contingencies - Allow (15%)				$446,580
			TOTAL PROJECT			**$3,870,360**

APPENDIX B

Western Water Technical Memo

western water ASSOCIATES LTD
Consultants in Hydrogeology and Water Resources Management

Technical Memorandum

Date:	19 October 2020
File:	20-105-01VR
To:	Dave Underwood, P.Eng., TRUE
From:	Doug Geller, M.Sc.,P.Geo., Western Water
Subject	**DISTRICT OF BARRIERE GROUNDWATER SUPPLIES**

INTRODUCTION

We understand TRUE Consulting is assisting the District of Barriere (DoB) with a pending grant application to undertake water system improvements at the existing production well site located at Spruce Crescent in Barriere. This location currently contains a well pump house and two production wells, DW1 and DW2, which were built in the 1990s. TRUE has undertaken a preliminary assessment of infrastructure needs to upgrade this facility and the summary recommended program is as follows:

- Install two new supply wells at Spruce Crescent (DW1 replacement and DW2 replacement)
    - Target water supply of at least 500 USgpm per well
    - Target water quality: elevated iron (over AO), elevated manganese (over MAC), GARP classification (worst case scenario)
- Refurbish existing treatment plant to achieve 500 USgpm treatment capacity for iron and manganese
- Construct addition to existing treatment plant to achieve AN ADDITIONAL 500 USgpm treatment capacity for iron and manganese
- Construct a chlorination room in treatment plant addition
- Construct UV disinfection in the treatment plant addition (only needed if wells are classified as GARP)
- Construct a contact chamber and high lift pumping system

The remainder of this brief technical memo discusses the approach to the well installation program and related hydrogeological work programs including planning level cost estimates for installing the new wells, test pumped, and ready for completion of well site improvements (well pumps, power supply, and connection to existing and planned infrastructure).

WELLS AND LOCAL AQUIFER DESCRIPTION

The table below summarizes the main information about the wells as provided in a 1997 report by Kala and a 1994 report by Seacor for DW1.

Table 1: Summary information for DW1 and DW2

Well #	Ministry Plate #	Completed depth (ft / m)	Casing diameter	Screen interval (ft / m)	Yield (US gpm / L/s)	Year Drilled
DW1		232.4 / 70.9	12 inch	200.9 – 232.4 / 61.2-70.9	700 / 44	1993
DW2		158 / 48.2	10 inch	138-158 / 42.1 – 48.2	~800 / 50	1997?

Sources of information: Kala (1997), Seacor (1994) and TRUE drawings 346-042-21 and 346-091-01

Local aquifers mapped in the Barriere area include Aquifers 293 and 294. Both of these aquifers are classified by the Ministry as relatively shallow, mostly unconfined aquifers. Aquifer factsheets for 293 and 294 are attached to this memo. From a brief review of this Ministry information it is possible that DW1 and DW2 are completed in a deeper zone of Aquifer 294. This aquifer is classified as having moderate productivity, moderate vulnerability with relatively low demand (low aquifer stress index). The well log for DW1 (in Seacor 1994) shows a relatively thick layer of grey silty clay overlying the aquifer and a static water level of about 12 m below ground; this suggests the aquifer is confined at this location. Water bearing sand with sand and gravel is noted on the log between depths of about 48 and 62 m; with the lowermost 4 m screened by the well. The driller's log for DW2 has not been located yet but will be reviewed prior to drilling any replacement wells.

The formation in which the wells are screened is described (by Kala) as a "coarse textured gravely sand" with "high transmissivity." These characteristics make the aquifer a good target for developing groundwater. Replacement wells completed in this aquifer have high potential to produce at least 500 US gpm (31.5 L/s) and possibly more. 1990s testing of DW1 and DW2 showed wells capacities at that time were in the range of 600 to 800 US gpm.

WATER QUALITY OF DW1 AND DW2

Recent testing of samples collected from each well confirms that DW2 produces better-quality water than DW1. Although the existing information suggests the wells are completed in the same aquifer, the deep zone within which DW1 is screened appears to be geochemically different than the zone that DW2 produces from. Table 2 below summarizes the most recent data (from October 2015). It is worth noting that DW1 has not normally been operated whereas DW2 has seen nearly continuous operation in recent years. Data we reviewed suggest that the water quality of DW2 has remained stable over time, and that parameters such as manganese, iron and TDS (which are higher in the deeper well) do not seem to be escalating in DW2.

Table 2 Water Quality Summary

		DW1	DW2DW2	
Date		Oct 2015	Oct 2015	
Lab Work Order Number		L1687425	L1687424-1	
Parameter	**Units**			**GCDWQ**
pH (field / lab)	pH units	8.23	8.03	AO = 7 – 10.5
Conductivity lab)	ms/cm	573	372	
General Parameters and Nutrients				
Total Dissolved Solids	mg/L	331	221	AO ≤500
Hardness	mg/L	317	190	
Alkalinity (total)	mg/L`	283	180	
Nitrate, N	mg/L	<0.0050	0.226	MAC =10
Chloride	mg/L	0.63	2.73	AO ≤ 250
Sulfate	mg/L	48.5	20.2	AO ≤ 500
Selected Ions and Metals (total)				
Iron		0.682	<0.030	AO ≤ 0.30
Manganese		0.14	0.0052	AO ≤ 0.02; MAC = 0.12
Sodium		11.6	7.9	AO ≤ 200
Potassium		2.82	1.83	

Notes: GCDWQ = Guidelines for Canadian Drinking Water Quality;
MAC = Maximum Allowable Concentration Exceedances highlighted in orange;
AO = Aesthetic Objective Exceedances highlighted in green;

From the above summary, we see that water from DW1 is more mineralized with TDS, hardness and alkalinity higher than DW2 by a factor of approximately 1.5X. Iron and manganese in DW2 have been below the current AO and MAC (0.02 and 0.12 mg/L) since original testing of the well occurred in the 1990s. Nitrate and chloride are slightly elevated in DW2 compared to DW1 suggesting the shallower portion of the aquifer has received some anthropogenic water quality inputs, but only to a very minor degree as concentrations remain far below Guidelines.

From preliminary discussions with DoB and TRUE, it appears that there may be at least one additional test well located at the Spruce Crescent site. This test well may have been drilled around 2010 under the supervision of B.C. Groundwater Consulting (BCGW) but no further documentation is available.

From a water quality standpoint, it is our opinion that chances are good that a replacement well can be installed to a similar depth of DW2 that produces water of a similar quality and not requiring removal of iron and manganese. Further investigative work will be required in order to confirm this with a reasonable level of confidence; however, based on information available to us now, it seems feasible to develop the shallower aquifer zone that DW2 produces from with the long term prospect of water quality that remains lower in TDS, iron, and manganese than DW1. As noted above, choosing specific replacement well locations at the existing site will need to be done once we have had a chance to review the detailed lithology from all available well driller's reports.

A GARP study should also be done to help determine the level of treatment required. Based on the well depth (screens greater than 40 m deep in a sand formation), the wells would not likely be under direct influence of surface water and would likely be classified as either non-GARP or possibly GARP virus-only water sources. This will be resolved during Phase 1a of the work program as discussed below. The scope of the GARP study can be reviewed with Interior Health prior to implementation.

SUMMARY OF HYDROGEOLOGICAL PROGRAM Phase 1a and 1b

Following a detailed hydrogeological data review (including compilation of well driller's logs and well completion data for all wells at the Spruce Crescent location), and selection of a new well site at the Spruce Crescent property, **Phase 1a** would comprise the installation and testing of the first replacement well (DW3), targeting a similar depth zone for the well screen as in DW2 (approximately 45 to 50 m depth). The location of this well will be determined following additional detailed hydrogeological review and in consultation with the project team. TRUE's preliminary phasing plan (Drawing 346-161-G1) shows DW3 about 25 m north of DW2. Pending further review and a site visit, we would suggest moving the well closer to DW2 (about 6 to 10 m away). The replacement well would be nominal 12-inch (300 mm) diameter for the production casing with a target yield of at least 600 US gpm. Drilling would likely be undertaken with a dual-rotary rig for drilling and casing advancement followed by well development with a cable-tool rig to maximize well efficiency.

Concurrent with the well replacement program, a Level 2 GARP investigation would be undertaken to assess the GARP risk to DW2 and DW3. This would involve an approximate 9-month field sampling program including collecting concurrent surface water and groundwater samples and analyzing samples for conventional drinking water parameters, field parameters and microparticulate analysis (MPA) with supplemental aerobic spore enumeration. The 2017 Ministry of Health GARP Guidelines will be followed in completing this investigation at the end of which we will make a determination of the GARP risk of the wells and review the findings with Interior Health who would make the final decision about treatment / disinfection to be required in the long-term.

Phase 1b of the hydrogeological program would comprise installing the second replacement well (DW4), building on the success and learning from the DW3 program. This portion of the work is subject to pending grant application approval and would be undertaken in a separate effort from the DW3 program.

Once new wells are commissioned, any unused older wells will either be converted to observation wells or properly decommissioned in accordance with the Groundwater Protection Regulation.

COST ESTIMATE FOR NEW WELLS REPLACING DW1 AND DW2

The following table summarizes estimated budgets to complete two new test-production wells. The costs assume the work would be undertaken in different phases. The cost for the first replacement well, as noted, includes the budget for the recommended GARP study. The budgets provided include: well drilling, well development, well test pumping, hydrogeological oversight and reporting. Budgets do not include: site preparation, environmental permitting, archaeology services, installation of permanent pumps and infrastructure to connect new wells to the water system (such costs are estimated separately by TRUE). A suggested budget allowance for future well decommissioning of unused wells is also provided.

Table 3 Well Program Summary Budget Estimates

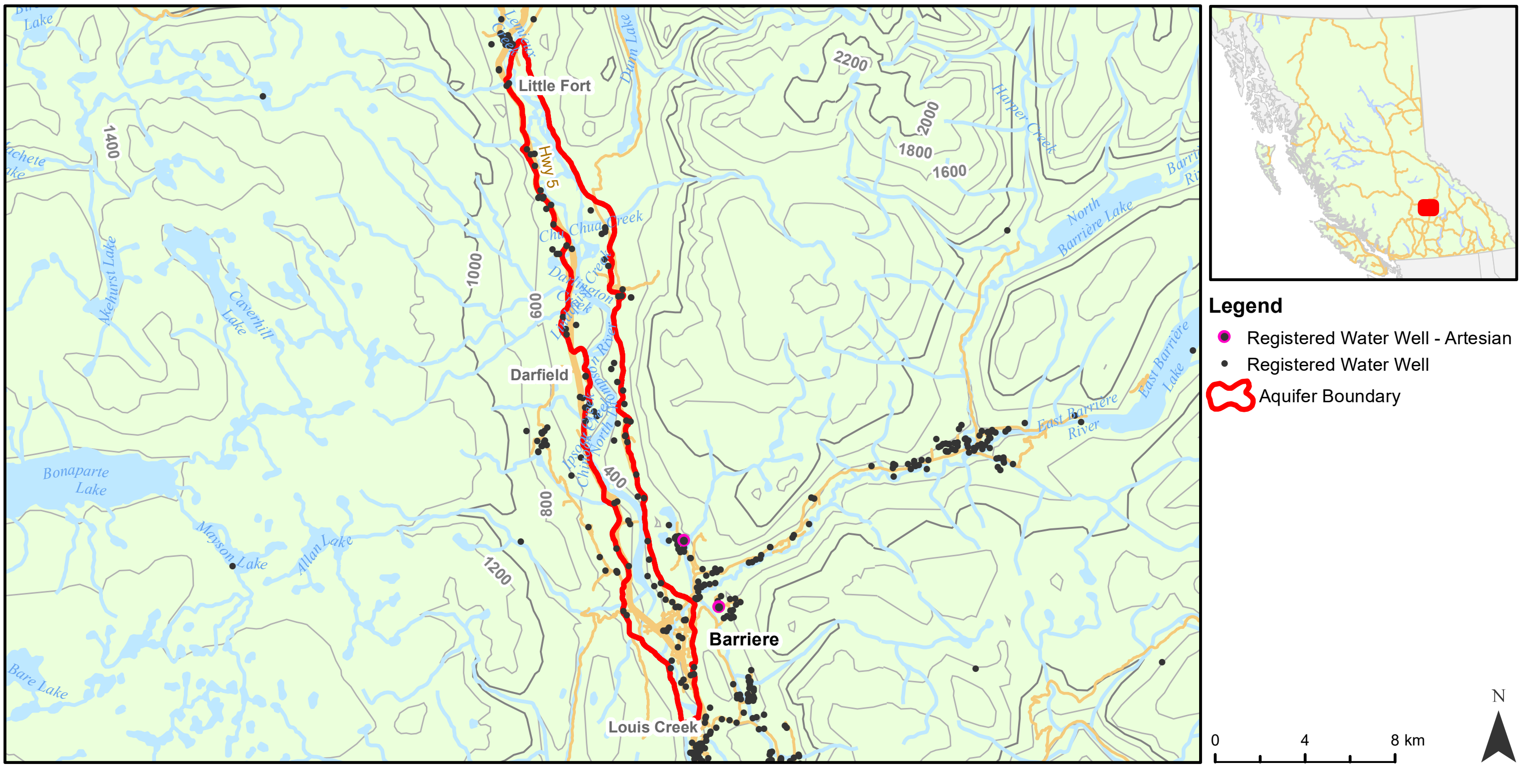
Component	Cost Estimate
Phase 1 a Replacement Well DW3	
Well Drilling, Installation and Development	$130,000
Pumping test (step test and 48 hr test with flows to 40 L/s)	$35,000
Hydrogeology - tendering, oversight, reporting, licensing (WWAL)	$38,000
Phase 1a GARP study (WWAL)	$23,000
Phase 1 a subtotal	$226,000
Phase 1a total with 15% contingency	**$259,900**
Phase 1 b Replacement Well DW4	
Well Drilling, Installation and Development	$130,000
Pumping test (step test and 48 hr test with flows to 40 L/s)	$35,000
Hydrogeology - tendering, oversight, reporting, licensing (WWAL)	$32,000
Phase 1 b subtotal	$197,000
Phase 1b total with 15% contingency	**$226,550**
TOTAL PROGRAM WELL DRILLING AND HYDROGEOLOGY	**$486,450**
Does not include: permanent well pumps, pitless units, power supply, connection to system, archaeology review, environmental permits or site preparation	
Allowance for decommissioning three wells (DW1, DW2 and one test well tbd)	$20,000

REFERENCES

Kala Groundwater Consulting 1997. Barriere Improvement District, Wellhead Protection Assessment, Barriere Deep Wells. Prepared for T.R. Underwood Engineering.

Seacor 1994. Groundwater Supply Development Program – 1994. Production Well PW94-01, Construction Supervision and Evaluation, Barriere Improvement District. Prepared for T.R. Underwood Engineering. (*DW1 completion report)*

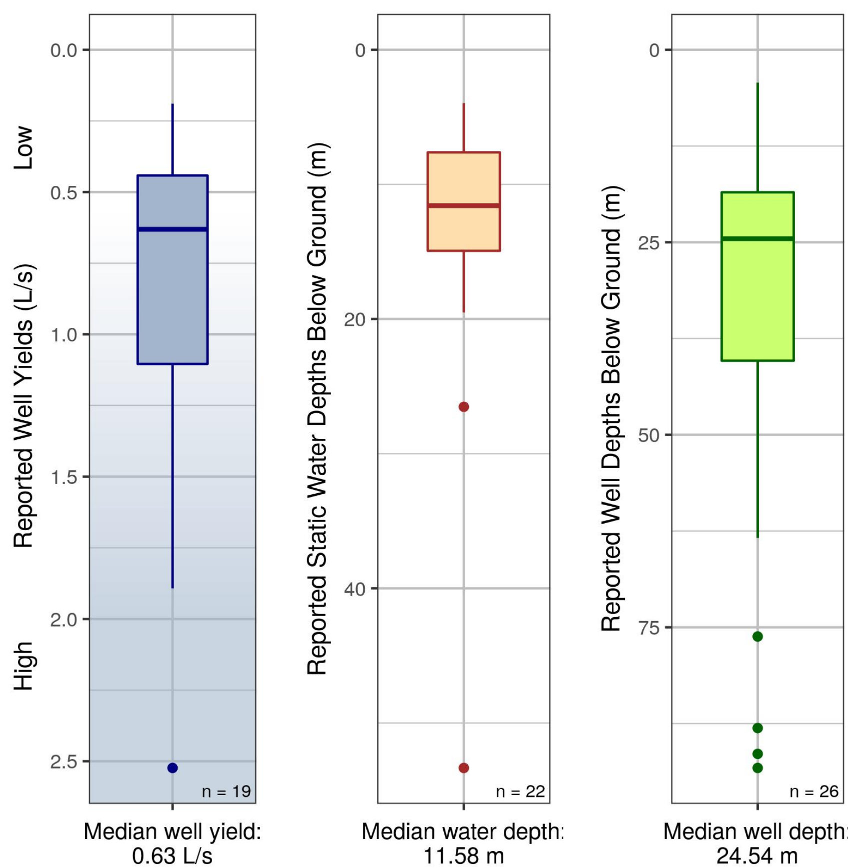
Aquifer #293



Aquifer Description (Mapping Report - 1996): Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along rivers of moderate stream order with the potential to be hydraulically influenced by the river (subtype = 1b).

