

**GROUNDWATER ASSESSMENT REPORT FOR  
CRYSTAL MOUNTAIN RETREAT CENTRE,  
GALIANO ISLAND**

Lot A, District Lots 88 and 89, Plan VIP68079 and  
Lot 9, District Lot 90, Plan 31200  
Galiano Island, Cowichan District

**Prepared for:**

**CRYSTAL MOUNTAIN SOCIETY**  
PO Box 123  
Galiano Island,  
British Columbia V0N 1P0

**Submitted by:**

Hy-Geo Consulting  
Victoria, British Columbia

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## EXECUTIVE SUMMARY

This report assesses the overall groundwater supply requirements for the Crystal Mountain Retreat Centre and provides an opinion on meeting the water demands from an existing well on the property. The maximum daily requirements or maximum day demand (MDD) that would likely occur at the retreat centre is estimated at 2839 liters/day or 625 Imperial gallons day which would serve a maximum of 30 persons accommodated on site. An existing well at the centre, designated the central well, was pump tested in October 2015 for a minimum period of 12 hours at a constant rate of 8.07 L/min and evaluated to have a long term yield of 2.826 L/min (4069 L/day) with a 70% safety factor. This calculated yield is 43% more than the estimated water supply requirements of 2839 L/day and would amount to a total potential supply of 1.49 million litres/year. Testing was conducted at the optimal time of the year when water levels are at their seasonal lowest.

No discernable pumping effects were observed in two observation wells at the centre that were monitored during the October testing. Based on these monitoring results, use of the central well at a rate of 1.972 L/min (2839 L/day) would have no measureable effect on any of the neighbouring wells or surface water sources in the region.

Water quality testing of the central well (*WID 23227*) indicates that the water meets or exceeds *Guidelines for Canadian Drinking Water* (Federal-Provincial-Territorial Committee on Drinking Water, 2015) for all parameters tested except for total coliforms. Total coliforms of 3 and 1 CFU/100mL were reported for two samples taken after chlorination of the well. No *E.coli* was detected. The source of the coliforms is not known and could be due to grey water discharge in the vicinity of the well and /or natural sources such as decaying vegetation in nearby wetland areas. Previous occurrences of coliform bacteria have been effectively reduced by well chlorination. As a precautionary measure against any future potential sources of coliform bacteria, water from the existing well source should be treated with an appropriately designed and maintained ultraviolet irradiation (UV) or chlorination treatment system.

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# GROUNDWATER ASSESSMENT REPORT FOR CRYSTAL MOUNTAIN RETREAT CENTRE, GALIANO ISLAND

## INTRODUCTION

Hy-Geo Consulting was retained by the Crystal Mountain Society (CMS) in August 2015, to provide hydrogeological engineering services to assess the quantity and quality of available groundwater for all proposed uses at their retreat centre on Galiano Island and to identify any potential risks to groundwater or surface waters.

The Crystal Mountain Retreat Centre (CMRC) is located adjacent to and east of Porlier Pass Road at the north end of the island near Spotlight Cove (Figure 1). The retreat centre encompasses Lot A, District Lots 88 and 89, Plan VIP68079 and Lot 9, District Lot 90, Plan 31200, Galiano Island, Cowichan District. Lot A is zoned Forrest 1 (F1) and Lot 9 is zoned Rural 2 (R2) in the *Galiano Land Use Bylaw* (Islands Trust Staff Report, 2015). The society has submitted an application to rezone the two lots to permit a year-round forest retreat centre on both lots. The Crystal Mountain Retreat Centre property is situated directly upslope of several waterfront properties near Spotlight Cove (Figure 1) where residential wells are reported. Three wells are located on the Crystal Mountain property, with the central well currently serving the water requirements of the retreat centre.

This report assesses the overall groundwater supply requirements for the Crystal Mountain Retreat Centre and provides an opinion on meeting the water demands from an existing well on the property. An assessment is also provided on the potential effects of the proposed groundwater use at the CMRC on neighbouring wells and overall groundwater quantity and quality in the region.

### Scope of Work

Scope of the work carried out by Hy-Geo-Consulting included:

- (a) reviewing and examining existing hydrogeologic data and reports for the property and adjoining region including topography, geology, climatic and well record information;
- (b) conducting one or more site visits to examine local geology, topography, drainage, surface water sources, existing well conditions, water supply infrastructure, neighbouring wells and land use;
- (c) determining the water uses and total estimated water demands for the retreat centre;

- (d) assessing the quantity and quality of the existing water sources on the property and their uses and determining whether any additional water quantity or water quality testing or monitoring may be required;
- (e) undertaking a minimum 12-hour constant rate pumping test of the central well on the property to determine its long-term capacity to meet the estimated total water demand, including sampling of water quality; This work was planned and completed in conjunction with a qualified pump testing contractor, Red Williams of Red Williams Well Drilling Ltd.
- (f) identifying any potential impacts arising from the proposed use and development of the property on groundwater and surface water;
- (g) reviewing and analyzing the results of the above investigations; and
- (h) preparing a final report suitable for submission to the Local Islands Trust Committee, Vancouver Island Health Authority (VIHA) and Capital Regional District.

## Topography and Drainage

The retreat property is situated along an irregular southwest facing slope (Figure 1), comprised of a series of bedrock ridges trending northwest to southeast with elevations rising from 20 metres above sea along Porlier Pass Road to just over 120 metres above sea level at the eastern end of the property. The central portion of the property lies between elevations 40 to 60 m. Towards the east, elevations rise abruptly along an escarpment to above 120 m. Spotlight Creek, appears to originate along the base of the escarpment and is the main drainage feature on the property flowing southeasterly towards the southeast boundary of the property and then southwesterly towards Spotlight Cove. Erickson (2014) reports that Spotlight Creek is intermittent and runs only during peak rainfall months from November through to the spring. No water flow was observed in the creek during the period of field investigations carried out in August, September and early October 2015. An existing surface water licence (No. C058557) for domestic use of 2273 L/day (Figure 1) is registered on Spotlight Creek. An examination of the intake in October 2015 indicated that it does not appear to have been active for some time. Another licence (No. C106042) for domestic use of 682 L/day exists on Stemo Spring. An examination of this source in October 2015 did not show any apparent water flow.