Aquifer Details	
Region	Thompson-Okanagan
Water District	Kamloops
Aquifer Area	51.6 km^2
No. Wells Correlated to Aquifer	26
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IIIB
Hydraulic Connectivity[1]	Likely
Aquifer Stress Index	Less stressed
No. Water Licences Issued to Wells	1
Observation Wells (**Active**, Inactive)	None

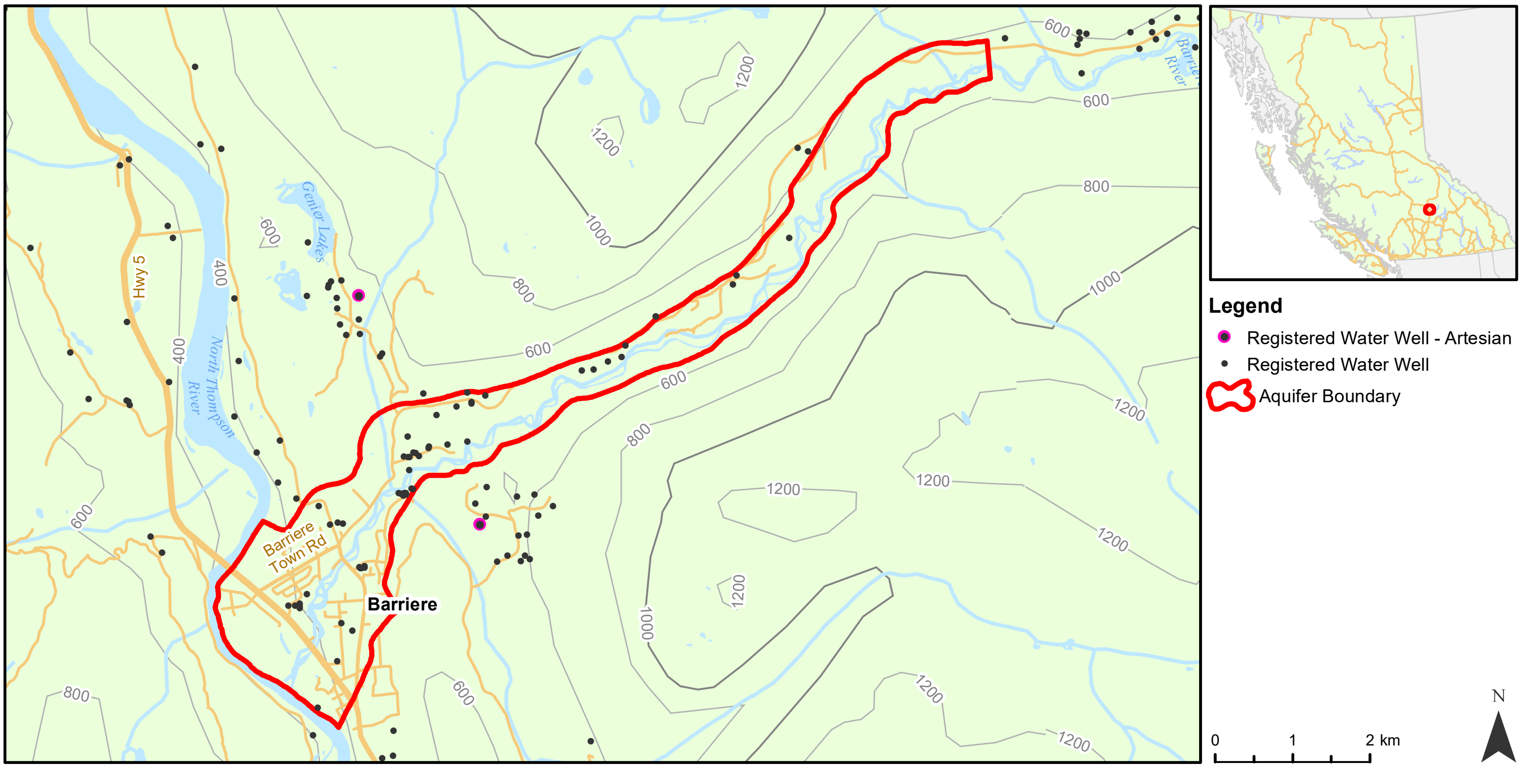
[1] Based on broad regional assessment



Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).

Factsheet generated: 2020-08-06. Aquifers online: https://apps.nrs.gov.bc.ca/gwells/aquifers.

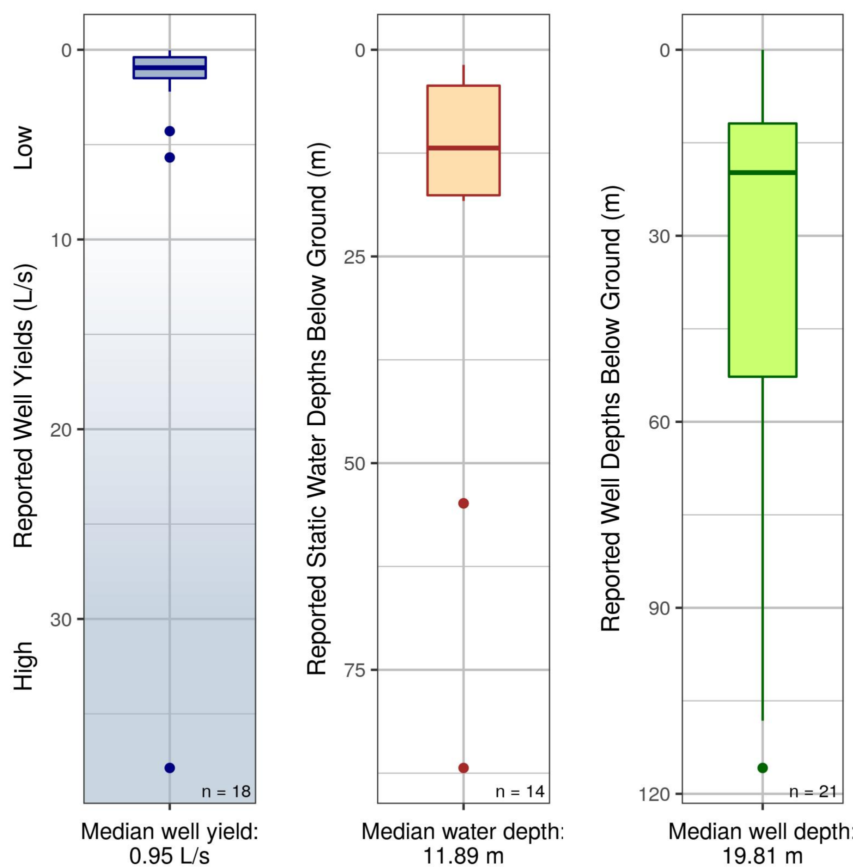
Aquifer #294



Aquifer Description (Mapping Report - 1996): Predominantly unconfined fluvial or glacio-fluvial sand and gravel Aquifers found along lower order (< 3-4) streams in confined valleys with relatively undeveloped floodplains, where aquifer thickness and lateral extent are more limited (subtype = 1c).

Aquifer Details	
Region	Thompson-Okanagan
Water District	Kamloops
Aquifer Area	11.7 km^2
No. Wells Correlated to Aquifer	21
Vulnerability to Contamination	Moderate
Productivity	Moderate
Aquifer Classification	IIIB
Hydraulic Connectivity[1]	Likely
Aquifer Stress Index	Less stressed
No. Water Licences Issued to Wells	Unknown
Observation Wells (**Active**, Inactive)	None

[1] Based on broad regional assessment



Detailed methods for all figures are described in the companion document (Aquifer Factsheet - Companion Document.pdf).

Factsheet generated: 2020-08-06. Aquifers online: https://apps.nrs.gov.bc.ca/gwells/aquifers.

APPENDIX C

Preliminary Design Drawings

PHASING LEGEND

PHASE 1

PHASE 2

NOTE:
LOCATION OF PROPOSED BUILDINGS AND WELLS ARE FOR DEMONSTRATION ONLY

No.	DATE	DESCRIPTION	BY	APP'D
2	OCT 14/20	NOTED CEILING HEIGHT	DH	DU
1	OCT 14/20	ISSUED FOR CLIENT INFORMATION	DH	DU

ISSUES / REVISIONS

CONSULTANT SEAL

TRUE CONSULTING
201 - 2079 Falcon Road ▪ Kamloops BC ▪ V2C 4J2
tel 250.828.0881 ▪ fax 250.828.0717
info@TRUE.bc.ca

DISTRICT OF BARRIERE

WATER TREATMENT AND SUPPLY WELLS

PROPOSED PHASING PLAN

SCALE	1:150 (24x36)
DESIGN BY	DH
DRAWN BY	DL
DATE	14 OCT 2020
PROJECT REFERENCE No.	346-141
DRAWING No.	346-141-G1
SHEET	1 OF 1
ISSUE/REV.	2

FILE: r:\clients\300-399\346\346-141\spruce crescent wtp expansion & wells\03 drawings\cad\design\dn-346-141-g1

western water ASSOCIATES
Consultants in Hydrogeology and Water Resources Management

DW2 & DW3, Spruce Crescent Water System, Barriere, BC
Stage 2 GARP Assessment

Prepared for:

District of Barriere
4936 Barriere Town Road
Barriere, B.C.

and

True Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

THE DISTRICT OF BARRIERE
grow with us

TRUE

October 2021
Project: 20-105-03VR

western water ASSOCIATES
Consultants in Hydrogeology and Water Resources Management

November 25, 2021

TRUE Consulting
201 – 2079 Falcon Road
Kamloops, B.C.

Re: Stage 2 GARP Assessment: DW2 & DW3, Spruce Crescent Well Field, District of Barriere, B.C.

Western Water Associates Ltd. was retained to conduct a Stage 2 GARP assessment for DW2 & DW3 at the Spruce Crescent Well Field, located in the District of Barriere, B.C.

DW2 and DW3 are located in close proximity (~5 m apart) and extend to depths of 48.1 m (158 ft) and 45.1 m (148 ft) respectively. The wells are installed in what is interpreted to be a confined/semi-confined sand and gravel aquifer, with a confining unit composed of silt/clay that measures 23 m (75 ft) in thickness at a minimum. DW3 was installed in the spring of 2021 and has yet to be put into operation. As a result, sampling data was collected exclusively from DW2 throughout our assessment. Given the proximity and similar construction of the two wells, we infer that the findings of this GARP assessment are suitable to also encompass the future operation of DW3.

We trust that the professional opinions and advice presented in this document are sufficient for your current requirements. Should you have any questions, or if we can be of further assistance in this matter, please contact the undersigned.

WESTERN WATER ASSOCIATES LTD.

25-11-2021

PROFESSIONAL
PROVINCE OF
P. A. WILLIAMSON
52128
BRITISH COLUMBIA
GEOSCIENTIST

Paul Williamson, M.Sc., P.Geo.
Hydrogeologist

Reviewed by:

Douglas Geller, M.Sc., P.Geo., FGC
Principal Hydrogeologist

TABLE OF CONTENTS

List of Figures (within text)

List of Figures (following text)

List of Tables

List of Appendices

1. INTRODUCTION

This report presents the results of Western Water Associates Ltd.'s (WWAL) assessment of the District of Barriere (DoB) Spruce Crescent water system (DW2 and DW3) for the potential to be considered groundwater at risk of containing pathogens (GARP). The District and its engineering consultant TRUE Consulting (TRUE) requested that we undertake this work in order to fulfill a condition on the municipality's drinking water system operating permit with Interior Health (IH).

1.1 Assessment Framework: BC GUDI-GARP Guidelines

DW2 and DW3 were assessed using the criteria outlined in the *Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) (Ministry of Health, September 2017)*. This guidance document is the third version released by the Ministry of Health and has evolved through several draft versions, which have been reviewed and commented on by regulatory agencies and groundwater professionals in the province.

Our assessment also included elements of the Ontario GUDI Guidelines (2001), a widely used tool used for Groundwater under Direct Influence of Surface Water (GUDI) screening, as well as elements of U.S. Environmental Protection Agency (EPA) guidance documents, on which the B.C. Guidance is largely based. Professional practice guidelines outlined by Engineers and Geoscientists (EGBC) in the document entitled *Assessment of Groundwater at Risk of Containing Pathogens (GARP)* were also considered.

1.1.1 Definitions

The BC guidance document uses the U.S. EPA's (1999) definition for GUDI, which is "any water beneath the surface of the ground with:

a) significant occurrence of insects or other macro-organisms, algae, organic debris or large-diameter pathogens such as *Giardia lamblia, Cryptosporidium,* or

b) significant and relatively rapid shifts in water characteristics such as turbidity, temperature, conductivity, or pH, which closely correlate to climatological or surface water conditions."

Although some groundwater supply sources may be hydraulically connected to surface water, the potential threat to human health only exists where conditions allow microbial pathogens to freely travel from surface water to the groundwater source (i.e., subsurface filtration of surface water is incomplete/inadequate). If a groundwater source is determined to be GUDI, the water must be treated to the same level as surface water with respect to pathogen removal and inactivation. The GUDI potential of a well source is determined by a professional hydrogeologist who applies professional judgment on a case-by-case basis.

The BC guidance document defines GARP as "any groundwater source that is likely to be contaminated from any sources of human disease-causing microorganisms (pathogens) including various types of bacteria, viruses and protozoa. Contamination may be continuous or intermittent". Potential sources of pathogens to groundwater may include sewage effluent discharge to land, agricultural waste stockpiles and surface water that is hydraulically connected to groundwater.

There is some overlap between the definitions of GARP and GUDI, which may lead to misinterpretation. GARP is a more encompassing definition that considers any possible source of microbiological contamination. GUDI should be considered a potential risk contributing to a well's GARP determination. It is possible for a well to not be considered GUDI, while being classified as GARP. For example, a well located a great distance from any surface water sources that is installed in an unconfined aquifer near a community wastewater dispersal field could be considered GARP but not GUDI.

1.2 Objectives

This project is intended to support the District of Barriere with long-term planning and decision making for the Spruce Crescent water system, as well as fulfilling its condition on permit. GARP assessments are key considerations in determining if treatment of groundwater supplies is required and, if so, to what degree. True groundwater sources found to be neither GUDI nor GARP may not require any water treatment, while sources with a higher risk of containing pathogens, surface water related or otherwise, typically require one or more forms of treatment to address the potential risk to human health.

The main objective of this study was to compile and collect the information necessary to assess the GARP status of wells DW2 and DW3 from the Spruce Crescent well field. Specifically, it was the intent of this study to classify the wells as either:

I. **GARP** – If one or more identified hazards pose an obvious risk of pathogenic contamination.
II. **GARP-viruses only** – If the source is only at risk of containing viruses but not at risk for large diameter pathogens associated with surface water (*Giardia* and *Cryptosporidium*).
III. **Low Risk** – The source has a low risk of containing pathogens ("secure groundwater").

2. WATER SYSTEM BACKGROUND AND OPERATION

The District of Barriere is located approximately 60 km north of Kamloops, at the confluence of the Barriere River and North Thompson River (Figure 1). The District provides water to approximately 780 residential and 75 commercial connections (DoB, 2020). At present, the District maintains two active well fields within the community: Spruce Crescent and Bradford Park. The District previously maintained a third well field containing two shallow wells that was taken offline in 2017 due to its GARP designation. The focus of this study is exclusively on DW2 and DW3 from the Spruce Crescent well field. DW1, the original well installed at Spruce Crescent, is currently offline and tentatively scheduled to be replaced. Select construction details of the three Spruce Crescent wells are provided in Table 2-1 below and well schematics are presented in Appendix A.

Table 2-1 Select Construction Details for the Spruce Crescent Supply Wells

Well Name	DW1	DW2	DW3
Well Plate Identification	12701	12702	40541
Well Tag Number	-	-	123551
Date Drilled	1994	1997	2021
Diameter	12-inch	8-inch	12-inch
Total Depth	230 ft	158 ft	148 ft
Screen Open Length	31.5 ft	20 ft	14 ft

Well Name	DW1	DW2	DW3
Screen Design	60 slot (196.5 to 228 ft)	100 slot (138 to 158 ft)	100 slot (133 to 147 ft)
Estimated Well Yield	45 L/s / 713 US gpm	63.1 L/s / 1000 US gpm	44.2 L/s / 700 US gpm

Notes: All depths given below ground; Well Plate Identification = the number on the metal identification plate attached to the well; Well Tag Number = the MFLNRORD unique database ID number for a given well

A fourth well, TW1, is also located on the Spruce Crescent site. Specific details surrounding this well's construction (e.g., well screen size and location) could not be located. However, the field measured depth of ~201 ft matches that of a written description of the well found in the DW1 completion report (SEACOR, 1994). Although the well is more than 40 ft deeper than DW2, our field observations indicate the wells have similar depths to water, and field testing demonstrated that pumping in DW2 and DW3 induced drawdown in TW1. Based on this, a transducer was installed in this well, as a means for measuring water levels in the aquifer over the duration of the GARP assessment.