## Climate

The climate of Galiano Island is characterized by cool dry summers and humid mild winters. Based on records from 1951 to 1980 (Environment Canada, 198\_) the average annual precipitation for a station on Galiano Island was 33.7 inches

(856 mm). Over 90 % of this total annual amount fell as rain with over 60% of the total falling during the period from November to February. Newer data for the 1981-2010 normal period reported by Environment Canada (2015) for Mayne Island and Saturna Island weather stations indicates annual mean precipitation of 842.0 and 812.2 mm., respectively. With the absence of a current climate station on Galiano Island, the Saturna Campon climate station may be considered representative of the general longer-term (monthly) precipitation patterns on Galiano (Figure 2). Global climate models (Allen *et al.*, 2008) suggest precipitation may increase slightly in the future, particularly during the winter months. Table 1 indicates that the cumulative precipitation for the Saturna Campon CS climate station was 90.9 percent of normal from January to end of September 2015. The months of April to July 2015 were particularly dry and well below normal while September 2015 was relatively wet and well above normal.

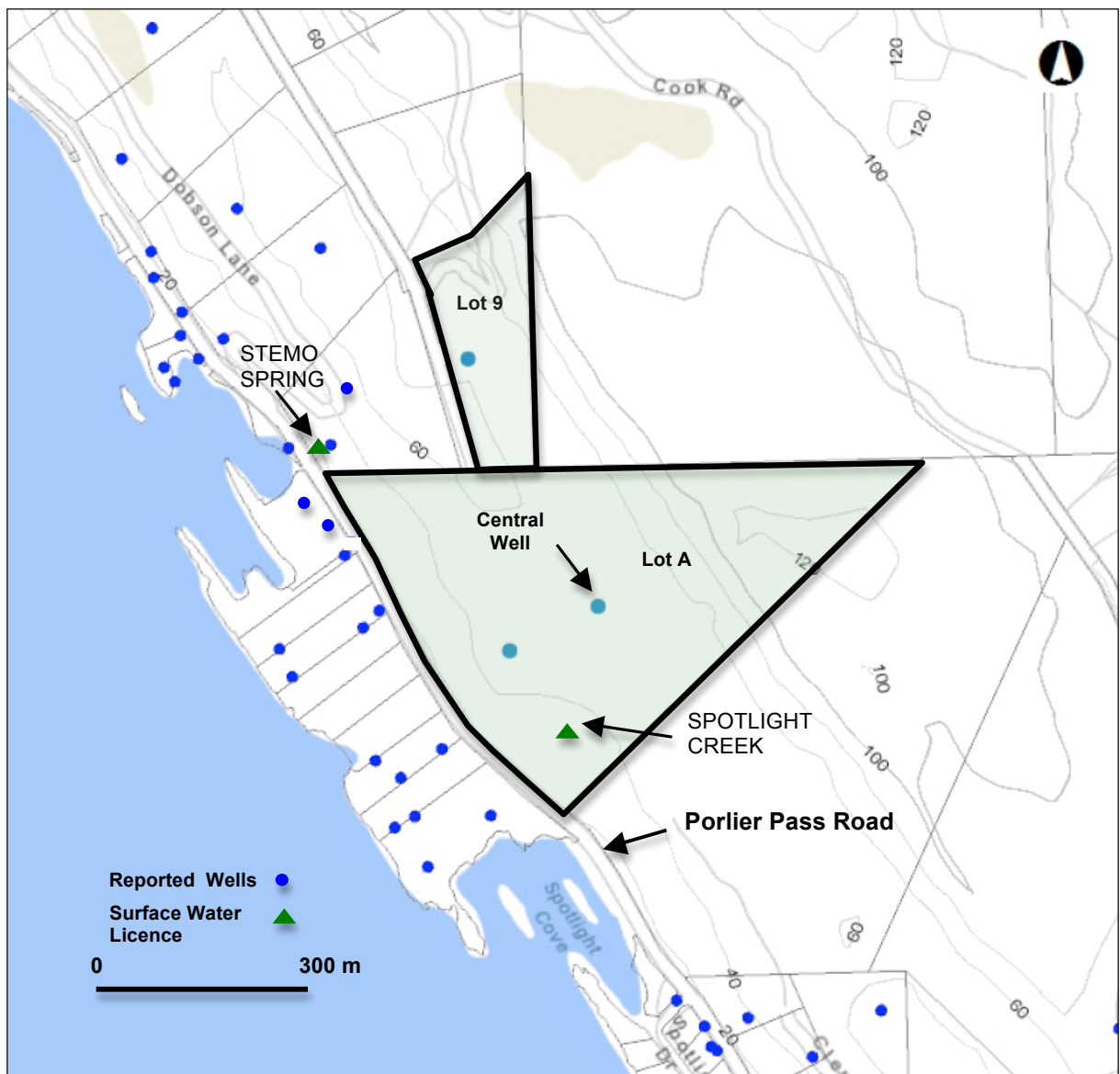


Figure 1. Location of Crystal Mountain properties, wells and water licences. Basemap and from Ministry of Environment (2015a).

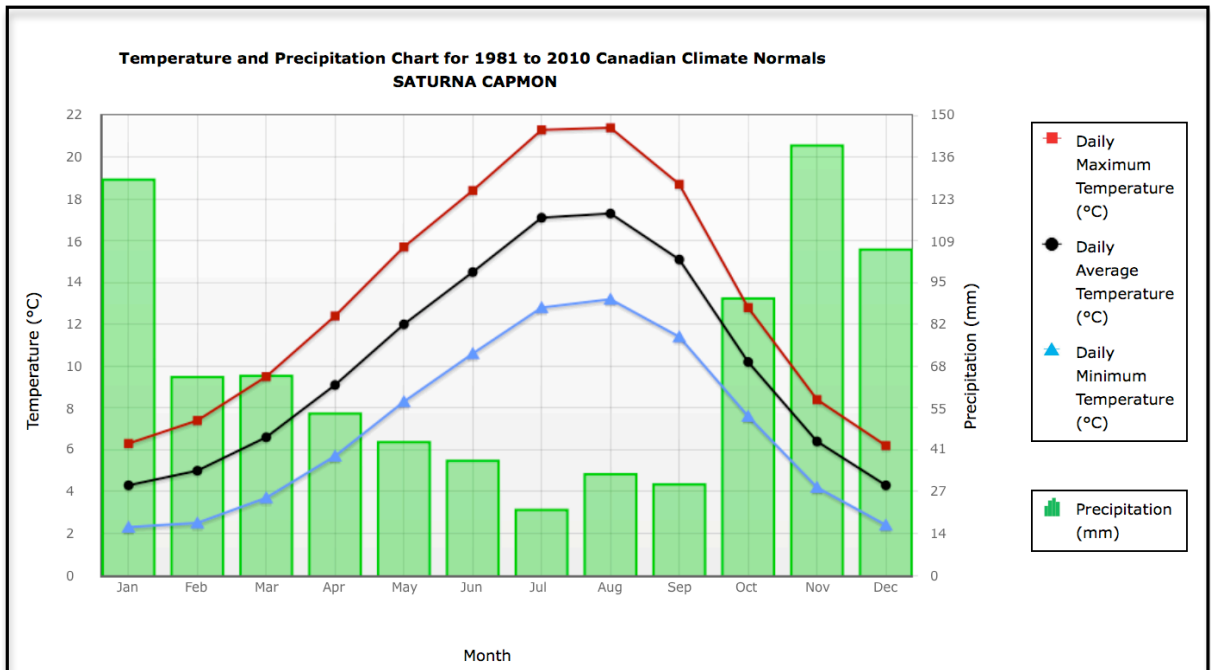


Figure 2. Graph of monthly normal monthly precipitation for Saturna Island Campon station (Climate ID. 1017098). Graph from Government of Canada (2015a).

Table 1. Monthly precipitation data for Saturna Campon CS climate station (Climate ID. 1017098) in 2015 compared to 1981-2010 normals

Month	Precipitation in 2015 (mm)	Precipitation Normal (mm)	Percent of Normal	Cumulative Percent of Normal
January	115.4	129.0	89.5	89.5
February	72.5*	64.6	112.2	97.1
March	107.5	65.0	165.4	114.2
April	16.2*	52.7	30.7	100.1
May	2.6	43.4	6.0	88.6
June	4.8*	37.3	12.9	81.4
July	7.5	21.3	35.2	79.0
August	27.8	32.9	84.5	79.4
September	78.4	29.6	264.9	90.9

\* Incomplete data.  
Data from Government of Canada (2015b).

### Hydrogeologic Conditions

The general groundwater conditions of Galiano Island have been reported by several authors including Harrison (1994), Kohut and Johanson (1998) and Waterline Resources Inc. (2011). Galiano is comprised of sedimentary clastic rocks belonging to the Nanaimo Group of Late Cretaceous age (Muller and Jeletzky, 1970). These consist of alternating interbeds of sandstone, mudstone,



siltstone, shale and some conglomerate. The retreat centre property and surrounding region is principally underlain by the Gabriola Formation that is dominantly sandstone with some shale (mudstone) interbeds.

Groundwater on the island is found primarily in open fractures in the bedrock formations as they are encountered during drilling of water wells. These fractures constitute the major zones for groundwater storage and movement. The retreat centre property lies entirely within the North Trincomali groundwater region as outlined by Kohut and Johanson (1998). In 1998, Kohut and Johanson estimated the demand to groundwater in storage ratio in this region to be relatively low at 0.11. Existing well density at that time was also determined to be low to medium at 0.077 wells/acre. The current well density based on the number of wells reported in the Ministry of Environment WELL database (Ministry of Environment, 2015) is 0.086 wells/acre. Higher well densities also occur locally along the coastline.

From historic observation well data in the Gulf Islands, groundwater levels in bedrock wells generally rise and fall with the seasons, in response to available precipitation, becoming highest during the late fall and winter months. Water levels then normally decline during the dry summer months reaching seasonal lows in the late fall months (Kohut *et al.*, 1984). Figure 3 shows the groundwater level trend for 2015 falling below historic mean levels from May to September as shown in the graph of provincial observation well 258.