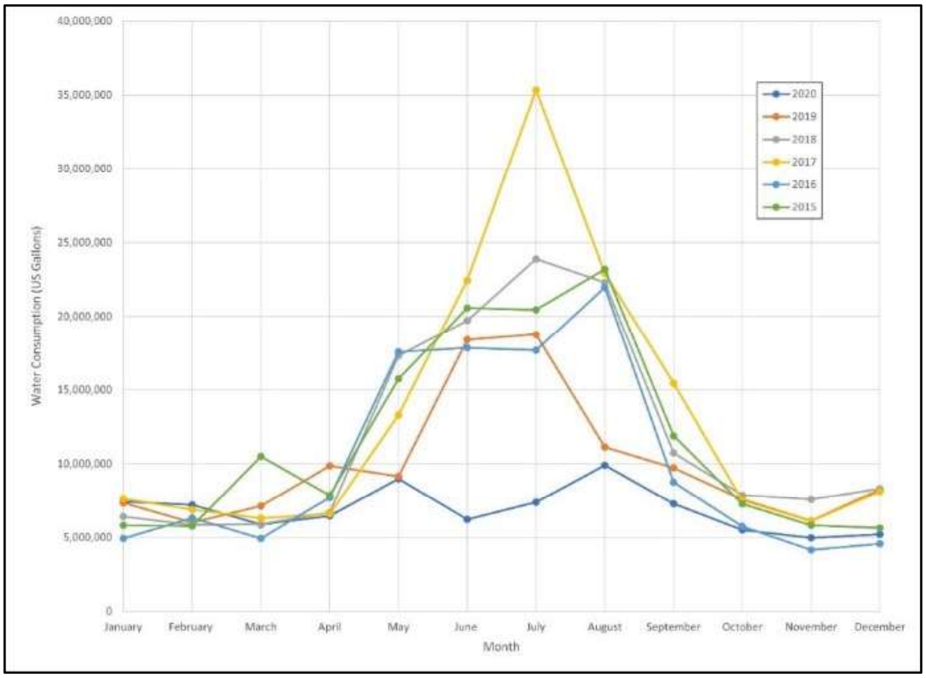
Over the last several years, the District has encountered elevated levels of iron and manganese in DW1, and a failure in the one of the well's filtration units limits production to a maximum flow rate of 28 L/s (400 US gpm) (DoB, 2020). Additionally, the Bradford Park well field is only used as an emergency backup due to consistent aesthetic water quality concerns and a limited maximum production rate (12 L/s /190 US gpm). As a result, the District has relied heavily on DW2 to meet the community's water demand in recent years. In the spring of 2021, DW3 was constructed at the site to address the lack of redundancy in the Spruce Crescent water system.

A large portion of the Stage 2 GARP assessment occurred at the same time as the construction of DW3, and the new well has yet to be incorporated into the water system. As a result, our assessment focused on DW2 (as its operation enabled us to conduct multiple rounds of sampling) and the Barriere River, which is located approximately 35 m from the well. Since DW3 is located in close proximity (5 m) and at a similar depth to DW2, we infer that the findings of this GARP assessment should be extended to encompass the future operation of DW3.

During testing of DW3, the well experienced persistent turbidity issues upon start up that eventually cleared after continued pumping. From a GARP perspective, turbidity in surface water can be the result of soil particles, organic matter, human waste discharge or potentially pathogens. If a connection to groundwater is established, infiltrating surface water can represent a risk to the water source containing pathogens. In the case of DW3 however, the source of turbidity is related exclusively to the aquifer formation, where a higher than typically silt content was discovered. We anticipate that once DW3 is placed into operation and continuously pumped, the turbidity issue will eventually be resolved.

As shown in Figure 2-1 below, the annual pattern in consumption for the DoB is typical of most domestic water systems in BC: low consumption during the late fall and winter, peak consumption in June, July and August. Total water demand for the Barriere community has steadily declined since 2017 (Table 2-2). This reduction is largely related to the District's implementation of water metering and billing throughout the community in 2019. Water restrictions related to lawn watering were implemented in 2020, which also lead to a further decrease.

Figure 2-1 District of Barriere Monthly Water Consumption (2015 – 2020)



Source: DoB, 2021

Table 2-2 District of Barriere Annual Water Consumption (2015-2020)

Year	Total Water Consumption (US Gallons)
2020	82,478,189
2019	119,537,215
2018	145,826,200
2017	158,865,845
2016	122,206,199
2015	142,223,460

3. SITE DESCRIPTION AND HYDROGEOLOGIC SETTING

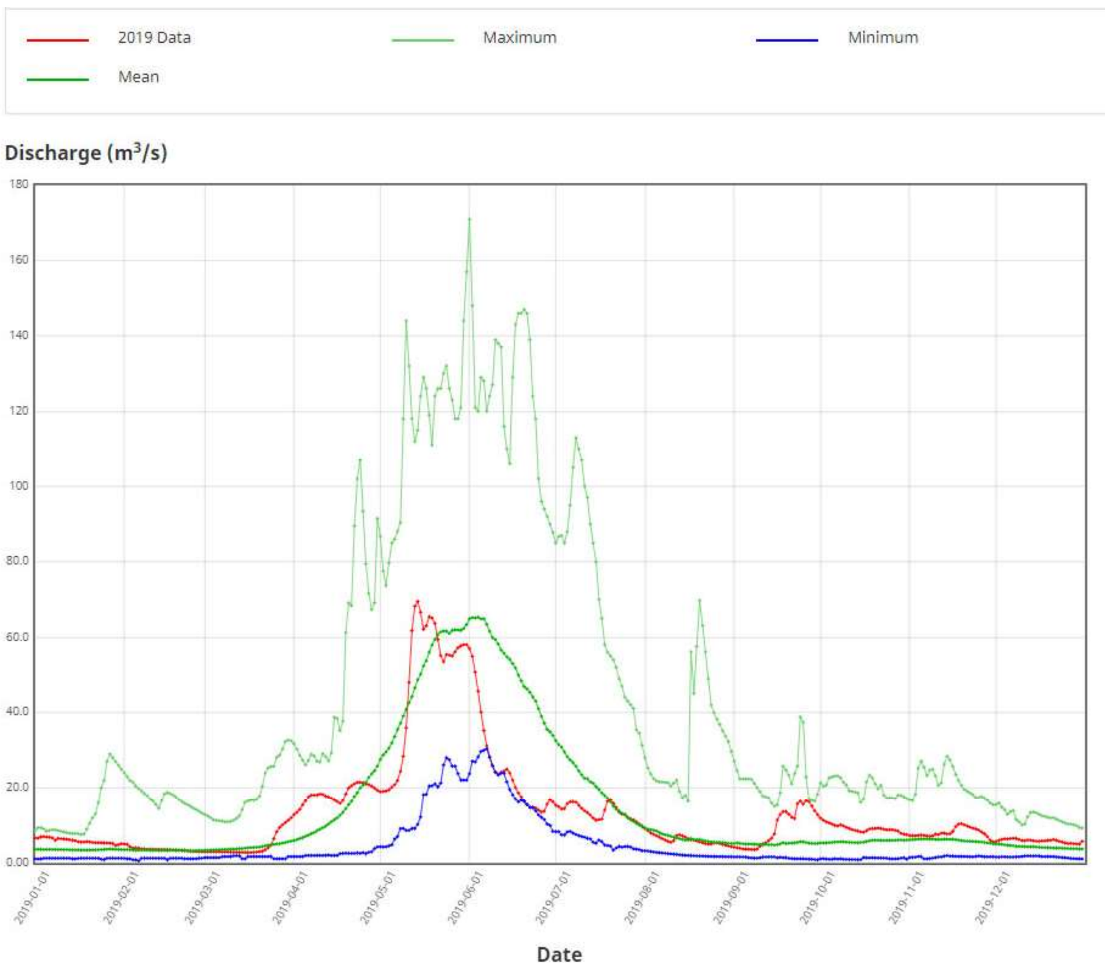
3.1 Physiography and Climate

The community of Barriere is located in the Shuswap highlands, on the large alluvial fan/deltaic complex associated with the ingress of Barriere River into North Thompson River. Local relief ranges from the North Thompson River to the west at an elevation of 373 m above sea level (asl) up to Barriere mountain to the east at an elevation of 1283 m asl. The Spruce Crescent well field is located on the southern banks of Barriere River, near the eastern edge of the community (Figure 2). The property is on level ground in a predominately residential area at an elevation of 388 m asl.

The Barriere River flows to the southwest and passes the DW2 and DW3 at an approximate distance of 35 m before entering North Thompson River 2.3 km from the site. The North Thompson then flows south before joining the Thompson River in the Kamloops area. Dixon Creek, which captures water from the highlands to the southeast, joins the Barriere River approximately 700 m to the northeast of the site. Several unnamed tributaries of Barriere River are also located upstream of the Spruce Crescent well field.

The Water Survey of Canada maintains a hydrometric station on Barriere River at the Barriere Town Road bridge, approximately 550 m downstream of the site. Figure 3-1 below presents a hydrograph of Barriere River that illustrates its freshet dominated discharge regime. Water levels typically begin to rise in early April in response to snowmelt, with peak levels occurring in late May or early June. Flows subsequently decline steadily towards baseflow levels in August or September.

Figure 3-1 Barriere River Discharge Hydrograph at Station 08LB020



Climate Normal data from the McLure climate station (ID 1165030) are summarized below. This station is approximately 15 km southwest of the project site at an elevation of 381 m asl, which is in the same range as the well site. The data indicate an average annual precipitation from a combination of rain and snowfall of 487 mm. Precipitation remains relatively consistent throughout the year, with peaks occurring in late spring/early summer and the late fall, and the driest period occurring in the late winter. The daily average air temperature is 7.7 degrees, with July and August typically the warmest months and December and January the coldest. Note that past climate data are not necessarily indicative of the future climate.

Table 3-1 Climate Normal Data 1981-2010 for McLure Station, ID 1165030

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	11.7	14.0	23.8	30.9	43.3	55.0	46.7	39.7	40.5	39.6	35.1	10.1	390.3
Snowfall (cm)	26.2	9.4	4.6	0.4	0.2	0.0	0.0	0.0	0.0	0.9	17.9	36.8	96.2
Precipitation (mm)	37.9	23.4	28.4	31.2	43.5	55.0	46.7	39.7	40.5	40.4	53.0	46.8	486.5
Daily Average (°C)	-4.5	-1.7	3.8	9.0	13.1	16.9	19.7	19.6	14.2	6.9	0.5	-4.5	7.7

3.2 Hydrogeologic Setting

Surficial geology mapping of the area (Paulen et al., 1998) indicates the surficial unit beneath the project site is characterized as fluvial plain deposits that include well sorted sand, gravel and over bank silt in post-Fraser glaciation floodplains, terraces and/or fans.

Bedrock mapping indicates the site overlies the boundary of two adjoining assemblages. The first is the metamorphic rocks of the Eagle Bay Assemblage that date back to 400 to 500 million years before present. The second is basaltic volcanic rocks of the Fennell Assemblage dated to 200 to 300 million years before present.

Provincial mapping identifies two aquifers that underlie the site: 1) Aquifer 293 III B, which extends north-south from the community of Little Fort to Barriere and remains in close proximity to the banks of the North Thompson River in the east-west direction, and 2) Aquifer 294 III B, which follows the banks of the Barriere River and extends from the community of Barriere to approximately 12 km upstream. Both aquifers are characterized as mostly unconfined sand and gravel units with low demand, moderate productivity and moderate vulnerability to contamination.

Attached Figure 2 displays transect A-A' and Figure 3 displays a cross section from this transect that we developed by interpreting available well logs from the area. The cross section indicates there are potentially multiple unmapped aquifers in the Barriere region, including a perched unit in upland areas northeast of the Spruce Crescent well field, a confined unit in which DW2 and DW3 are installed and a another deeper confined unit in which the DoB's Bradford water wells are installed. Based on the information provided on the well logs, the confined aquifer is moderately to highly productive, with a confining unit that ranges between 20-30 m in thickness near the drill site. We infer that recharge to the aquifer originates from multiple sources including leakage from Barriere River, infiltration of precipitation and snowmelt from upland areas and discharge from underlying bedrock.

Using data collected during the testing of DW3, WWAL estimated the transmissivity (T) and the storativity (S) of the confined aquifer beneath the Spruce Crescent well field. Our analysis indicated a T value of 2.5×10^3 m^2/day, which has an equivalent hydraulic conductivity (K) that is consistent with textbook values for sand & gravel aquifers (Freeze & Cherry, 1979). Additionally, we generated an S value of 6.7×10^{-4}, which is in line with typical values for confined aquifers (Freeze & Cherry, 1979).

The provincial GWELLS application indicates twenty-two wells (including those at the Spruce Crescent and Bradford Park well files) are registered within 1 km of the subject site wells. It should be noted that submission of well driller's logs to the Ministry was not mandatory until 2016; therefore, it is possible that other unreported wells exist in the area. A summary of select well construction details is included in Table 3-2 below and the location of each well is displayed in Figure 2.

Table 3-2 Select Details for Wells within 1 km of the Spruce Crescent Well Field

WTN	Well Use	Finished Well Depth (ft)	Diameter (in)	Depth to Water (ft)	Reported Well Yield (US gpm)
DW1	Water Supply	230	12	-	713
DW2	Water Supply	158	8	-	1000
DW3	Water Supply	148	12	45	700
103072	Monitoring	336	6	-	100
112533	Monitoring	288	6	-	-
114383 (PW1)	Water Supply System	268	10	40	-
112850 (PW2?)	Water Supply System	258	10	40	-
114384 (PW3)	Water Supply System	313	10	-	-
40611	Unknown	250	6	175	10
116334	Private Domestic	159	6	82	10
27951	Unknown	138	6	64	10
105971	Irrigation	134	6	87	35
92069	Irrigation	118	6	85	40
59264	Irrigation	35	8	12	90
59348	Irrigation	39	8	6	-
76035	Water Supply System	158	10	45	-
103071	Monitoring	436	6	-	-
75937	Unknown	20	6	-	-
75939	Unknown	20	6	-	-
75940	Unknown	41	6	28	-
75938	Unknown	20	6	-	-
83966	Private Domestic	383	6	190	30
116544	Private Domestic	96	6	-	-

3.3 Land Use near the Spruce Crescent Well Field

Land use in the vicinity of the Spruce Crescent well field is predominately residential, with some agricultural activities in the area (Figure 4). Undeveloped forested areas and agricultural lands dominate the upland areas to the east and southeast. Barriere's commercial district is located south of the site.

Three potential sources of enteric viruses are located within 300 m of the Spruce Crescent wells, as shown in Figure 4: a cattle grazing area located immediately west of the well field, the Riverwalk wastewater treatment facility located ~170 m east of DW2 and DW3, and several residential septic fields located to the south-southwest of the well field. Field observations of the cattle grazing area did not identify any stockpiling of manure in the vicinity of the wells. The wastewater treatment facility is a relatively small operation that can services 27 residential properties in the area. Our understanding of the system is that effluent is treated to "Class A" standards (high quality municipal effluent receiving advanced treatment with the addition of UV disinfection and nitrogen reduction) and is discharged to two disposal fields located to the north and south of the building. At present, the treatment plant is operating at ~15% of its maximum authorized daily discharge amount (True Consulting, 2021). Of the known residential septic fields in the area, the closest is located approximately 160 m from DW2/DW3. Discussion on the risk associated with these potential sources is provided in Section 5 below.

4. 2020-2021 FIELD PROGRAM – METHODS AND RESULTS

The following sections provide the methodology and results of the 2020-2021 field program. The program was designed to collect several types of data so that multiple lines of evidence could be used in the GARP determination. The works completed by WWAL constitute much of the scope for Level 1 and 2 hydrogeological investigations suggested by the BC guidance document. The field investigation program included:

1. Continuous water level monitoring of the aquifer and Barriere River throughout the assessment period.
2. Collection of multiple untreated groundwater samples from the DW2 wellhead and surface water from Barriere River for total coliform and *E. coli* analysis to better quantify the presence of bacteriological pathogens.
3. Collection of untreated groundwater samples from the supply wells and Barriere River for general potability to provide a means for geochemical comparison between sources.
4. Collection of biweekly field parameter data (pH, conductivity, temperature) from the supply well.
5. Collection of untreated samples from the supply well and Barriere River (when possible) for enumeration of aerobic spores. This is an experimental technique used by Hyperion Research intended to provide a qualitative measurement of the amount of groundwater filtration occurring in an aquifer. Aerobic spores are of similar size and shape to *Giardia* and *Cryptosporidium* and are common in surface water but absent in secure groundwater.
6. Collection of untreated groundwater samples from the supply wells for modified Method 1623 MPA analysis.

The field data collection program spanned from December 2020 to October 2021. The timing of the study included the period of peak surface water and groundwater levels (early spring). DoB Utilities Operator, Mr. Paul Amos, completed much of the field water quality measurements and WWAL hydrogeologist, Paul Williamson, P.Geo., visited the site on three occasions to collect MPA samples, water quality samples and field parameters.

4.1 Hydrometric Data (Monitoring Well and Barriere River)

The aquifer in which DW2 and DW3 are completed is interpreted to be under confined and/or semi-confined conditions. This means the aquifer is not in equilibrium with the earth's atmosphere, and water level changes occur in response to a change in pressure (or piezometric head) in the aquifer. Such changes are the result of a combination of stressors to the aquifer, including well pumping, natural groundwater recharge and discharge processes (i.e., the "hydrologic cycle"), barometric pressure, and induced groundwater recharge.

As mentioned above, a transducer was installed in an onsite monitoring well (TW1) to measure groundwater levels throughout the project. TW1 is located approximately 23 m from DW2. Water levels for Barriere River were downloaded from the hydrometric station located ~550 m downstream of DW2. Both the monitoring well and the hydrometric station were benchmark surveyed to provide an elevation relative to sea level. Due to an internal error in the transducer, groundwater level data from December 2020 through March 2021could not be recovered. Groundwater and surface water elevation data are provided in Figure 4-1, while

Figure 4-2 provides groundwater elevation and total precipitation and mean temperature data from Vavenby Station, located 50 km northeast of the well site (the closest climate station with available data, in an area that is likely slightly wetter than Barriere on average). The following discussion summarizes findings based on review of the data and figures.