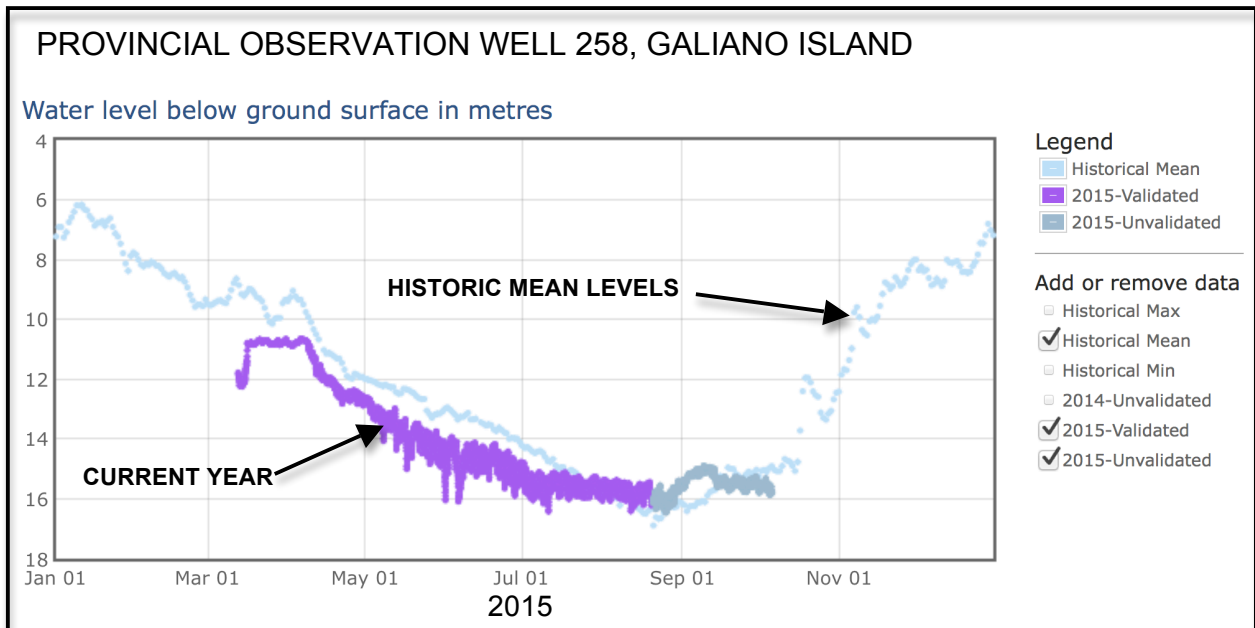


Figure 3. Groundwater level trend in 2015 compared to historic mean data for Observation Well 258. From Ministry of Environment (2015b).

## EXISTING WELLS

Figure 4 shows the location of 30 known and reported water wells and springs within 0.64 km. of the central well on the Crystal Mountain property. It should be noted that all well locations have not been verified in the field. Table 2 provides a brief description of the wells within the 0.64 km radius of the central well. Wells currently within the Ministry of Environment's database are identified in Table 2 with a Ministry well tag number (WTN) that is a unique computer generated identification number. In recent years, the Ministry has also provided well identification plate (WID) numbers to well drillers for attaching to the casing of new wells for their identification in the field.

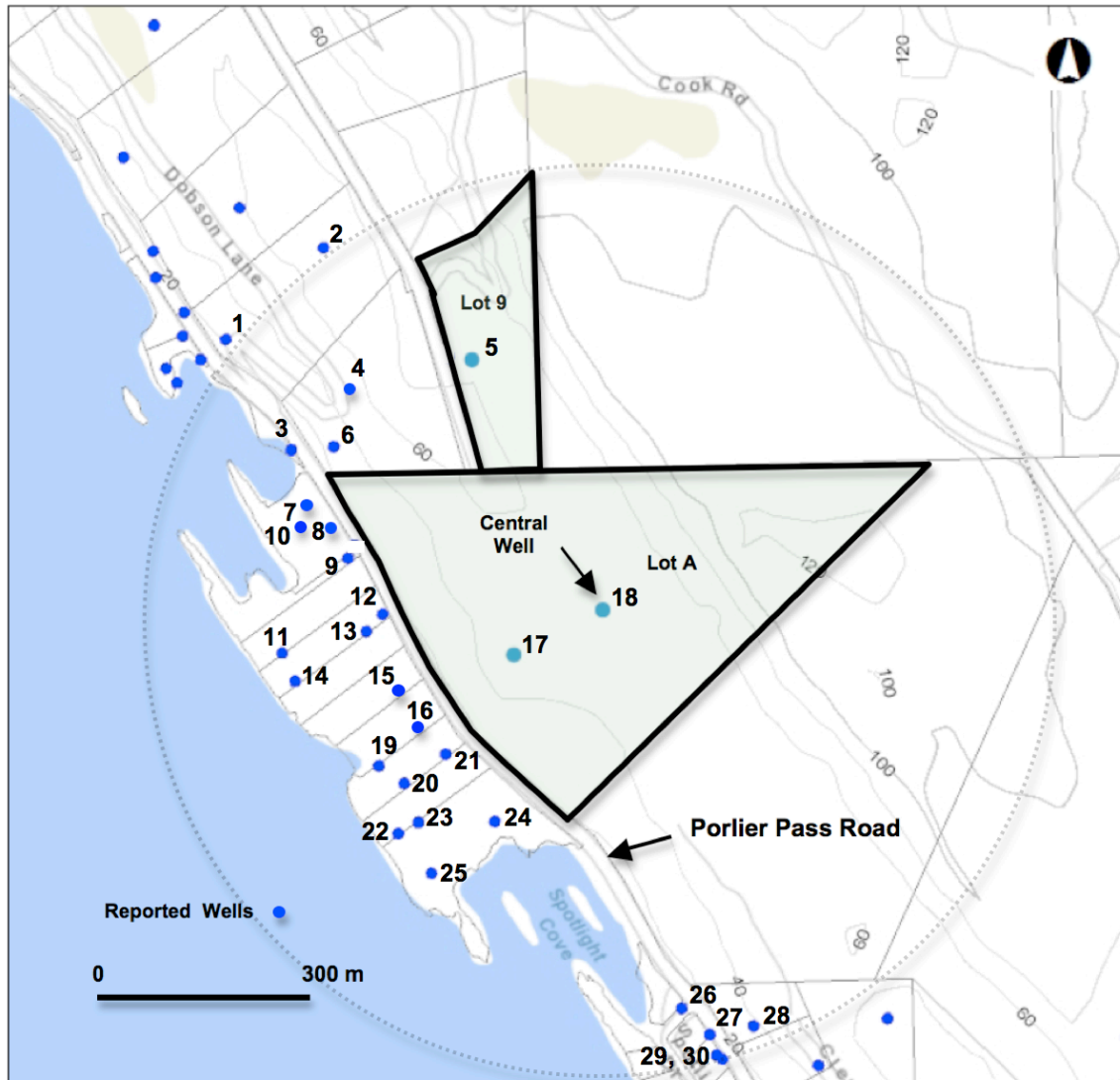


Figure 4. Existing wells and springs within 0.64 km of the central well on Crystal Mountain property.

Table 2. Summary of reported water wells and springs at and in vicinity of Crystal Mountain Retreat Centre.

Site Number on Map	Well Tag No. (WTN)	Well Identification No. (WID)	Address	Depth Drilled/ Dug (feet)	Depth Well Drilled/ Dug (m)	Diameter (in)	Diameter (cm)	Driller's Estimated Yield Value	Yield Unit Description	Water Depth (feet)	Water Depth (m)	Depth to Bedrock (feet)	Depth to Bedrock (m)	Construction Start Date	General Remarks	Legal District Lot	Legal Plan	Lot No.	Owner When Constructed	Well Use
1	49351			172	52.43	6	15.24	4	GPM			14	4.27	14-Oct-81	4 gpm at 158-164 feet	90	31200	7	Brian Preston	Private Domestic
2	97038			400	121.92			6	GPM			6	1.83	04/15/(2008)	0.5 gpm at 95 feet, 1.5 gpm at 345 feet, 4 gpm at 375	90	31200	7	Harding & Nation	Private Domestic
3	13409			50	15.24			8 ?	GPM	45	13.72			01/01/1950*		90	4164	5	Halling	Unknown Well Use
4		26548				6	15.24													
5	56583	23228		280	85.34	6	15.24	6	GPM	55	16.76	9	2.74	30-Sep-86		90	31200	9	Crystal Mountain Retreat Centre	Private Domestic
6	13368							150	GPD	0				01/01/1950*	spring, from crack in sandstone beside road, east side, Licence C.L. 24457	90			Stafford	Drinking Water
7	13358		21035 Porlier Pass Road	14	4.27									01/01/1950*		89	12139	A	W.J. Stafford	Garden
8	18719		21035 Porlier Pass Road	80	24.38	5	12.70	5	GPM	8	2.44	20	6.10	01-Jun-64		89	12139	A	W.J. Stafford	Private Domestic
9	105861		20925 Porlier Pass Road	100	30.48			5	GPM			13	3.96	05/14/(2009)					Gray	Private Domestic
10	96239			84	25.60	6	15.24	2	GPM	11	3.35			04-Dec-92	well unstable, requires well liner, pitless unit welded	89	12139	A	Grey	Water Supply System
11	27570			97	29.57	6	15.24	5	GPM	11	3.35	15	4.57	24-Jan-73	15 gph at 35 feet, 5 gpm at 89 feet	89	22608	1	Stewart	Private Domestic
12	42140			146	44.50	6	15.24	5	GPM	10	3.05	13	3.96	20-Apr-79		89	22608	2	E. Scott	Unknown Well Use
13	40306			115	35.05	6	15.24	0.66	GPM	7	2.13	12	3.66	09-Aug-78	20 gph at 58, 20 gph at 75 and 6 gph at 106 ft	89	22608	2	E. Scott	Unknown Well Use
14	31547			110	33.53	6	15.24	4	GPM	18	5.49	12	3.66	09-Oct-74		89	22608	2	E. Scott	Unknown Well Use
15			20775 Porlier Pass Road			6	15.24													
16			20705 Porlier Pass Road			6	15.24													
17		23229		183	55.78	6	15.24	7	GPM	68	20.73	24	7.32	25-Nov-94	7 gpm at 177 feet				Fibermax	Private Domestic
18		23227		125	38.10	6	15.24	5	GPM	60	18.29	4	1.22	19-Aug-94	Well # 2, 1 gpm at 100 feet and 5 gpm at 120 feet				Fibermax	Private Domestic
19	32075			80	24.38	6	15.24	3	GPM	11	3.35	15	4.57	07-Feb-75	1 gpm at 22 ft, 2 gpm at 36 feet	89	22608	5	John Innes	Unknown Well Use
20	37329			70	21.34	6	15.24	2	GPM	19	5.79	12	3.66	22-Jun-77	1 gpm at 58 ft, 2 gpm at 63 feet	89	22608	6	N. Ritchie	Unknown Well Use
21	52553			182	55.47	6	15.24	2	GPM	10	3.05	10	3.05	03-Aug-83	80 gph at 82 ft, 40 gph at 175 feet	89	22608	6	Alice Alexander & Nora Ritchie	Private Domestic
22	35507			55	16.76	6	15.24	0.33	GPM			1	0.30	19-Aug-76	10 gph at 40 ft, 10 gph at 55 feet, salt water well	89	22608	7	Alistair F. Ross	Unknown Well Use
23	35516			80	24.38	6	15.24	3	GPM	16	4.88	19	5.79	22-Aug-76	15 gph at 30 ft, 45 gph at 48 feet and 2 gpm at 73 feet	89	22608	7	Alistair F. Ross	Unknown Well Use
24	39464		20445 Porlier Pass Road	166	50.60	6	15.24	4	GPM	14	4.27	22	6.71	17-Apr-78	5 gph at 37 ft, 35 gph at 85 feet, 20 gph at 120 ft, 1 gpm at 135 feet and 2 gpm at	89	22608	8	P.N. Thornsteinsson	Unknown Well Use
25	23428			60	18.29	6	15.24	2	GPM			8	2.44	03-Apr-70	well reported not in use in 1996	89	22608	8	Whittale	Unknown Well Use
26	45829			92	28.04	6	15.24	4	GPM	14	4.27	20	6.10	15-Aug-80	1 gpm at 60 feet, 3 gpm at 65 feet	89	22690	1	Lee Kolosoff	Private Domestic
27	50413			82	24.99	6	15.24	12	GPM	25	7.62	7	2.13	09-Jun-82	4 gpm at 55 feet, 8 gpm at 72 feet	89	20266	7	Bill Patey	Private Domestic
28	58986			180	54.86	6	15.24	4	GPM	70	21.34	0	0	27-Jul-89	4 gpm at 165 feet	89	21465	1	John Ince	Private Domestic
29	59848			164	49.99	6	15.24	4	GPM	25	7.62	9	2.74	25-Sep-91	2 gpm at 55 feet, 1 gpm at 75 feet and 1gpm at 110 feet, deepened in 1998	89	20266	8	Spotlight Cove Community Well	Water Supply System
30	43162			75	22.86	6	15.24	3	GPM	17	5.18	19	5.79	16-Aug-79	1.5 gpm at 35 and 58 feet	89	20266	8	A. Haksi	Unknown Well Use

Data from BC Water Resources Atlas (Ministry of Environment, 2015), copies of original well records filed with Ministry of Environment, Victoria, Crystal Mountain Retreat Centre and field checking.