- The Barriere River hydrograph exhibits the characteristic pattern for streams in the interior regions of British Columbia: seasonal lows during the winter and early spring, an abrupt increase during spring freshet, with peak flow values in late spring/early summer; peak flow recession, as snowpacks became depleted by melt-off; followed by a steady and slow recession toward baseflow into the late summer and fall months.
- Groundwater responded in a somewhat similar fashion, as levels began to increase steadily around the time of freshet and began to decline approximately a week peak levels were reached in the river.
- Unexpectedly, groundwater levels began to recover at the beginning of July, when the river was continuing to approach seasonal low values. Typically, we would expect groundwater levels to continue declining at least into the early fall, if not straight through into the winter. DoB operational staff believed this may have coincided with the repair of two large water leaks in the distribution system. Additionally, several wildfires were present in the area around this time, and a call was made to the community to voluntarily reduce water consumption. Although unconfirmed, both events may have resulted in reduced pumping at DW2 and subsequent recovery in groundwater levels.
- Throughout the freshet period and subsequent decline, groundwater and river levels appear to rise and fall at similar times, with groundwater lagging a few days behind any changes that occurred in the river. This provides a good indicator that a hydraulic connection potentially exists between aquifer and the river. Since the aquifer is confined or semi-confined, this should be thought of as a pressure relationship, where the river exerts a hydraulic pressure across the confining layers, to which the aquifer responds with a corresponding change in aquifer pressure (piezometric head). The actual volume of water exchanged during this process is likely small compared to a) flow in the river and b) water held in storage in the aquifer. This is best seen in the way the water chemistries and microbiological content of surface water and groundwater remain distinct from each other over the long term (discussed in detail below).
-

- Figure 4-2 indicates that groundwater elevation tends to rise shortly after precipitation events. This suggests that precipitation may be a direct source of recharge to the aquifer. It is more likely, however, that this is a pressure response to the river (as described above), whereby precipitation results in a river level rise which is subsequently transferred to the aquifer.
- The river's elevation is consistently several metres higher than the elevation of groundwater. Under these conditions, if a connection between the aquifer and the river exists, the river will represent a source of recharge to the aquifer. This recharge, should it occur, would involve vertical flow (or more likely, pressure propagation) through fine-grained confining layers.

Figure 4-1 Groundwater (TW1) and Surface Water (Barriere River) Elevations

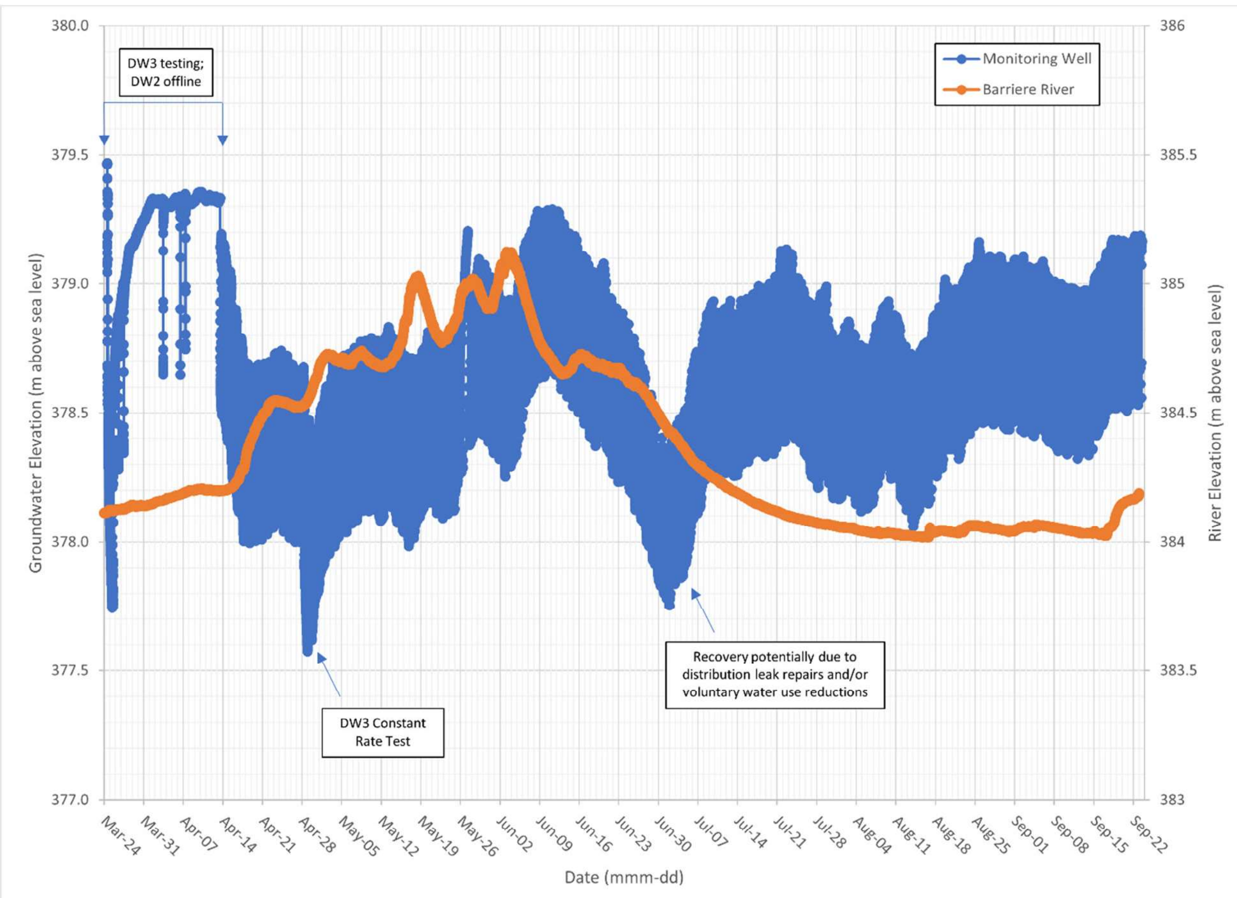
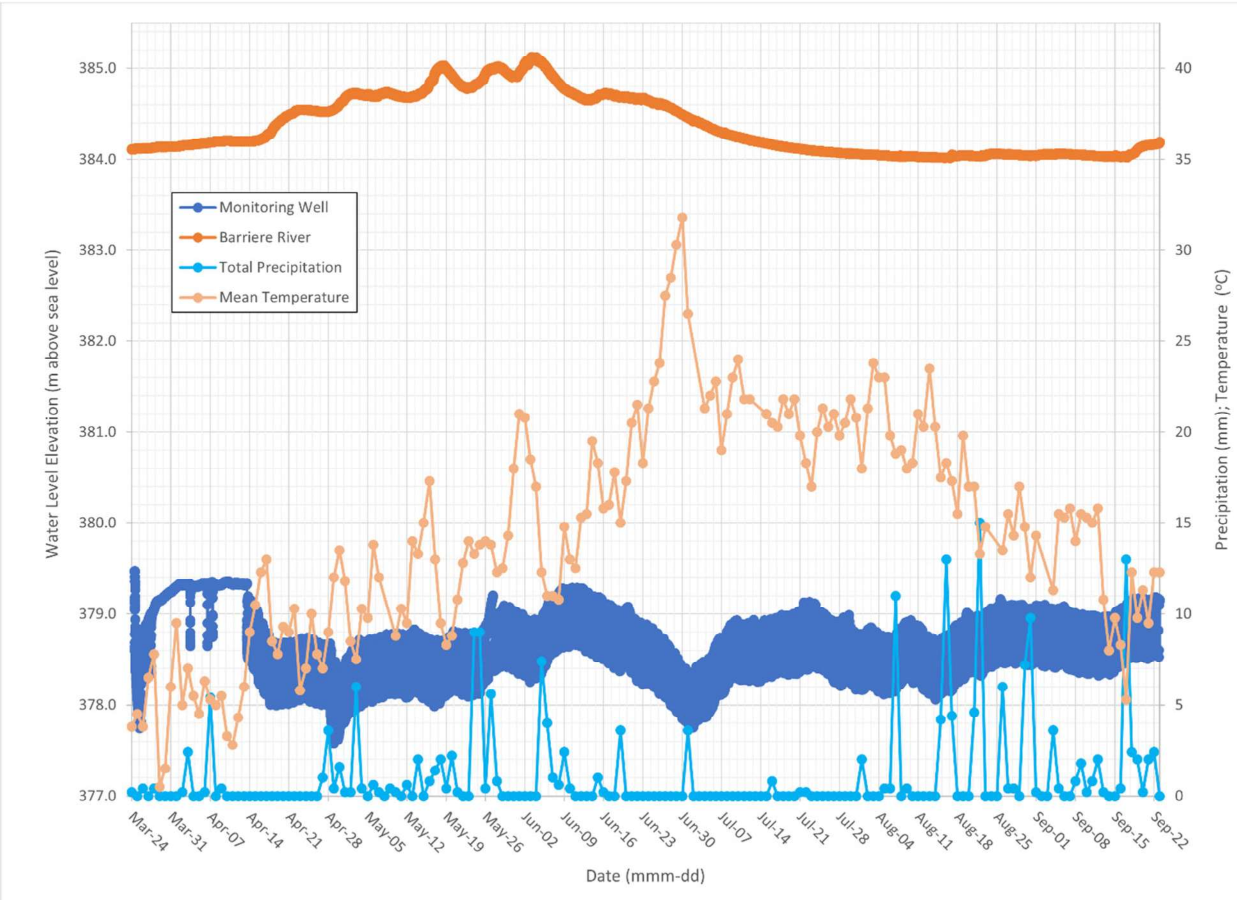


Figure 4-2 Groundwater & Surface Water Elevation, Precipitation and Temperature



4.2 Untreated Groundwater Microbiological Sampling

Throughout the assessment, a total of eight bacteriological samples (total coliforms and *E. coli*) were collected from DW2 (laboratory reports provided in Appendix B). During the construction of DW3, DW2 was temporarily not in use; therefore, samples were not collected between from early February until late April. A sampling tap in the pumphouse was used to collect the samples. The tap was wiped down with a chlorine solution and opened for 15 minutes to flush any stagnant, non-representative water from the system. To avoid cross contamination, a disposable pair of nitrile gloves was worn throughout sample collection and the sample was collected in clean, laboratory supplied bottles. Bacteriological samples were also collected from Barriere River, approximately 60 m to the north of the supply well.

All samples were transported to a laboratory in an ice-filled cooler within 24 hours. Water quality testing was completed by CARO Analytical, in Kelowna, BC, a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). Laboratory reports for the samples collected by WWAL are provided in Appendix B.

As shown in Table 4-1 below, the results of the microbiology testing indicated total coliforms and *E. coli* were not detected in groundwater from DW2. As expected, total coliforms were detected in Barriere

River during all sampling events and *E. coli* was detected during six of the eight events. The results are consistent with monitoring conducted by WWAL at other groundwater supply well locations across B.C.

Table 4-1 Microbiological Testing of Untreated Groundwater/Surface Water

Sample Date	DW2		Barriere River	
	Total Coliform	*E. coli*	Total Coliform	*E. coli*
01-Dec-2020	<1	<1	122	3
15-Dec-2020	<1	<1	>80	<1
26-Jan-2021	<1	<1	68	<1
27-Apr-2021	<1	<1	40	>10
17-May-2021	<1	<1	13	>1
15-Jun-2021	<1	<1	>80	7
29-Jun-2021	<1	<1	816	13
13-July-2021	<1	<1	1990	15
28-Sept-2021	<1	<1	>2420	5

4.2.1 Historical Microbiological Sampling

Comprehensive water quality samples, collected directly from the wellhead (i.e., prior to treatment), have been taken three times over the last six years by DoB operational staff. As shown in Table 4-2 below, total coliforms and *E. coli* were not detected in any of these samples. Laboratory results for these samples are provided in Appendix B.

Table 4-2 Summary of Historical DW2 Wellhead Bacteriological Testing Results

Sample Date	DW2	
	Total Coliform	*E. coli*
08-Oct-2013	<1	<1
13-Oct-2015	<1	<1
01-Nov-2020	<1	<1

4.3 Field Water Quality

During the assessment period, DoB water system operators completed field water quality measurements of groundwater and Barriere River on a biweekly basis. Dedicated field probes and calibration solutions were purchased for the project to measure temperature, pH, conductivity and Oxidation-Reduction Potential (ORP). The field instruments were calibrated prior to each sampling event. From the period of early February to late April 2020, DW2 was inactive due to the construction of DW3. A summary of all field measurements collected is presented in

Table 4-3. Time series plots for the four parameters are provided below.

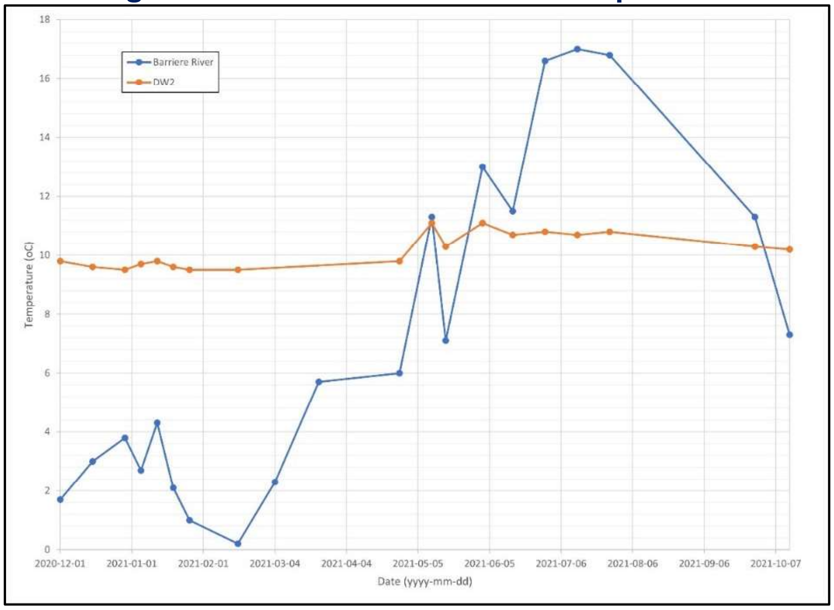
Table 4-3 Supply Well Field Measurement Summary

Date	Barriere River				DW2			
	Temp. (°C)	pH (unitless)	Cond. (µS/cm)	ORP (mV)	Temp, (°C)	pH (unitless)	Cond. (µS/cm)	ORP (mV)
2020-12-01	1.7	8.29	148.4	191	9.8	7.46	358	298
2020-12-15	3	8.69	152	279	9.6	7.64	346	259
2020-12-29	3.8	8.73	156.9	237	9.5	7.61	346	236
2021-01-05	2.7	8.77	187.5	212	9.7	7.54	355	241
2021-01-12	4.3	8.82	169.2	201	9.8	7.56	361	227
2021-01-19	2.1	8.71	169.6	202	9.6	7.62	345	209
2021-01-26	1	8.58	159.5	171	9.5	7.59	320	194
2021-02-16	0.2	8.72	146.5	184	9.5	7.5	331	197
2021-03-04	2.3	8.41	159.6	175	-	-	-	-
2021-03-23	5.7	8.64	174.5	175	-	-	-	-
2021-04-27	6	8.17	121.7	161	9.8	7.81	327	190
2021-05-11	11.3	8.58	111.5	127	11.1	7.46	343	207
2021-05-17	7.1	8.37	64.5	145	10.3	7.53	348	154
2021-06-02	13	8.5	59.2	146	11.1	7.52	363	198
2021-06-15	11.5	8.1	62	133	10.7	7.54	381	190
2021-06-29	16.6	7.93	62	153	10.8	7.48	405	189
2021-07-13	17	8.29	99.8	139	10.7	7.64	405	154
2021-07-27	16.8	8.35	112.9	142	10.8	7.61	414	154
2021-09-28	11.3	8.69	94.8	109	10.3	7.58	373	153
2021-10-13	7.3	9.06	91.6	112	10.2	7.60	374	176

4.3.1 Temperature

In most settings, ambient groundwater temperatures are found to be in the range of the mean annual air temperature for a given location. This proved to be true for DW2, where the mean annual value for the well (10.2 °C) was slightly warmer than the mean annual daily temperature from the closest climate station (7.7 °C; see Table 3-1 above). Also typical for groundwater, the measured temperatures for the well remained relatively consistent throughout the study with values that hovered around 10 to 11 °C. A slight uptick in temperature was noted after May of 2020. For Barriere River, temperatures varied considerably (typical of surface water) and followed seasonal trends, with the coldest measurements collected in the winter (minimum = 0.2°C in December) and the warmest in the late summer (maximum = 17°C in July).

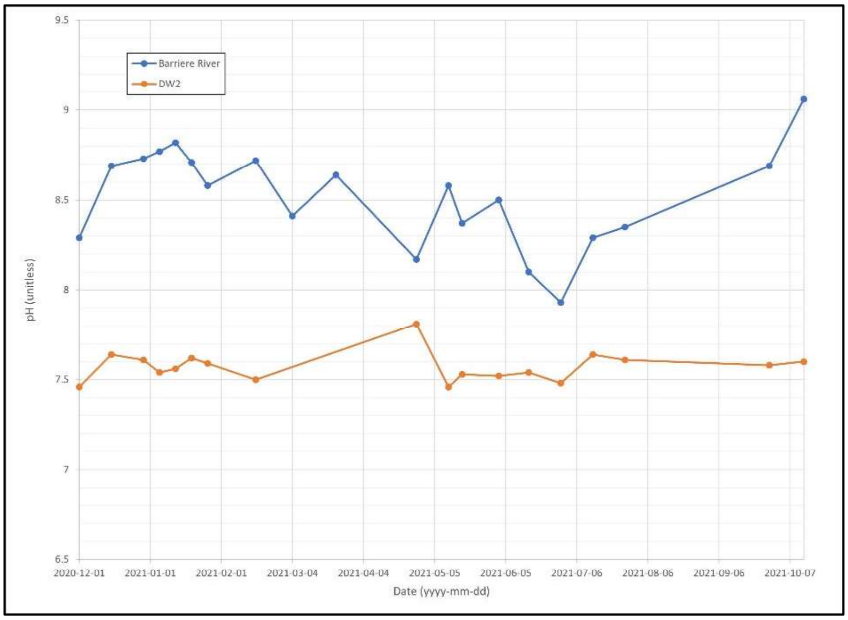
Figure 4-3 Time-series Plot – Temperature



4.3.2 pH

pH is the measure of the acidity/basicity of a given water source and is interrelated with other water characteristics such as temperature, dissolved organic carbon, hardness and buffering capacity (alkalinity). Over the assessment period, pH values from Barriere River ranged from 7.93 to 9.06, indicating a basic composition. The pH of the river remained consistently higher than groundwater throughout the study, and an overall downward trend in the pH of the river is observed from January to late June 2021. For groundwater, pH remained much more stable, with values that are slightly above neutral and range from 7.46 to 7.81. Fluctuations in the field pH data do not follow any apparent seasonal trend.