Note that data has not been field verified in all instances.

\* Ministry assumed construction date for computer database.

## ESTIMATED WATER SUPPLY DEMAND

The proposed retreat centre development is to be comprised of the following units connected to a small water supply system served by the central well:

1 single detached residence (caretakers dwelling) to be occupied year-round for up to 2 persons;

1 main kitchen facility serving up to 30 persons including drinking water and hand washing needs;

1 utility building with 4 shower units, 4 toilets, sinks and limited laundry facilities to serve short-term and long-term visitors.

In addition, water would also be provided in containers (e.g. 20 to 40 liters) for drinking water and hand washing needs for up to 15 forestry hut sites, accommodating up to 28 persons at any one time.

It is anticipated that the maximum number of persons to be accommodated at the centre over any long-term intervals of one to two months duration would not exceed 30 persons. Occasionally for some weekend day events (e.g. 1 to 3 per year) up to 60 persons may be in attendance at the centre.

Table 3 outlines the estimated maximum daily water demand anticipated for the retreat centre based on a number of assumptions. Maximum Day Demand (MDD) is the single highest total 24-hour daily water consumption occurring over a one-year period. MDD for a water system is generally comprised of a number of subcomponents including indoor usage, a water loss allowance and irrigation demand. In the case of the retreat centre, potential water losses and irrigation demands would be insignificant given the small size of the water system. There are also no plans to include watering of lawns or gardens on the property.

Indoor water use for conventional water systems, based on the *Design Guidelines for Rural Residential Community Systems* (Ministry of Forests, Lands & Natural Resource Operations, 2012) suggests that a minimum of 230 L/capita/day or 50.6 Imperial gallons/capita/day would need to be considered for a water system design. Environment Canada (2015) reports a similar water use figure of 251 L/day per capita for metered urban household water systems monitored across Canada in 2011. Using a per capita demand figure of 230 L/day suggests 30 persons could possibly require up to maximum of 6900 L/day or 1518 Imperial gallons per day (IGPD).

Apart from water use at the one, year-round caretaker dwelling, it is unlikely, however, that visitors to the retreat centre would be using water at a rate as high as 230 L/day/person for all their needs. It is anticipated that visitors would follow water conservation practices. In addition, the water system will incorporate water-saving appliances such as dual-flush toilets, coin-metered showers, high efficiency washing machines, low flow fixtures, and faucet aerators to reduce

water consumption. Water use would also be metered to monitor water use. Table 3 outlines a more detailed estimate of the anticipated maximum day demand (2839 liters/day or 625 IGPD) that may likely occur at the centre. This estimate is regarded as conservative. Actual reported water use during the period July 4 to August 2, 2015, for example, ranged from 75 to 225 US gals/day (284 to 852 liters/day) to provide water for 12 to 22 persons on the property for kitchen, hand washing and drinking water purposes (pers. comm., K. Lenglet, August 2015). During special event days (2 to 3 per year) when up to 60 persons maybe in attendance at the centre, kitchen and bathroom water use could approach 720 liters/day based on 12 liters/day/person. During these days, however, the maximum day demand of (2839 liters/day or 625 IGPD) would remain unchanged as it unlikely that there would be any significant shower or laundry use on these days.

Table 3. Estimates of maximum day demands (MDD) for retreat centre.

Number of Persons Served	Facilities Used	Period	Estimated MDD (liters/day)	Comments
2	caretaker dwelling septic system	year-round	460	residential use
28	15 forestry hut sites compost toilets	July-August	560 700 84	washing <sup>1</sup> showers <sup>2</sup> drinking water <sup>3</sup>
30	main kitchen, 3 meals/day/person  septic system	July-August	360	food preparation, dish washing and limited toilet use <sup>4</sup>
30	laundry septic system	July-August	675	periodic use <sup>5</sup>
Total:			2839	

<sup>1</sup> based on 20 liters/day/person

<sup>2</sup> based on 50 liters/person and 50 % of guests with alternate day use

<sup>3</sup> based on 3 liters/day/person

<sup>4</sup> based on 12 liters/day/person

<sup>5</sup> based on 45 liters/load and 50 % alternate day use

The largest potential use of water on any day would be for laundry and shower facilities. Overall water demands could be readily reduced, if necessary by utilizing off site laundry facilities and limiting shower use to less than half of the guests, every other day.

## **WATER SUPPLY SOURCES**

There are three wells at the centre which could conceivably provide water for the facility. These are indicated as well site numbers 5, 17 and 18 in Figure 4 and Table 2. A brief description of these wells is outlined below and copies of the available well records are provided in Appendix A.

### *Well Site 5, (WTN 56583/WID 23228)*

This is a 6 inch (15.24 cm) diameter bedrock well, that was drilled to a depth of 280 feet (85.34 m) in 1986. It was reported to yield 6 gpm at the time of drilling with a non-pumping water level of 55 feet (16.76 m). The well has been used to supply the retreat centre in the past and reported to provide adequate quantities, although it produced water with elevated turbidity (pers. comm., S. Foster, August 2015). Depth to bedrock was reported at 9 feet (2.74 m). Currently, the well is not being used.

### *Well Site 17, (WID 23229)*

This is a 6 inch (15.24 cm) diameter bedrock well, that was drilled in 1994 to a depth of 183 feet (55.78 m) and completed in grey sandstone. It was reported to yield 7 gpm from a depth of 177 feet (53.95 m) at the time of drilling with a non-pumping water level of 68 feet (20.73 m). Depth to bedrock was reported at 24 feet (7.32 m) with the well completed with 28 feet (8.53 m) of surface casing. Currently, the well is not being used.