Figure 4-4 Time-series Plot – pH



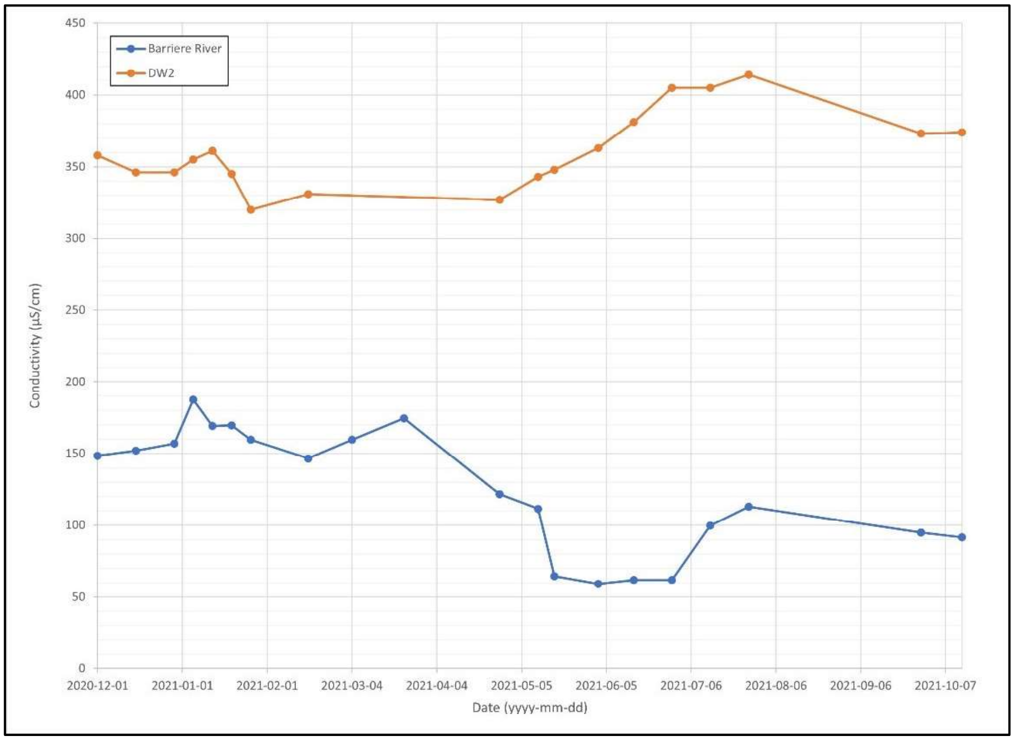
4.3.3 Conductivity

Conductivity is a measure of water's capability to transmit electrical flow and is directly related to the concentration of ions in solution, with higher ion concentrations producing higher conductivity readings. Ions in water can originate from natural sources such as carbonaceous minerals in the aquifer and/or from anthropogenic sources such as road salt or fertilizers. Groundwater generally has a higher conductivity than surface water, due to the extended duration the water spends in contact with the aquifer's matrix. Conductivity is perhaps the most useful field parameter for highlighting the differences between groundwater and surface water geochemistry.

From December 2020 to April 2021, the conductivity of the Barriere River was at its highest, with values that ranged from 147 to 188 µS/cm. This period is representative of baseflow conditions in the river when the proportion of discharged groundwater contributing to streamflow would typically be at its highest. From late April to October 2021, the values for conductivity decreased to a range of 59 to 121 µS/cm, during the period when snowmelt and/or precipitation represent a much more significant input of fresher (less mineralized) water into the river and the proportion of discharged groundwater in the river is reduced.

As expected, the conductivity of groundwater was consistently higher than the river measurements. Values throughout the assessment period remained relatively stable and ranged from 320 to 414 µS/cm. A slight increasing trend was noted to begin in late April and peak in July.

Figure 4-5 Time-series Plot – Conductivity

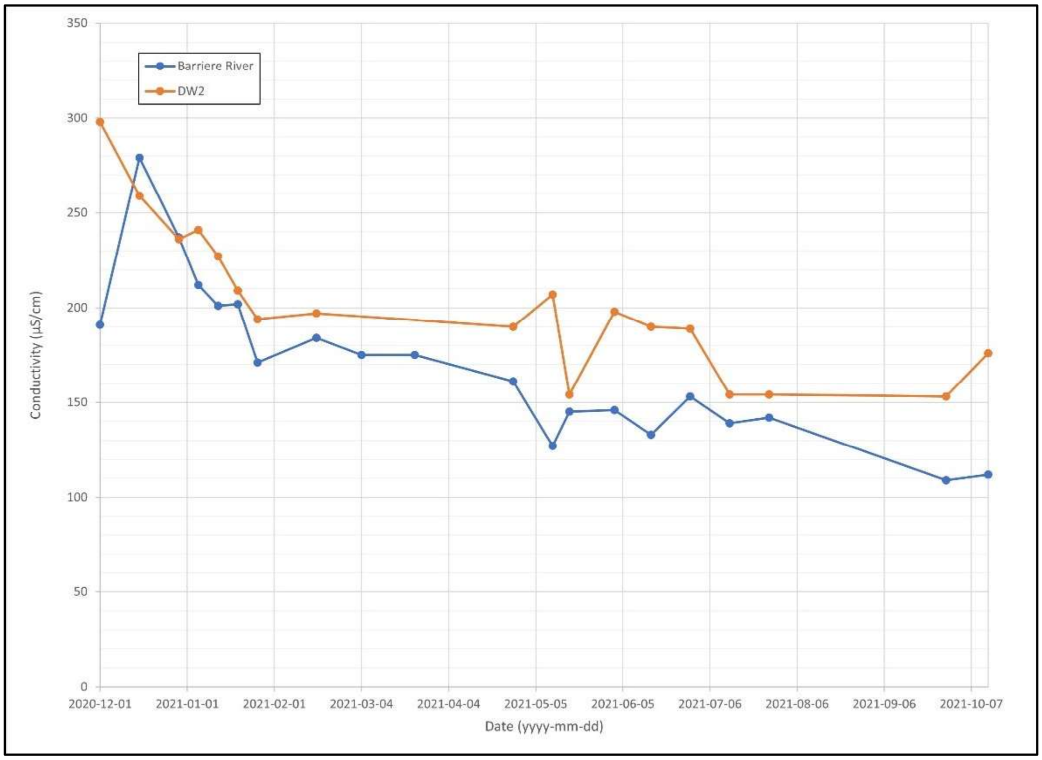


4.3.4 Oxidation-Reduction Potential (ORP)

ORP is a measurement of water's potential to gain or lose electrons. As it relates to groundwater flow systems, the theory is that in areas of groundwater recharge, infiltrating groundwater will have a higher concentration of dissolved oxygen and, therefore, a higher potential to be reduced and higher ORP values when measured. As groundwater moves through the aquifer's matrix, oxygen can be consumed by bacteriological and chemical reactions. In this case, groundwater is in a more reduced state, which results in lower and possibly negative ORP values when measured. Low and negative ORP values in groundwater can be associated with aquifers isolated from surface waters and nearby recharge sources.

ORP values for DW2 and Barriere River tracked closely together throughout the measurement period, with groundwater typically having slightly higher values than the river. A declining trend in ORP values was observed throughout the study, with the highest values occurring in December 2020 and the lowest in the late summer/fall of 2021. This is likely related to increasing ambient temperatures, as the solubility of dissolved oxygen in water decreases as temperatures increase.

Figure 4-6 Time-series Plot - ORP



4.4 Comparison of Groundwater-Surface Water Geochemistry

WWAL collected three sets of concurrent groundwater and surface water samples for potability testing. (laboratory reports provided in Appendix B). As expected, groundwater is more mineralized than the river and changes in chemistry from one sample to the next are typically less pronounced in the groundwater samples versus the surface water samples. For example, turbidity and iron values varied considerably in surface water over the three sampling events, whereas no variation was detected in groundwater. Parameters associated with anthropogenic impacts, such as nitrate and chloride, were slightly elevated in the groundwater samples compared to typical background conditions. However, these parameters were present at low concentrations, indicating limited impacts on the aquifer from local land use activities. The water samples were compared to the Guidelines for Canada Drinking Water Quality (GCDWQ) guidelines. These guidelines are only applicable to the groundwater samples and were therefore not applied to the surface water samples. As displayed in Table 4-4 below, all parameters in groundwater were found at concentrations less than the applicable standards.

Figure 4-7 presents a piper plot for the surface water and groundwater chemistry data collected for this project. The piper plot is a means for visualizing the relative proportion of common ions for a given sample and can highlight subtle differences between the samples. The piper plot indicates the chemical composition of the two water types is quite similar, with a slightly higher proportion of magnesium in groundwater samples. Overall, the two water types are classified as calcium-bicarbonate waters, as these two ions make up the bulk of the dissolved constituents in the samples. We typically expect to see water sampled from the same area, whether groundwater or surface water, to have a similar overall chemical composition.

Figure 4-7 Piper Plot of Groundwater and Surface Water

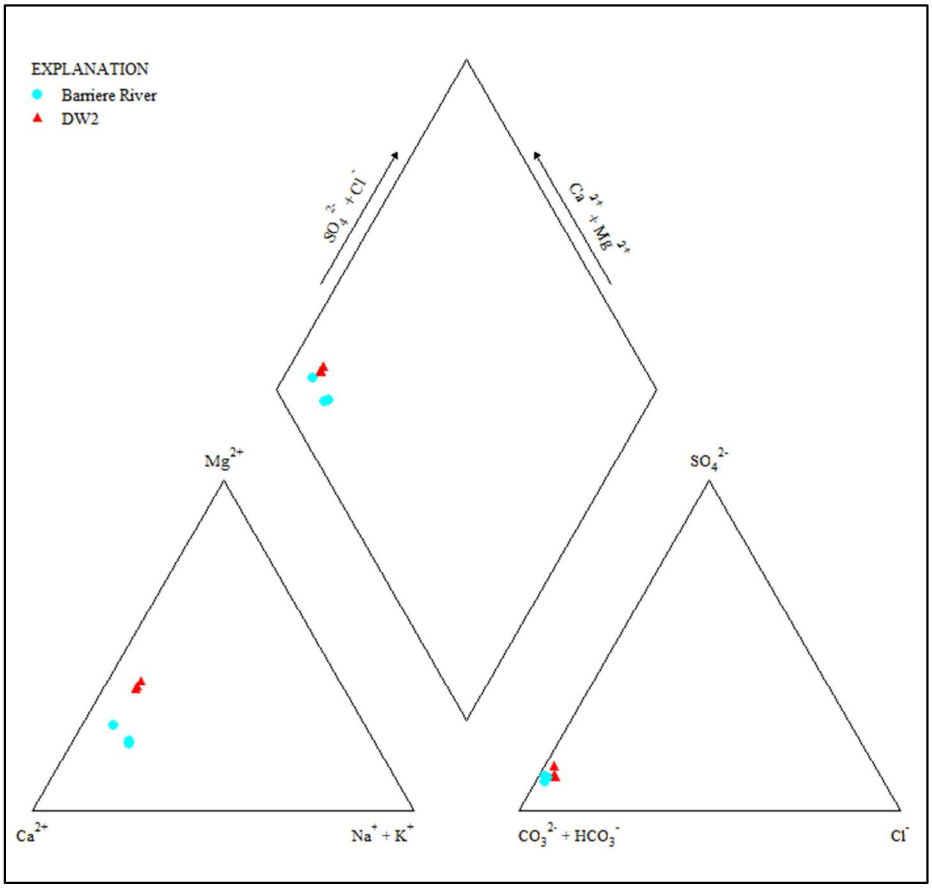


Table 4-4 Summary of Groundwater and Surface Water Geochemistry

Parameters	Units	DW2 2020-12-01	Barriere River* 2020-12-01	DW2 2021-05-17	Barriere River* 2021-05-17	DW2 2021-06-29	Barriere River* 2021-06-29	GCDWQ
General Parameters								
Conductivity	us/cm	314	132	348	60.4	381	58.5	n/a
Turbidity	NTU	<0.10	0.18	<0.10	8.65	<0.10	0.50	varies
Total Dissolved Solids	mg/L	180	87	194	53	238	43	AO ≤ 500
Hardness, Total (CaC03)	mg/L	152	62.7	162	30.2	190	27.8	n/a
Alkalinity, Total (CaCO3)	mg/L	150	59.5	156	27.6	188	30.3	n/a
Select Ions								
Fluoride	mg/L	0.069	0.044	0.088	0.037	0.089	0.033	MAC = 1.5
Nitrate, N	mg/L	0.503	0.0642	0.499	0.0854	0.379	0.0201	MAC =10
Nitrite, N	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	MAC = 1
Chloride	mg/L	4.65	0.72	4.84	<0.50	3.69	<0.50	AO ≤ 250
Sulfate	mg/L	13.7	5.76	15.5	2.35	23.4	2.44	AO ≤ 500
Total Metals								
Aluminum	mg/L	<0.0100	0.0242	<0.0100	0.554	<0.0100	0.0536	OG < 0.1
Arsenic	mg/L	0.00110	0.00016	0.00118	0.00048	0.00122	0.00122	MAC = 0.01
Barium	mg/L	<0.0200	<0.0200	<0.0200	<0.0200	<0.0200	<0.00200	MAC = 2
Boron	mg/L	<0.100	<0.100	<0.100	<0.100	<0.100	<0.100	MAC = 5
Cadmium	mg/L	<0.000200	<0.000200	<0.000200	<0.000200	<0.000200	<0.000200	MAC = 0.007
Calcium	mg/L	36.7	18.0	38.4	9.09	43.7	8.46	n/a
Chromium	mg/L	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	MAC = 0.05
Copper	mg/L	0.00333	<0.00100	0.00249	0.00231	0.00112	<0.00100	MAC = 2 AO = 1
Iron	mg/L	<0.030	0.032	<0.030	0.694	<0.030	0.060	AO ≤ 0.3
Lead	mg/L	0.00192	<0.000500	<0.000500	0.000891	<0.000500	<0.000500	MAC = 0.005
Manganese	mg/L	<0.00200	0.00501	0.00710	0.0343	0.00766	0.00310	MAC = 0.12 AO ≤ 0.02
Sodium	mg/L	6.12	2.09	6.50	<2.00	7.65	<2.00	AO ≤ 200
Uranium	mg/L	0.00194	0.00140	0.00214	0.00162	0.00211	0.000980	MAC = 0.02
Zinc	mg/L	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	<0.0500	AO ≤ 5

Notes: GCDWQ – Guidelines for Canadian Drinking Water Quality Guidelines, OG = Operational Guideline (designed for water treatment facilities); AO = Aesthetic Objective); MAC = Maximum Acceptable Concentration; *Surface water sample, not compared to GCDWQ

4.5 Microparticulate Analysis (MPA)

MPA sampling for this project was completed by a WWAL hydrogeologist following the methodology outlined by Hyperion Research, which is the only CALA Accredited laboratory in Western Canada for MPA testing. Microscopic analysis was completed by Peter Wallis, Ph.D. and his staff at Hyperion Research in Medicine Hat, AB.

The MPA sampling method conforms to U.S. EPA Method 1623 for identifying *giardia* and *Cyptosporidium* (US EPA, 2005) and the Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using Microparticulate Analysis (US EPA, 1992). The type of filter used (IDEXX Filta-Max) during sampling is named as an acceptable alternative filter in the Method 1623 guidance document and was recommended by Hyperion Research. According to Hyperion, the Filta-Max filter has superior organism recovery and requires smaller sampling volumes when compared to the standard filter. Particles trapped on the filter media are identified and enumerated in the laboratory. Based on the number and proportion of primary and secondary particles, a matrix is used to assign a score that determines the risk of surface water contamination for a source, with 0-9 indicating a low risk, 10-19 a moderate risk and 20+ a high risk. Table 4-5 below summarizes the results of the modified MPA testing and the aerobic spore forming bacteria testing. Laboratory reports from Hyperion Research are provided in Appendix C.

The results of the MPA sampling from DW2 identified very few surface water indicator particles (laboratory reports provided in Appendix C). As a result, all three samples were assigned a low-risk rating for surface water contamination. Algae was detected during the May 2021 sample. Assuming the wellhead is secured from surface contamination, the presence of algae in the well sample would appear to be suspect. Moreover, the finding of algae occurred on only one occasion and only a single algae particle was noted by the analyst. Additionally, *Giardia* and *Cryptosporidium* were not detected in any of the three samples. Overall, the results indicate a consistent low risk of GUDI and that effective filtration is occurring in the subsurface, as would be expected given the geology and the confined aquifer setting.