### *Well Site 18, Central Well (WID 23227)*

This is a 6 inch (15.24 cm) diameter bedrock well, that was drilled in 1994 to a depth of 125 feet (38.10 m) and completed in shaley and grey sandstone. It was reported to yield 5 gpm from a depth of 120 feet (36.58 m) at the time of drilling with a non-pumping water level of 60 feet (18.29 m). Depth to bedrock was reported at 4 feet (1.22 m) with the well completed with 20 feet (6.10 m) of surface casing and 125 feet (38.10 m) of 4-inch (10.2 cm) diameter PVC well liner.

This central well located on the property near the outdoor kitchen, is currently being used to supply water for the retreat centre. Water is pumped to a small 1137 L (300 USgal) storage tank (cistern) situated about 65 m northwest of the well. Grey water from the kitchen and outdoor shower is currently discharged to a drainage pit situated 20 to 25 m from the central well. An outhouse (pit latrine) serving the kitchen also exists 30.5 m south of the central well.

Since the central well was equipped with a pump and already serving the retreat centre, it was decided to carry out a constant rate pumping test on this well for a minimum period of 12 hours duration to assess its capacity for meeting the projected water demands of the retreat centre. The methodology employed and results of the testing are provided in the next sections.

## PUMP TESTING METHODOGY FOR THE CENTRAL WELL

Given the relatively low water demands of the retreat centre, a constant rate pumping test of 12 hours duration was considered sufficient for determining the yield of the central well as the well driller's record had indicated a potential yield of 0.315 L/s (5 USgpm). Testing was conducted at the optimal time of the year when water levels are at their seasonal lowest (Figure 3). Only 0.2 mm of precipitation was recorded at the Saturna Campon CS climate station during the 10 days prior to the testing. Initially the well was tested on October 5, 2015 (Test 1) at a rate of 0.285 L/s (4.52 USgpm) but it soon became apparent within 2 hours that the well was being over-pumped at that rate since excessive drawdown was occurring. A second test (Test 2) was therefore started on the well on October 6, 2015 at a reduced rate of 0.135 L/s (2.14 USgpm). Water levels were monitored in the pumped well with a pressure transducer at one minute intervals prior to testing, during the testing and for 16.7 hours after pumping. Manual water level readings were also taken in the pumped well during the testing at frequent intervals following general standards for pump testing. Pumped water was discharged down slope 75 m away from the wellhead towards the east. Water level dataloggers were also employed at *Well Site 5, (WTN 56583/WID 23228)* and *Well Site 17, (WID 23229)* which were used as observation wells to record any well interference effects during the testing.

Pumped water samples were taken from the central well after 7.5 hours of pumping and delivered with cooler packs to the Maxxam Analytics laboratory in Saanich for analysis of chemical and bacteriological parameters. All samples were unadulterated and delivered to the laboratory within 24 hours of sampling.

## PUMP TESTING RESULTS

Pumping test data for the second test including drawdown and recovery plots are provided in Appendix B. The drawdown plot is also shown in Figure 5. A copy of the analytical laboratory report from Maxxam Analytics is provided in Appendix C and Table 4 provides a summary of the water quality results. Figures 6 and 7 show the water levels in the two observation wells, *Well Site 5, (WTN 56583/WID 23228)* and *Well Site 17, (WID 23229)* which were monitored prior to, during and after the pumping tests.

During the pumping test (Test 2) drawdown in the pumped well (Figure 5) reached a level of 20.505 m below the pre-pumping level of 13.290 m, utilizing 86.7 percent of the available drawdown of 23.65 m to the major water-bearing fracture at a depth of 36.58 m (120 feet). Specific capacity at the end of the test of was 0.3936 L/min per meter. As the drawdown showed no evidence of stabilization at the pumping rate of 8.07 L/min it is evident that the well would not be able to sustain this rate for a period of 100 days without recharge. Reducing the pumping rate by 50% to 4.035 L/min as shown in Figure 5 would result in the drawdown reaching the main water-producing fracture after 100 days of pumping. Applying a 70% safety factor (i.e. utilizing only 70 percent of the

available drawdown in the well) would indicate a potential long-term well yield of 2.826 L/min (4069 L/day). This calculated yield is 43% more than the estimated water supply requirements of 2839 L/day and would amount to a total potential supply of 1.49 million litres/year. Water level in the well recovered to within 95% of the pre-pumping level after 1000 minutes following pump shutdown. The recovery graph (Figure 2, Appendix B) indicates that the well would fully recover within a reasonable time.