Table 4-5 Summary of MPA Testing Results

Parameter	DW2	DW2	DW2
Sampling Date	01-Dec-2020	17-May-2021	29-June-2021
Water Filtered	250.8 L	250.8 L	250.8 L
Primary Particulates			
Diatoms	1	0	4
Other Algae	0	1	0
Insects/Larvae	0	0	0
Rotifers	0	0	0
Plant Debris	0	0	0
Giardia/Crypto	0	0	0
Secondary Particulates			
Nematodes	3	4	5
Pollen	1	6	5
Crustacea	0	0	0
Unknown	0	0	0
Additional Parameters			
Giardia cysts	0.0/100L	0.0/100L	0.0/100L
Cryptosporidium oocysts	0.0/100L	0.0/100L	0.0/100L
Overall Risk Factor	6 (low risk)	4 (low risk)	6 (low risk)

Note: Pollen is sometimes introduced during sample collection from suspended pollen in the air at the time of sampling.

4.6 Aerobic Spore Forming Bacteria Enumeration

The results of the aerobic spore forming bacteria (ASFB) in groundwater and surface water for the three sampling events are summarized in Table 4-6. As expected, ASFB were detected in all samples collected from Barriere River, with the highest concentrations occurring during the May sampling event. For the supply well, two of the three samples tested negative for ASFB, while the June sample contained 10 CFU/L. Qualitative interpretation of these results indicates that substantial filtration of groundwater is occurring in the aquifer prior the reaching DW2, and ASFB (and similarly sized *Giardia* and *Cryptosporidium*) are effectively being filtered.

Table 4-6 Results of Aerobic Spore Forming Bacteria Enumeration

Sample Location	01-Dec-2020	17-May-2021	29-Jun-2021
WPID 12702 (Supply Well)	0 CFU/L	0 CFU/L	10 CFU/L
Barriere River	110 CFU/L	9,516 CFU/L	770 CFU/L

5. DISCUSSION AND CONCLUSIONS

The Stage 2 GARP Assessment of DW2 (and by proxy, DW3) was commissioned based on the potential risk for pathogens to enter the supply well. The wells are positioned in relative close proximity to Barriere River and multiple potential pathogen sources have been identified within 300 m of the well.

Hydrometric data provides a good indication that a hydraulic connection potentially exists between the aquifer and Barriere River. This connection is related to pressure changes transmitted across the confining unit (aquitard) whereby the river exerts a hydraulic pressure across the fine-grained layers, to which the aquifer responds with a corresponding response expressed as a change in piezometric head (or water level in a well). The river's elevation was consistently found to be several metres higher than the elevation of groundwater. Under these conditions, the river represent a steady but slow source of recharge to the aquifer. This recharge, should it occur, would involve vertical flow through fine-grained confining layers, and water exchanged during this process is likely much less than flow in the river or water held in storage that flows naturally through the aquifer.

During testing of DW3, the well experienced persistent turbidity issues upon start up that eventually cleared after continued pumping. In this case, the source of turbidity is related exclusively to the aquifer formation, where a higher than typically silt content was discovered, and is not related to infiltrating surface water. As a result, the elevated turbidity does not represent a risk to the GARP status of the well and we anticipate that once DW3 is placed into operation and continuously pumped, the turbidity issue will eventually be resolved.

The measurement of field parameters throughout the assessment highlighted the difference between surface water and groundwater from the site. Temperature, pH and conductivity tended to be more stable (i.e., less fluctuations) in groundwater and were typically measured in distinctly different ranges for the two water sources. ORP, however, was found to be quite similar between groundwater and the river throughout the assessment, with groundwater tending to be slightly higher compared to the river.

Analytical testing indicates the supply well is chemically and bacteriologically of good quality and meets all Canadian drinking water aesthetic and health-based guidelines. DW2 is noted for being more mineralized than Barriere River, with the two sources, proportionally speaking, have a similar geochemical makeup.

Multiple lines of evidence suggest the aquifer is providing adequate filtration of any recharging water from Barriere River. Microbiological testing carried out during this study indicated total coliform and E. coli are present in Barriere River throughout the year, while testing of DW2 did not detect the presence of microbiological parameters in any of the samples analyzed. Additionally, historical sampling of untreated groundwater from DW2 did not detect total coliform or *E. coli.* in any of the samples.

ASFB testing also detected the ubiquitous presence of spores in Barriere River throughout the year, while ASFB was only found on one occasion in a DW2 sample at a value equal to the method detection limit. MPA sampling of DW2 identified a limited number of indicator particles, and *Giardia* or *Cryptosporidium* were not detected in any of the samples. Each of the three samples were assigned a low-risk rating for surface water contamination.

Potential pathogen sources within 300 m of the wells include a cow grazing area, infiltration fields from the Riverwalk wastewater treatment plant and multiple residential septic fields. The cattle grazing area is used on a seasonal basis and does not presently contain any observable stockpiles of manure. Additionally, the field is located in what is inferred to be a downgradient position relative to the supply wells; therefore, we consider the potential risk from this source to be low.

The infiltration beds from the Riverwalk treatment plant and multiple residential septic systems are located less than 200 m from the supply wells in potentially upgradient positions. A well head protection assessment of the wells (Kala, 1997) suggests the infiltration beds and septic fields fall within the 5-year capture zone of the wells. However, wastewater from these systems is disposed of in an upper, unconfined water bearing unit, and the Riverwalk plant is currently operating at around 15% of its intended capacity. Given the presence of a 23 m thick confining unit that separates the upper unconfined aquifer from the lower confined aquifer, it is likely that the DW2 and DW3 are sufficiently protected from wastewater disposal above, and that a pathway for virus or bacteria transport from surface to the confined aquifer likely does not exist.

We note that historical water quality data from DW2 appears to indicate that parameters associated with wastewater disposal (chloride and nitrate) have gradually increased over time (See Table 5-1 below). With that said, sampling for these parameters has been sporadic and it is challenging to draw any conclusions as to what trends may persist into the future with such a limited dataset. Additionally, the concentrations of these parameters remain low and far below Canadian Drinking Water Quality Guidelines (MAC = 10 mg/L for nitrate; AO = 200 mg/L for chloride) and, at the concentrations present, cannot necessarily be linked to wastewater disposal in the vicinity of the wells. Annual collection of untreated groundwater should be incorporated into the regular sampling program for the distribution system.

Table 5-1 Historical Chloride and Nitrate Concentrations from DW2

Date	Chloride (mg/L)	Nitrate (mg/L)
2013-10-08	2.1	0.178
2015-10-13	2.73	0.226
2020-11-04	4.98	0.511
2020-12-01	4.65	0.503
2021-05-17	4.84	0.499
2021-06-29	3.69	0.379

Note: CDWQG MAC = 10 mg/L for Nitrate; CDWQG AO = 200 mg/L for Chloride

Based on the evidence provided, it is our opinion that the aquifer for DW2 and DW3 supply wells receives sufficient filtration of recharging waters such that *Giardia* and *Cryptosporidium* are not likely to be present at any time of the year. As a result, the District of Barriere water system is unlikely to require additional filtration or UV inactivation for these pathogens. As viruses are typically one or two orders of magnitude smaller than bacteria, there is some risk that viruses, if present in Barriere River or in the upper, unconfined aquifer, may reach the wells. However, the river is relatively pristine and lacks significant upstream inputs of sewage and other wastes that would increase the viral risk. Additionally, the presence of a 23 m thick confining layer above the source aquifer should provide sufficient protection from viruses present in the near subsurface.

In summary, we conclude that DW2 and DW3 are at **low risk of containing pathogens**. The existing practice of primary disinfection with contact time and maintaining a chlorine residual in the distribution system should remain in place to meet other Interior Health supported water system guidelines (e.g., Distribution System Guidelines, 2016).

6. RECOMMENDATIONS

Based on the above conclusions, we offer the following recommendations:

R1 The existing level of primary and residual disinfection should remain in place for the Barriere water distribution system. Ultimately, the level and type of water treatment required for a water source is at the discretion of the responsible Drinking Water Officer with the Interior Health Authority. This GARP report should be reviewed by Interior Health prior to a final determination on water treatment requirements.

R2 Efforts should be made to limit any potential sources of pathogens in proximity to the well (e.g., manure stockpiles, septic systems, compost heaps, animal grazing, etc.). We realize the well is located adjacent to private properties, and it will take a concerted effort to change any current land management practices. Education on the protection of the local water supply and potential sources of contamination should be provided to users of the community's water system.

R3 A comprehensive potability sample of untreated groundwater should be collected a minimum of every two years to monitor for any changes in the geochemistry of the water over time.

R4 We understand that future plans for the community's infrastructure potentially includes the decommissioning of the Riverwalk wastewater treatment plant. If feasible, we would support this action, as it would eliminate a potential source of risk to the community's water supply. Consideration should also be given to connecting all residential properties in the area to the municipal wastewater collection system.

REFERENCES

British Columbia Ministry of Environment and Climate Change Strategy (ENC). 2021. Water Resources Atlas. Retrieved from: http://www.env.gov.bc.ca/wsd/data_searches/wrbc/

District of Barriere (DoB). 2020. 2020 Annual Water Report. Retrieved from: https://www.barriere.ca/Home/DownloadDocument?docId=043cd5f0-dc5f-443e-9a35-30f34795d33b

Environment Canada. 2021. Climate Normals Website. Retrieved from: http://climate.weather.gc.ca/climate_normals/index_e.html#1981

Engineers & Geoscientists (EGBC). 2019. Assessment of Groundwater at Risk of Containing Pathogens (GARP). Retrieved from: https://www.egbc.ca/getmedia/33073ee7-ab69-4834-966b-3b0cfb6b4d6e/EGBC-Assessment-of-GARP-V1-0.aspx

Health Canada 2020. Guidelines for Canadian Drinking Water Quality. Retrieved from:: https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/water-quality/guidelines-canadian-drinking-water-quality-summary-table.html

Kala Groundwater Consulting Ltd. 1997. Barriere Improvement District New Well Installation, Barriere, British Columbia

Ministry of Health. 2017. Guidance Document for Determining Groundwater at Risk of Containing Pathogens (GARP) – Version 3. Retrieved from: https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/how-drinking-water-is-protected-in-bc/garp_assessment_oct_2017.pdf

Paulen, R.C., Bobrowsky, P.T., Little, E.C., Prebble, A.C., Ledwon, A. 1998. Terrain Geology of the Louis Creek Area. Open File 1998-2. Retrieved from: http://cmscontent.nrs.gov.bc.ca/geoscience/PublicationCatalogue/OpenFile/BCGS_OF1998-02.pdf

Province of Ontario. 2001. Guideline for Determining Groundwater Under Direct Influence of Surface Water.

SEACOR Environmental Engineering Inc. 1994. Groundwater Supply Development Program – 1994; Production Well PW94-01; Construction Supervision and Evaluation; Barriere Improvement District, Barriere B.C.

US Environmental Protection Agency. 2005. Method 1623: Cryptosporidium and Giardia in Water by Filtration/IMS/FA.

US Environmental Protection Agency. 1992. Consensus Method for Determining Groundwater Under Direct Influence of Surface Water using Microparticulate Analysis. Report No. 910/9-92-029.

True Consulting. 2020. Master Water Plan – Part 1: District of Barriere. Project Number 346-371.

True Consulting. 2021. Wastewater Treatment Feasibility Study; District of Barriere

Water Survey of Canada (2021). Online Hydrometric Data Web Portal. Retrieved from: https://wateroffice.ec.gc.ca/

Western Water Associates Ltd. 2021. Installation and Testing of Replacement Supply Well; District of Barriere; WPID 40541.

Western Water Associates Ltd.
Standard Report Limitations

1. This Document has been prepared for the particular purpose outlined in the work scope that has been mutually agreed to with the Client.
2. The scope and the period of service provided by Western Water Associates Ltd are subject to restrictions and limitations outlined in subsequent numbered limitations.
3. A complete assessment of all possible conditions or circumstances that may exist at the Site or within the Study Area referenced, has not been undertaken. Therefore, if a service is not expressly indicated, it has not been provided and if a matter is not addressed, no determination has been made by Western Water Associates Ltd. in regards to it.
4. Conditions may exist which were undetectable given the limited nature of the enquiry that Western Water Associates Ltd. was retained to undertake with respect to the assignment. Variations in conditions may occur between investigatory locations, and there may be special conditions pertaining to the Site, or Study Area, which have not been revealed by the investigation and which have not therefore been taken into account in the Document. Accordingly, additional studies and actions may be required.
5. In addition, it is recognised that the passage of time affects the information and assessment provided in this Document. Western Water Associates Ltd's opinions are based upon information that existed at the time of the production of the Document. It is understood that the Services provided allowed Western Water Associates Ltd to form no more than an opinion of the actual conditions of the Site , or Study Area, at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the Site, or Study Area, nor the surroundings, or any laws or regulations.
6. Any assessments made in this Document are based on the conditions indicated from published sources and the investigation described. No warranty is included, either expressed or implied, that the actual conditions will conform exactly to the assessments contained in this Document.
7. Where data supplied by the Client or other external sources, including previous site investigation data, have been used, it has been assumed that the information is correct unless otherwise stated.
8. No responsibility is accepted by Western Water Associates Ltd for incomplete or inaccurate data supplied by others.
9. The Client acknowledges that Western Water Associates Ltd may have retained sub-consultants affiliated to provide Services. Western Water Associates Ltd will be fully responsible to the Client for the Services and work done by all of its sub-consultants and subcontractors. The Client agrees that it will only assert claims against and seek to recover losses, damages or other liabilities from Western Water Associates Ltd.
10. This Document is provided for sole use by the Client and is confidential to it and its professional advisers. No responsibility whatsoever for the contents of this Document will be accepted to any person other than the Client. Any use which a third party makes of this Document, or any reliance on or decisions to be made based on it, is the responsibility of such third parties. Western Water Associates Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this Document.

western water
ASSOCIATES LTD

Groundwater Supply Development and Management

Source Water Assessment and Protection

Well Monitoring & Maintenance

Environmental & Water Quality Monitoring

Storm & Wastewater Disposal to Ground

Groundwater Modeling

Aquifer Test Design and Analysis

Geothermal / Geoexchange Systems

Policy and Guideline Development

Applied Research

Rural Subdivision Services

Environmental Assessment & Permitting

| #106 – 5145 26th Street, Vernon, BC, Canada, V1T 8G4 | Prince George | Victoria | P:1.250.541.1030 | www.westernwater.ca |

Barriere Water Consumption - Monthly

Month	PW1	DW2	DW3	2022	2018	2017
January	31410	6805520	-	6,836,930	8,132,300	7,629,400
February	0	6391427	-	6,391,427	5,822,600	6,897,000
March	0	6464290	-	6,464,290	5,912,900	6,292,600
April	0	1211884	4,867,882	6,079,766	7,672,500	6,602,600
May	73281	3323020	3,541,490	6,937,791	15,381,300	13,297,400
June	155491	4445487	4,057,947	8,658,925	19,346,900	22,539,545
July	761317	5446963	8,456,675	14,664,955	25,568,800	35,465,600
August	745625	5636586	8,687,033	15,069,244	22,099,500	22,934,300
September	469407	4459488	5,813,898	10,742,793	11,090,200	15,454,700
October	614596	3256184	3,184,594	7,055,374	9,413,900	7,513,400
November	172636	2688214	2,796,525	5,657,375	7,024,300	6,111,800
December	155412	3076811	3,231,352	6,463,575	9,361,000	8,127,500
Total-	**3179175**	**53,205,874**	**44,637,396**	**101,022,445**	**146,826,200**	**158,865,845**

week 1	1931800
week 2	1900800
week 3	1816500
week 4	1845500
week 5	1866400
	9361000

2016	2015	2014	2013	2012	2011	2010	2009
4,931,000	5,819,900	5,555,900	6,909,800	8,810,300	7,479,500	8,964,760	8,228,800
6,322,000	5,767,600	5,489,800	7,177,500	7,201,200	6,192,500	7,935,800	8,666,900
4,934,600	10,512,500	6,689,866	8,274,909	7,028,400	6,117,500	8,202,000	11,768,800
7,709,200	7,865,100	6,555,300	9,402,500	10,952,300	7,365,100	12,056,100	10,906,600
17,569,100	15,967,200	11,338,800	20,060,956	15,872,872	16,946,810	22,268,300	26,501,260
17,845,000	21,164,500	13,766,400	16,667,706	16,885,600	18,818,531	18,814,200	27,949,090
17,679,600	21,006,160	24,194,237	31,200,388	26,626,100	20,278,437	27,079,572	28,624,600
21,965,999	23,471,200	22,019,582	26,598,207	26,648,860	21,863,717	27,247,326	37,856,685
8,767,500	11,904,700	16454200	18,750,881	20,836,600	16,665,443	12,368,713	21,686,434
5,742,000	7,276,100	9,607,100	9,672,127	12,938,100	11,864,000	8,510,800	12,333,800
4,161,900	5,827,800	7,800,600	7,646,500	7,255,900	6,721,000	6,301,702	12,055,396
4,578,300	5,640,800	9,221,900	5,621,200	8,413,200	6,698,500	7,862,200	8,339,062
122,206,199	**142,223,560**	**141,532,585**	**167,982,674**	**169,469,432**	**147,011,038**	**167,611,473**	**214,917,427**

2008	2007	2006
8,515,280	10,341,728	9,192,825
7,328,727	11,366,219	7,371,602
9,796,731	8,815,042	7,579,964
10,272,251	14,703,249	15,335,458
18,827,791	24,058,670	19,470,990
28,682,838	20,415,974	18,269,040
34,120,661	35,735,947	46,549,771
30,283,306	26,477,583	14,966,611
17,825,100	17,337,280	19,062,722
9,187,800	7,541,492	12,022,164
9,352,900	7,726,349	8,147,196
8,228,800	10,367,737	11,214,368
192,422,185	**194,887,270**	**189,182,711**

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **KS2204438**	Page	: 1 of 5
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Chris Matthews	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere Water	Date Samples Received	: 22-Nov-2022 14:45
PO	: ----	Date Analysis Commenced	: 23-Nov-2022
C-O-C number	: ----	Issue Date	: 05-Dec-2022 10:49
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS02 Water		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Parnian Sane	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	Description
-	no units
%	percent
% T/cm	% transmittance per centimetre
µS/cm	microsiemens per centimetre
AU/cm	absorbance units per centimetre
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
MPN/100mL	most probable number per hundred millilitres
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result is greater than the Guideline Upper Limit or the result is lower than the Guideline Lower Limit.
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit .

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water)**

Analyte	Method	LOR	Unit	Client sample ID: Spruce Crescent DW2 - Raw Water Analysis; Sampling date/time: 22-Nov-2022 10:00; KS2204438-001	CDWG AO/OG	CDWG MAC				
Physical Tests										
absorbance, UV (@ 254nm), unfiltered	E405	0.0050	AU/cm	0.0120	--	--	--	--	--	--
alkalinity, bicarbonate (as CaCO3)	E290	1.0	mg/L	148	--	--	--	--	--	--
alkalinity, carbonate (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, hydroxide (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, phenolphthalein (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, total (as CaCO3)	E290	1.0	mg/L	148	--	--	--	--	--	--
colour, true	E329	5.0	CU	<5.0	15 CU	--	--	--	--	--
conductivity	E100	2.0	µS/cm	311	--	--	--	--	--	--
hardness (as CaCO3), from total Ca/Mg	EC100A	0.60	mg/L	160	--	--	--	--	--	--
Langelier index (@ 15°C)	EC105A	0.010	-	0.415	--	--	--	--	--	--
Langelier index (@ 20°C)	EC105A	0.010	-	0.488	--	--	--	--	--	--
Langelier index (@ 25°C)	EC105A	0.010	-	0.560	--	--	--	--	--	--
Langelier index (@ 4°C)	EC105A	0.010	-	0.240	--	--	--	--	--	--
Langelier index (@ 60°C)	EC105A	0.010	-	1.00	--	--	--	--	--	--
Langelier index (@ 77°C)	EC105A	0.010	-	1.20	--	--	--	--	--	--
pH	E108	0.10	pH units	8.15	7 - 10.5 pH units	--	--	--	--	--
solids, total dissolved [TDS]	E162	10	mg/L	197	500 mg/L	--	--	--	--	--
turbidity	E121	0.10	NTU	0.18	1 NTU	--	--	--	--	--
transmittance, UV (@ 254nm), unfiltered	E405	1.0	% T/cm	97.3	--	--	--	--	--	--
Anions and Nutrients										
ammonia, total (as N)	E298	0.0050	mg/L	<0.0050	--	--	--	--	--	--
bromide	E235.Br-L	0.050	mg/L	<0.050	--	--	--	--	--	--
chloride	E235.Cl	0.50	mg/L	4.70	250 mg/L	--	--	--	--	--
fluoride	E235.F	0.020	mg/L	0.069	--	1.5 mg/L	--	--	--	--
Kjeldahl nitrogen, total [TKN]	E318	0.050	mg/L	0.067	--	--	--	--	--	--

Analyte	Method	LOR	Unit	KS2204438-001 (Continued)	CDWG AO/OG	CDWG MAC				
Anions and Nutrients - Continued										
nitrate (as N)	E235.NO3-L	0.0050	mg/L	0.541	--	10 mg/L	--	--	--	--
nitrite (as N)	E235.NO2-L	0.0010	mg/L	<0.0010	--	1 mg/L	--	--	--	--
nitrogen, total organic	EC363	0.050	mg/L	0.067	--	--	--	--	--	--
sulfate (as SO4)	E235.SO4	0.30	mg/L	12.7	--	--	--	--	--	--
Cyanides										
cyanide, strong acid dissociable (total)	E333	0.0050	mg/L	<0.0050	--	--	--	--	--	--
Organic / Inorganic Carbon										
carbon, total organic [TOC]	E355-L	0.50	mg/L	1.27	--	--	--	--	--	--
Microbiological Tests										
coliforms, total	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
coliforms, Escherichia coli [E. coli]	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
Ion Balance										
anion sum	EC101A	0.10	meq/L	3.40	--	--	--	--	--	--
cation sum (total)	EC101A	0.10	meq/L	3.53	--	--	--	--	--	--
ion balance (APHA)	EC101A	0.010	%	1.88	--	--	--	--	--	--
Total Metals										
aluminum, total	E420	0.0030	mg/L	<0.0030	0.1 mg/L	2.9 mg/L	--	--	--	--
antimony, total	E420	0.00010	mg/L	<0.00010	--	0.006 mg/L	--	--	--	--
arsenic, total	E420	0.00010	mg/L	0.00102	--	0.01 mg/L	--	--	--	--
barium, total	E420	0.00010	mg/L	0.0166	--	2 mg/L	--	--	--	--
beryllium, total	E420	0.000100	mg/L	<0.000100	--	--	--	--	--	--
bismuth, total	E420	0.000050	mg/L	<0.000050	--	--	--	--	--	--
boron, total	E420	0.010	mg/L	<0.010	--	5 mg/L	--	--	--	--
cadmium, total	E420	0.0000050	mg/L	<0.0000050	--	0.007 mg/L	--	--	--	--
calcium, total	E420	0.050	mg/L	36.4	--	--	--	--	--	--
cesium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
chromium, total	E420	0.00050	mg/L	0.00102	--	0.05 mg/L	--	--	--	--
cobalt, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
copper, total	E420	0.00050	mg/L	0.00352	1 mg/L	2 mg/L	--	--	--	--
iron, total	E420	0.010	mg/L	0.011	0.3 mg/L	--	--	--	--	--
lead, total	E420	0.000050	mg/L	0.000208	--	0.005 mg/L	--	--	--	--
lithium, total	E420	0.0010	mg/L	0.0014	--	--	--	--	--	--
magnesium, total	E420	0.0050	mg/L	16.7	--	--	--	--	--	--
manganese, total	E420	0.00010	mg/L	0.00233	0.02 mg/L	0.12 mg/L	--	--	--	--

Analyte	Method	LOR	Unit	KS2204438-001 (Continued)	CDWG AO/OG	CDWG MAC				
Total Metals - Continued										
mercury, total	E508	0.0000050	mg/L	<0.0000050	--	0.001 mg/L	--	--	--	--
molybdenum, total	E420	0.000050	mg/L	0.00125	--	--	--	--	--	--
nickel, total	E420	0.00050	mg/L	<0.00050	--	--	--	--	--	--
phosphorus, total	E420	0.050	mg/L	<0.050	--	--	--	--	--	--
potassium, total	E420	0.050	mg/L	1.49	--	--	--	--	--	--
rubidium, total	E420	0.00020	mg/L	0.00056	--	--	--	--	--	--
selenium, total	E420	0.000050	mg/L	0.000335	--	0.05 mg/L	--	--	--	--
silicon, total	E420	0.10	mg/L	7.76	--	--	--	--	--	--
silver, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
sodium, total	E420	0.050	mg/L	6.85	200 mg/L	--	--	--	--	--
strontium, total	E420	0.00020	mg/L	0.225	--	7 mg/L	--	--	--	--
sulfur, total	E420	0.50	mg/L	4.37	--	--	--	--	--	--
tellurium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--
thallium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
thorium, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
tin, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
titanium, total	E420	0.00030	mg/L	<0.00030	--	--	--	--	--	--
tungsten, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
uranium, total	E420	0.000010	mg/L	0.00250	--	0.02 mg/L	--	--	--	--
vanadium, total	E420	0.00050	mg/L	0.00081	--	--	--	--	--	--
zinc, total	E420	0.0030	mg/L	0.0117	5 mg/L	--	--	--	--	--
zirconium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--

Please refer to the General Comments section for an explanation of any qualifiers detected.

No Breaches Found

Key:

CDWG — Canada Guidelines for Canadian Drinking Water Quality (JUN, 2022)

- AO/OG — Aesthetic Objective/Operational Guideline
- MAC — Maximum Acceptable Concentrations

ALS Canada Ltd.

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **KS2204440**	Page	: 1 of 5
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Chris Matthews	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere Water	Date Samples Received	: 22-Nov-2022 14:45
PO	: ----	Date Analysis Commenced	: 23-Nov-2022
C-O-C number	: ----	Issue Date	: 02-Dec-2022 16:34
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS02 Water		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Parnian Sane	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non -infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
% T/cm	% transmittance per centimetre
µS/cm	microsiemens per centimetre
AU/cm	absorbance units per centimetre
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
MPN/100mL	most probable number per hundred millilitres
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result is greater than the Guideline Upper Limit or the result is lower than the Guideline Lower Limit.
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit .

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	Method	LOR	Unit	Client sample ID: Spruce Crescent DW3 - Raw Water Analysis; Sampling date/time: 22-Nov-2022 10:40; KS2204440-001	CDWG AO/OG	CDWG MAC				
Physical Tests										
absorbance, UV (@ 254nm), unfiltered	E405	0.0050	AU/cm	0.0130	--	--	--	--	--	--
alkalinity, bicarbonate (as CaCO3)	E290	1.0	mg/L	156	--	--	--	--	--	--
alkalinity, carbonate (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, hydroxide (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, phenolphthalein (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, total (as CaCO3)	E290	1.0	mg/L	156	--	--	--	--	--	--
colour, true	E329	5.0	CU	<5.0	15 CU	--	--	--	--	--
conductivity	E100	2.0	µS/cm	326	--	--	--	--	--	--
hardness (as CaCO3), from total Ca/Mg	EC100A	0.60	mg/L	168	--	--	--	--	--	--
Langelier index (@ 15°C)	EC105A	0.010	-	0.484	--	--	--	--	--	--
Langelier index (@ 20°C)	EC105A	0.010	-	0.559	--	--	--	--	--	--
Langelier index (@ 25°C)	EC105A	0.010	-	0.629	--	--	--	--	--	--
Langelier index (@ 4°C)	EC105A	0.010	-	0.310	--	--	--	--	--	--
Langelier index (@ 60°C)	EC105A	0.010	-	1.07	--	--	--	--	--	--
Langelier index (@ 77°C)	EC105A	0.010	-	1.27	--	--	--	--	--	--
pH	E108	0.10	pH units	8.18	7 - 10.5 pH units	--	--	--	--	--
solids, total dissolved [TDS]	E162	10	mg/L	209	500 mg/L	--	--	--	--	--
turbidity	E121	0.10	NTU	0.42	1 NTU	--	--	--	--	--
transmittance, UV (@ 254nm), unfiltered	E405	1.0	% T/cm	97.0	--	--	--	--	--	--
Anions and Nutrients										
ammonia, total (as N)	E298	0.0050	mg/L	0.0126	--	--	--	--	--	--
bromide	E235.Br-L	0.050	mg/L	<0.050	--	--	--	--	--	--
chloride	E235.Cl	0.50	mg/L	3.64	250 mg/L	--	--	--	--	--
fluoride	E235.F	0.020	mg/L	0.082	--	1.5 mg/L	--	--	--	--
Kjeldahl nitrogen, total [TKN]	E318	0.050	mg/L	0.063	--	--	--	--	--	--

Analyte	Method	LOR	Unit	KS2204440-001 (Continued)	CDWG AO/OG	CDWG MAC				
Anions and Nutrients - Continued										
nitrate (as N)	E235.NO3-L	0.0050	mg/L	0.458	--	10 mg/L	--	--	--	--
nitrite (as N)	E235.NO2-L	0.0010	mg/L	0.0019	--	1 mg/L	--	--	--	--
nitrogen, total organic	EC363	0.050	mg/L	0.050	--	--	--	--	--	--
sulfate (as SO4)	E235.SO4	0.30	mg/L	15.4	--	--	--	--	--	--
Cyanides										
cyanide, strong acid dissociable (total)	E333	0.0050	mg/L	0.0060	--	--	--	--	--	--
Organic / Inorganic Carbon										
carbon, total organic [TOC]	E355-L	0.50	mg/L	1.06	--	--	--	--	--	--
Microbiological Tests										
coliforms, total	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
coliforms, Escherichia coli [E. coli]	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
Ion Balance										
anion sum	EC101A	0.10	meq/L	3.58	--	--	--	--	--	--
cation sum (total)	EC101A	0.10	meq/L	3.72	--	--	--	--	--	--
ion balance (APHA)	EC101A	0.010	%	1.92	--	--	--	--	--	--
Total Metals										
aluminum, total	E420	0.0030	mg/L	0.0223	0.1 mg/L	2.9 mg/L	--	--	--	--
antimony, total	E420	0.00010	mg/L	<0.00010	--	0.006 mg/L	--	--	--	--
arsenic, total	E420	0.00010	mg/L	0.00136	--	0.01 mg/L	--	--	--	--
barium, total	E420	0.00010	mg/L	0.0202	--	2 mg/L	--	--	--	--
beryllium, total	E420	0.000100	mg/L	<0.000100	--	--	--	--	--	--
bismuth, total	E420	0.000050	mg/L	<0.000050	--	--	--	--	--	--
boron, total	E420	0.010	mg/L	<0.010	--	5 mg/L	--	--	--	--
cadmium, total	E420	0.0000050	mg/L	0.0000232	--	0.007 mg/L	--	--	--	--
calcium, total	E420	0.050	mg/L	38.3	--	--	--	--	--	--
cesium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
chromium, total	E420	0.00050	mg/L	0.00089	--	0.05 mg/L	--	--	--	--
cobalt, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
copper, total	E420	0.00050	mg/L	0.00494	1 mg/L	2 mg/L	--	--	--	--
iron, total	E420	0.010	mg/L	0.034	0.3 mg/L	--	--	--	--	--
lead, total	E420	0.000050	mg/L	0.000360	--	0.005 mg/L	--	--	--	--
lithium, total	E420	0.0010	mg/L	0.0017	--	--	--	--	--	--
magnesium, total	E420	0.0050	mg/L	17.6	--	--	--	--	--	--
manganese, total	E420	0.00010	mg/L	0.0125	0.02 mg/L	0.12 mg/L	--	--	--	--

Analyte	*Method*	*LOR*	*Unit*	KS2204440-001 (Continued)	**CDWG AO/OG**	**CDWG MAC**				
Total Metals - Continued										
mercury, total	E508	0.0000050	mg/L	<0.0000050	--	0.001 mg/L	--	--	--	--
molybdenum, total	E420	0.000050	mg/L	0.00138	--	--	--	--	--	--
nickel, total	E420	0.00050	mg/L	<0.00050	--	--	--	--	--	--
phosphorus, total	E420	0.050	mg/L	<0.050	--	--	--	--	--	--
potassium, total	E420	0.050	mg/L	1.73	--	--	--	--	--	--
rubidium, total	E420	0.00020	mg/L	0.00088	--	--	--	--	--	--
selenium, total	E420	0.000050	mg/L	0.000390	--	0.05 mg/L	--	--	--	--
silicon, total	E420	0.10	mg/L	8.28	--	--	--	--	--	--
silver, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
sodium, total	E420	0.050	mg/L	7.12	200 mg/L	--	--	--	--	--
strontium, total	E420	0.00020	mg/L	0.260	--	7 mg/L	--	--	--	--
sulfur, total	E420	0.50	mg/L	5.83	--	--	--	--	--	--
tellurium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--
thallium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
thorium, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
tin, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
titanium, total	E420	0.00030	mg/L	0.00181	--	--	--	--	--	--
tungsten, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
uranium, total	E420	0.000010	mg/L	0.00236	--	0.02 mg/L	--	--	--	--
vanadium, total	E420	0.00050	mg/L	0.00102	--	--	--	--	--	--
zinc, total	E420	0.0030	mg/L	0.0229	5 mg/L	--	--	--	--	--
zirconium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--

Please refer to the General Comments section for an explanation of any qualifiers detected.

No Breaches Found

Key:

CDWG — Canada Guidelines for Canadian Drinking Water Quality (JUN, 2022)

- AO/OG — Aesthetic Objective/Operational Guideline
- MAC — Maximum Acceptable Concentrations

ALS Canada Ltd.

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **KS2204437**	Page	: 1 of 5
Client	: **District of Barriere**	Laboratory	: Kamloops - Environmental
Contact	: Chris Matthews	Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0	Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----	Telephone	: 1 250 372 3588
Project	: District of Barriere Water	Date Samples Received	: 22-Nov-2022 14:45
PO	: ----	Date Analysis Commenced	: 23-Nov-2022
C-O-C number	: ----	Issue Date	: 05-Dec-2022 10:54
Sampler	: ----		
Site	: ----		
Quote number	: 20DIOB100KS02 Water		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Parnian Sane	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
% T/cm	% transmittance per centimetre
μS/cm	microsiemens per centimetre
AU/cm	absorbance units per centimetre
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
MPN/100mL	most probable number per hundred millilitres
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result is greater than the Guideline Upper Limit or the result is lower than the Guideline Lower Limit.
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit .

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	Method	LOR	Unit	Client sample ID: Bradford Park PW1 - Raw Water Analysis Sampling date/time: 22-Nov-2022 09:25 KS2204437-001	CDWG AO/OG	CDWG MAC				
Physical Tests										
absorbance, UV (@ 254nm), unfiltered	E405	0.0050	AU/cm	0.119	--	--	--	--	--	--
alkalinity, bicarbonate (as CaCO3)	E290	1.0	mg/L	208	--	--	--	--	--	--
alkalinity, carbonate (as CaCO3)	E290	1.0	mg/L	9.0	--	--	--	--	--	--
alkalinity, hydroxide (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, phenolphthalein (as CaCO3)	E290	1.0	mg/L	4.5	--	--	--	--	--	--
alkalinity, total (as CaCO3)	E290	1.0	mg/L	217	--	--	--	--	--	--
colour, true	E329	5.0	CU	<5.0	15 CU	--	--	--	--	--
conductivity	E100	2.0	µS/cm	434	--	--	--	--	--	--
hardness (as CaCO3), from total Ca/Mg	EC100A	0.60	mg/L	217	--	--	--	--	--	--
Langelier index (@ 15°C)	EC105A	0.010	-	0.911	--	--	--	--	--	--
Langelier index (@ 20°C)	EC105A	0.010	-	0.984	--	--	--	--	--	--
Langelier index (@ 25°C)	EC105A	0.010	-	1.05	--	--	--	--	--	--
Langelier index (@ 4°C)	EC105A	0.010	-	0.738	--	--	--	--	--	--
Langelier index (@ 60°C)	EC105A	0.010	-	1.49	--	--	--	--	--	--
Langelier index (@ 77°C)	EC105A	0.010	-	1.69	--	--	--	--	--	--
pH	E108	0.10	pH units	8.41	7 - 10.5 pH units	--	--	--	--	--
solids, total dissolved [TDS]	E162	10	mg/L	284	500 mg/L	--	--	--	--	--
turbidity	E121	0.10	NTU	0.24	1 NTU	--	--	--	--	--
transmittance, UV (@ 254nm), unfiltered	E405	1.0	% T/cm	76.0	--	--	--	--	--	--
Anions and Nutrients										
ammonia, total (as N)	E298	0.0050	mg/L	0.0308	--	--	--	--	--	--
bromide	E235.Br-L	0.050	mg/L	<0.050	--	--	--	--	--	--
chloride	E235.Cl	0.50	mg/L	0.66	250 mg/L	--	--	--	--	--
fluoride	E235.F	0.020	mg/L	0.190	--	1.5 mg/L	--	--	--	--
Kjeldahl nitrogen, total [TKN]	E318	0.050	mg/L	<0.050	--	--	--	--	--	--

Analyte	*Method*	*LOR*	*Unit*	KS2204437-001 (Continued)	**CDWG AO/OG**	**CDWG MAC**				
Anions and Nutrients - Continued										
nitrate (as N)	E235.NO3-L	0.0050	mg/L	<0.0050	--	10 mg/L	--	--	--	--
nitrite (as N)	E235.NO2-L	0.0010	mg/L	<0.0010	--	1 mg/L	--	--	--	--
nitrogen, total organic	EC363	0.050	mg/L	<0.050	--	--	--	--	--	--
sulfate (as SO4)	E235.SO4	0.30	mg/L	27.8	--	--	--	--	--	--
Cyanides										
cyanide, strong acid dissociable (total)	E333	0.0050	mg/L	<0.0050	--	--	--	--	--	--
Organic / Inorganic Carbon										
carbon, total organic [TOC]	E355-L	0.50	mg/L	0.54	--	--	--	--	--	--
Microbiological Tests										
coliforms, total	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
coliforms, Escherichia coli [E. coli]	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
Ion Balance										
anion sum	EC101A	0.10	meq/L	4.94	--	--	--	--	--	--
cation sum (total)	EC101A	0.10	meq/L	5.01	--	--	--	--	--	--
ion balance (APHA)	EC101A	0.010	%	0.704	--	--	--	--	--	--
Total Metals										
aluminum, total	E420	0.0030	mg/L	0.0039	0.1 mg/L	2.9 mg/L	--	--	--	--
antimony, total	E420	0.00010	mg/L	<0.00010	--	0.006 mg/L	--	--	--	--
arsenic, total	E420	0.00010	mg/L	0.00669	--	0.01 mg/L	--	--	--	--
barium, total	E420	0.00010	mg/L	0.0386	--	2 mg/L	--	--	--	--
beryllium, total	E420	0.000100	mg/L	<0.000100	--	--	--	--	--	--
bismuth, total	E420	0.000050	mg/L	<0.000050	--	--	--	--	--	--
boron, total	E420	0.010	mg/L	0.011	--	5 mg/L	--	--	--	--
cadmium, total	E420	0.0000050	mg/L	0.0000238	--	0.007 mg/L	--	--	--	--
calcium, total	E420	0.050	mg/L	46.2	--	--	--	--	--	--
cesium, total	E420	0.000010	mg/L	0.000016	--	--	--	--	--	--
chromium, total	E420	0.00050	mg/L	<0.00050	--	0.05 mg/L	--	--	--	--
cobalt, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
copper, total	E420	0.00050	mg/L	0.00150	1 mg/L	2 mg/L	--	--	--	--
iron, total	E420	0.010	mg/L	0.076	0.3 mg/L	--	--	--	--	--
lead, total	E420	0.000050	mg/L	0.000072	--	0.005 mg/L	--	--	--	--
lithium, total	E420	0.0010	mg/L	0.0039	--	--	--	--	--	--
magnesium, total	E420	0.0050	mg/L	24.7	--	--	--	--	--	--
manganese, total	E420	0.00010	mg/L	0.104	0.02 mg/L	0.12 mg/L	--	--	--	--

Analyte	Method	LOR	Unit	KS2204437-001 (Continued)	CDWG AO/OG	CDWG MAC				
Total Metals - Continued										
mercury, total	E508	0.0000050	mg/L	<0.0000050	--	0.001 mg/L	--	--	--	--
molybdenum, total	E420	0.000050	mg/L	0.00363	--	--	--	--	--	--
nickel, total	E420	0.00050	mg/L	<0.00050	--	--	--	--	--	--
phosphorus, total	E420	0.050	mg/L	0.065	--	--	--	--	--	--
potassium, total	E420	0.050	mg/L	3.24	--	--	--	--	--	--
rubidium, total	E420	0.00020	mg/L	0.00397	--	--	--	--	--	--
selenium, total	E420	0.000050	mg/L	<0.000050	--	0.05 mg/L	--	--	--	--
silicon, total	E420	0.10	mg/L	15.6	--	--	--	--	--	--
silver, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
sodium, total	E420	0.050	mg/L	13.3	200 mg/L	--	--	--	--	--
strontium, total	E420	0.00020	mg/L	0.480	--	7 mg/L	--	--	--	--
sulfur, total	E420	0.50	mg/L	9.92	--	--	--	--	--	--
tellurium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--
thallium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
thorium, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
tin, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
titanium, total	E420	0.00030	mg/L	<0.00030	--	--	--	--	--	--
tungsten, total	E420	0.00010	mg/L	0.00063	--	--	--	--	--	--
uranium, total	E420	0.000010	mg/L	0.000188	--	0.02 mg/L	--	--	--	--
vanadium, total	E420	0.00050	mg/L	0.00137	--	--	--	--	--	--
zinc, total	E420	0.0030	mg/L	0.0082	5 mg/L	--	--	--	--	--
zirconium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--

Please refer to the General Comments section for an explanation of any qualifiers detected.

Summary of Guideline Breaches by Sample

SampleID/Client ID	Matrix	Analyte	Analyte Summary	Guideline	Category	Result	Limit
Bradford Park PW1 - Raw Water Analysis	Water	manganese, total	Based on taste and staining of laundry and plumbing fixtures.	CDWG	AO/OG	0.104 mg/L	0.02 mg/L

Key:

CDWG — Canada Guidelines for Canadian Drinking Water Quality (JUN, 2022)

AO/OG — Aesthetic Objective/Operational Guideline

MAC — Maximum Acceptable Concentrations

ALS Canada Ltd.

right solutions.
right partner.

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **KS2204435**		Page	: 1 of 5
Client	: **District of Barriere**		Laboratory	: Kamloops - Environmental
Contact	: Chris Matthews		Account Manager	: Amanda Lampreau
Address	: PO Box 219 Barriere BC Canada V0E 1E0		Address	: 1445 McGill Road, Unit 2B Kamloops, British Columbia Canada V2C 6K7
Telephone	: ----		Telephone	: 1 250 372 3588
Project	: Louis Creek Water		Date Samples Received	: 22-Nov-2022 14:45
PO	: ----		Date Analysis Commenced	: 23-Nov-2022
C-O-C number	: ----		Issue Date	: 05-Dec-2022 10:51
Sampler	: ----			
Site	: ----			
Quote number	: 20DIOB100KS02 Water			
No. of samples received	: 1			
No. of samples analysed	: 1			

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Amanda Lampreau	Laboratory _ Supervisor	Microbiology, Kamloops, British Columbia
Caitlin Macey	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Cindy Tang	Team Leader - Inorganics	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Inorganics, Burnaby, British Columbia
Kevin Duarte	Supervisor - Metals ICP Instrumentation	Metals, Burnaby, British Columbia
Parnian Sane	Analyst	Metals, Burnaby, British Columbia

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
% T/cm	% transmittance per centimetre
µS/cm	microsiemens per centimetre
AU/cm	absorbance units per centimetre
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
MPN/100mL	most probable number per hundred millilitres
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result is greater than the Guideline Upper Limit or the result is lower than the Guideline Lower Limit.
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit .

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water)**

Analyte	Method	LOR	Unit	Client sample ID: Louis Creek - Raw Water Analysis Sampling date/time: 22-Nov-2022 08:35 KS2204435-001	CDWG AO/OG	CDWG MAC				
Physical Tests										
absorbance, UV (@ 254nm), unfiltered	E405	0.0050	AU/cm	0.0110	--	--	--	--	--	--
alkalinity, bicarbonate (as CaCO3)	E290	1.0	mg/L	186	--	--	--	--	--	--
alkalinity, carbonate (as CaCO3)	E290	1.0	mg/L	7.2	--	--	--	--	--	--
alkalinity, hydroxide (as CaCO3)	E290	1.0	mg/L	<1.0	--	--	--	--	--	--
alkalinity, phenolphthalein (as CaCO3)	E290	1.0	mg/L	3.6	--	--	--	--	--	--
alkalinity, total (as CaCO3)	E290	1.0	mg/L	193	--	--	--	--	--	--
colour, true	E329	5.0	CU	<5.0	15 CU	--	--	--	--	--
conductivity	E100	2.0	µS/cm	427	--	--	--	--	--	--
hardness (as CaCO3), from total Ca/Mg	EC100A	0.60	mg/L	223	--	--	--	--	--	--
Langelier index (@ 15°C)	EC105A	0.010	-	0.954	--	--	--	--	--	--
Langelier index (@ 20°C)	EC105A	0.010	-	1.03	--	--	--	--	--	--
Langelier index (@ 25°C)	EC105A	0.010	-	1.10	--	--	--	--	--	--
Langelier index (@ 4°C)	EC105A	0.010	-	0.780	--	--	--	--	--	--
Langelier index (@ 60°C)	EC105A	0.010	-	1.54	--	--	--	--	--	--
Langelier index (@ 77°C)	EC105A	0.010	-	1.73	--	--	--	--	--	--
pH	E108	0.10	pH units	8.38	7 - 10.5 pH units	--	--	--	--	--
solids, total dissolved [TDS]	E162	10	mg/L	298	500 mg/L	--	--	--	--	--
turbidity	E121	0.10	NTU	<0.10	1 NTU	--	--	--	--	--
transmittance, UV (@ 254nm), unfiltered	E405	1.0	% T/cm	97.5	--	--	--	--	--	--
Anions and Nutrients										
ammonia, total (as N)	E298	0.0050	mg/L	0.0193	--	--	--	--	--	--
bromide	E235.Br-L	0.050	mg/L	<0.050	--	--	--	--	--	--
chloride	E235.Cl	0.50	mg/L	2.26	250 mg/L	--	--	--	--	--
fluoride	E235.F	0.020	mg/L	0.106	--	1.5 mg/L	--	--	--	--
Kjeldahl nitrogen, total [TKN]	E318	0.050	mg/L	<0.050	--	--	--	--	--	--

Analyte	Method	LOR	Unit	KS2204435-001 (Continued)	CDWG AO/OG	CDWG MAC				
Anions and Nutrients - Continued										
nitrate (as N)	E235.NO3-L	0.0050	mg/L	<0.0050	--	10 mg/L	--	--	--	--
nitrite (as N)	E235.NO2-L	0.0010	mg/L	<0.0010	--	1 mg/L	--	--	--	--
nitrogen, total organic	EC363	0.050	mg/L	<0.050	--	--	--	--	--	--
sulfate (as SO4)	E235.SO4	0.30	mg/L	38.4	--	--	--	--	--	--
Cyanides										
cyanide, strong acid dissociable (total)	E333	0.0050	mg/L	<0.0050	--	--	--	--	--	--
Organic / Inorganic Carbon										
carbon, total organic [TOC]	E355-L	0.50	mg/L	0.94	--	--	--	--	--	--
Microbiological Tests										
coliforms, total	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
coliforms, Escherichia coli [E. coli]	E010	1	MPN/100mL	<1	--	1 MPN/100mL	--	--	--	--
Ion Balance										
anion sum	EC101A	0.10	meq/L	4.72	--	--	--	--	--	--
cation sum (total)	EC101A	0.10	meq/L	4.77	--	--	--	--	--	--
ion balance (APHA)	EC101A	0.010	%	0.527	--	--	--	--	--	--
Total Metals										
aluminum, total	E420	0.0030	mg/L	0.0046	0.1 mg/L	2.9 mg/L	--	--	--	--
antimony, total	E420	0.00010	mg/L	<0.00010	--	0.006 mg/L	--	--	--	--
arsenic, total	E420	0.00010	mg/L	0.00151	--	0.01 mg/L	--	--	--	--
barium, total	E420	0.00010	mg/L	0.00802	--	2 mg/L	--	--	--	--
beryllium, total	E420	0.000100	mg/L	<0.000100	--	--	--	--	--	--
bismuth, total	E420	0.000050	mg/L	<0.000050	--	--	--	--	--	--
boron, total	E420	0.010	mg/L	<0.010	--	5 mg/L	--	--	--	--
cadmium, total	E420	0.0000050	mg/L	<0.0000050	--	0.007 mg/L	--	--	--	--
calcium, total	E420	0.050	mg/L	61.9	--	--	--	--	--	--
cesium, total	E420	0.000010	mg/L	0.000019	--	--	--	--	--	--
chromium, total	E420	0.00050	mg/L	<0.00050	--	0.05 mg/L	--	--	--	--
cobalt, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
copper, total	E420	0.00050	mg/L	0.00116	1 mg/L	2 mg/L	--	--	--	--
iron, total	E420	0.010	mg/L	0.061	0.3 mg/L	--	--	--	--	--
lead, total	E420	0.000050	mg/L	<0.000050	--	0.005 mg/L	--	--	--	--
lithium, total	E420	0.0010	mg/L	0.0021	--	--	--	--	--	--
magnesium, total	E420	0.0050	mg/L	16.7	--	--	--	--	--	--
manganese, total	E420	0.00010	mg/L	0.0668	0.02 mg/L	0.12 mg/L	--	--	--	--

Analyte	Method	LOR	Unit	KS2204435-001 (Continued)	CDWG AO/OG	CDWG MAC				
Total Metals - Continued										
mercury, total	E508	0.0000050	mg/L	<0.0000050	--	0.001 mg/L	--	--	--	--
molybdenum, total	E420	0.000050	mg/L	0.00263	--	--	--	--	--	--
nickel, total	E420	0.00050	mg/L	<0.00050	--	--	--	--	--	--
phosphorus, total	E420	0.050	mg/L	0.068	--	--	--	--	--	--
potassium, total	E420	0.050	mg/L	3.49	--	--	--	--	--	--
rubidium, total	E420	0.00020	mg/L	0.00255	--	--	--	--	--	--
selenium, total	E420	0.000050	mg/L	<0.000050	--	0.05 mg/L	--	--	--	--
silicon, total	E420	0.10	mg/L	11.6	--	--	--	--	--	--
silver, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
sodium, total	E420	0.050	mg/L	4.95	200 mg/L	--	--	--	--	--
strontium, total	E420	0.00020	mg/L	0.373	--	7 mg/L	--	--	--	--
sulfur, total	E420	0.50	mg/L	13.7	--	--	--	--	--	--
tellurium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--
thallium, total	E420	0.000010	mg/L	<0.000010	--	--	--	--	--	--
thorium, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
tin, total	E420	0.00010	mg/L	<0.00010	--	--	--	--	--	--
titanium, total	E420	0.00030	mg/L	<0.00030	--	--	--	--	--	--
tungsten, total	E420	0.00010	mg/L	0.00010	--	--	--	--	--	--
uranium, total	E420	0.000010	mg/L	0.000025	--	0.02 mg/L	--	--	--	--
vanadium, total	E420	0.00050	mg/L	<0.00050	--	--	--	--	--	--
zinc, total	E420	0.0030	mg/L	0.0035	5 mg/L	--	--	--	--	--
zirconium, total	E420	0.00020	mg/L	<0.00020	--	--	--	--	--	--

Please refer to the General Comments section for an explanation of any qualifiers detected.

Summary of Guideline Breaches by Sample

SampleID/Client ID	Matrix	Analyte	Analyte Summary	Guideline	Category	Result	Limit
Louis Creek - Raw Water Analysis	Water	manganese, total	Based on taste and staining of laundry and plumbing fixtures.	CDWG	AO/OG	0.0668 mg/L	0.02 mg/L

Key:

CDWG — Canada Guidelines for Canadian Drinking Water Quality (JUN, 2022)

AO/OG — Aesthetic Objective/Operational Guideline

MAC — Maximum Acceptable Concentrations