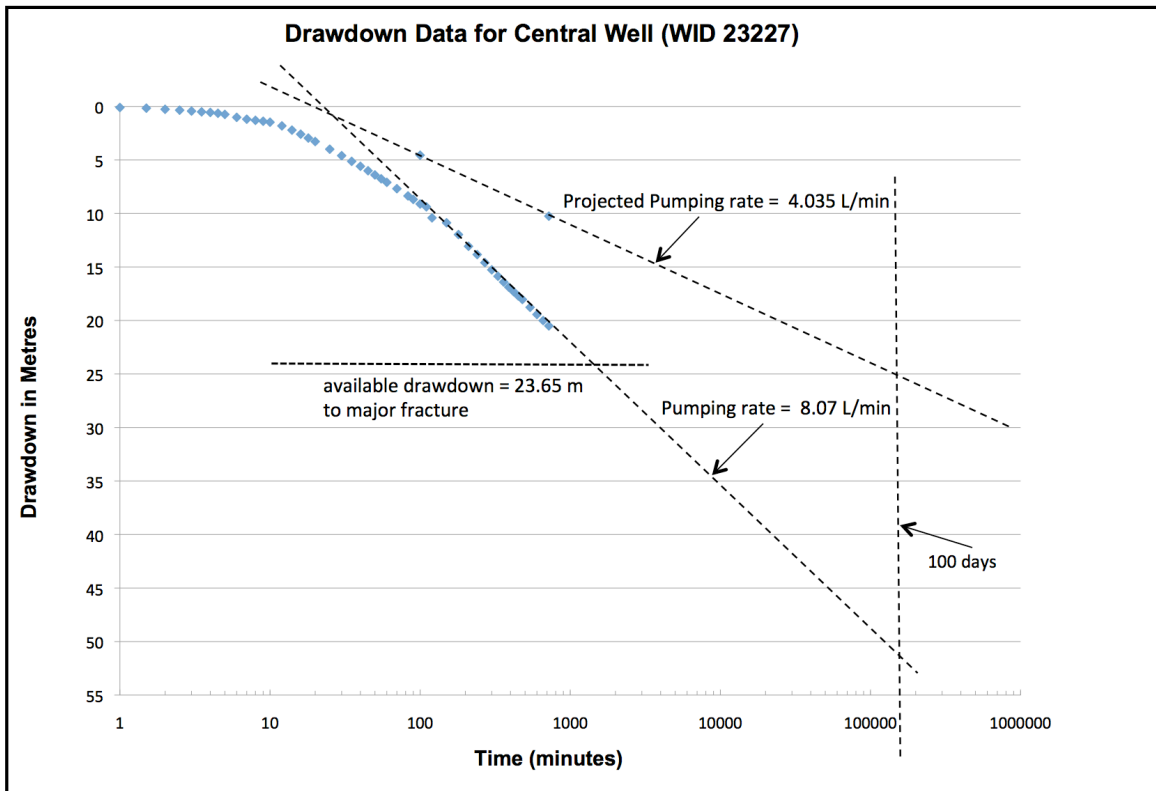


Figure 5. Drawdown in the central well observed during pumping at 8.07 L/min and projected drawdown at a pumping rate of 4.035 L/min.

No discernable pumping effects were observed in the two observation wells monitored during the October 5 pumping test as water levels were rising slightly in these wells at the time (Figures 6 and 7). Similarly, well site 17 showed a rising trend during the October 6 pumping test while well site 5 showed a slight declining trend, dropping less than 5 cm during the test. This minor decline was likely due mainly to tidal effects. Both wells show daily water level changes that range from 3 to 7 cm due to tidal effects. During the period September 23 to October 7, the water level in well site 17 showed an overall downward trend falling about 15 cm. During the same period the water level in well site 5 showed an initial rising trend over 3 days, followed by a declining trend for 6 days and then rising again for 5 days before declining again. Total water level variation was about 20 cm. The longer term variations shown at well site 5 suggest some pumping effects of a nearby well, likely down-slope, but these effects are not due to any pumping of the central well. The above data indicates that pumping the central well at a rate of 1.972 L/min (2839 L/day) would have no measureable effect on any of the neighbouring wells or surface water sources in the region.



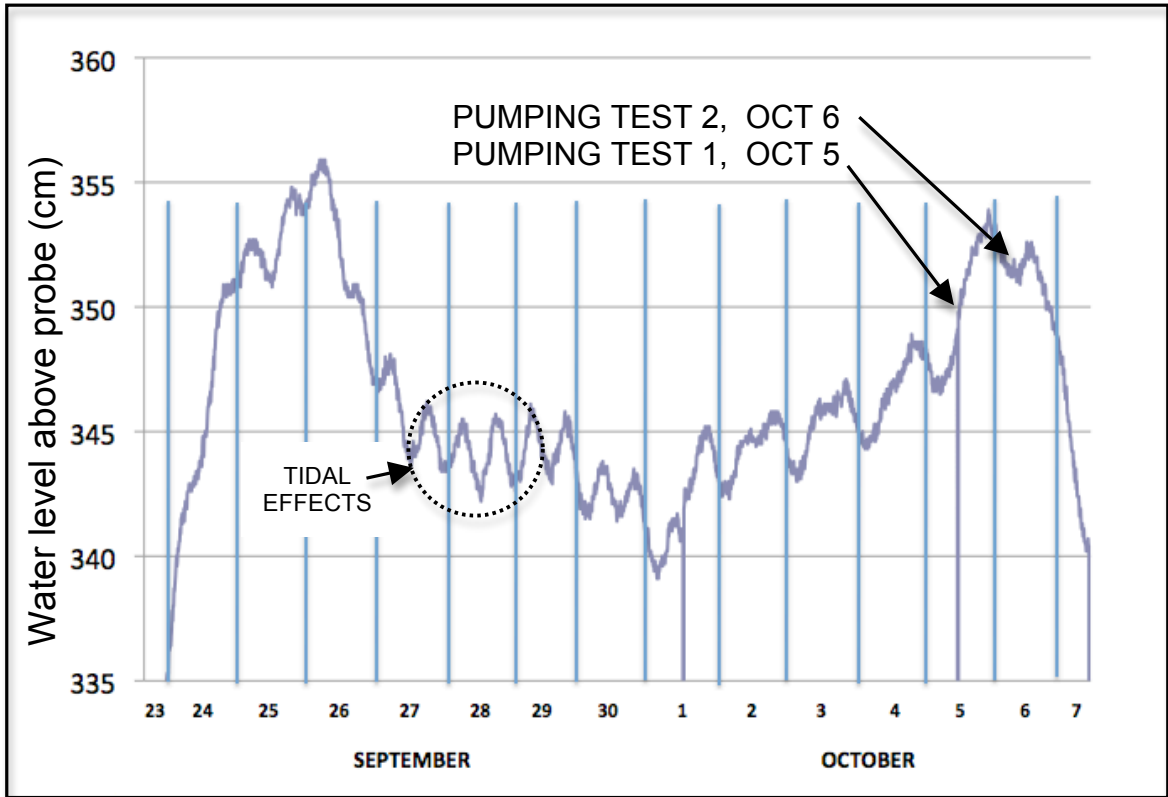


Figure 6. Water levels in observation well site 5, (WTN 56583/WID 23228).

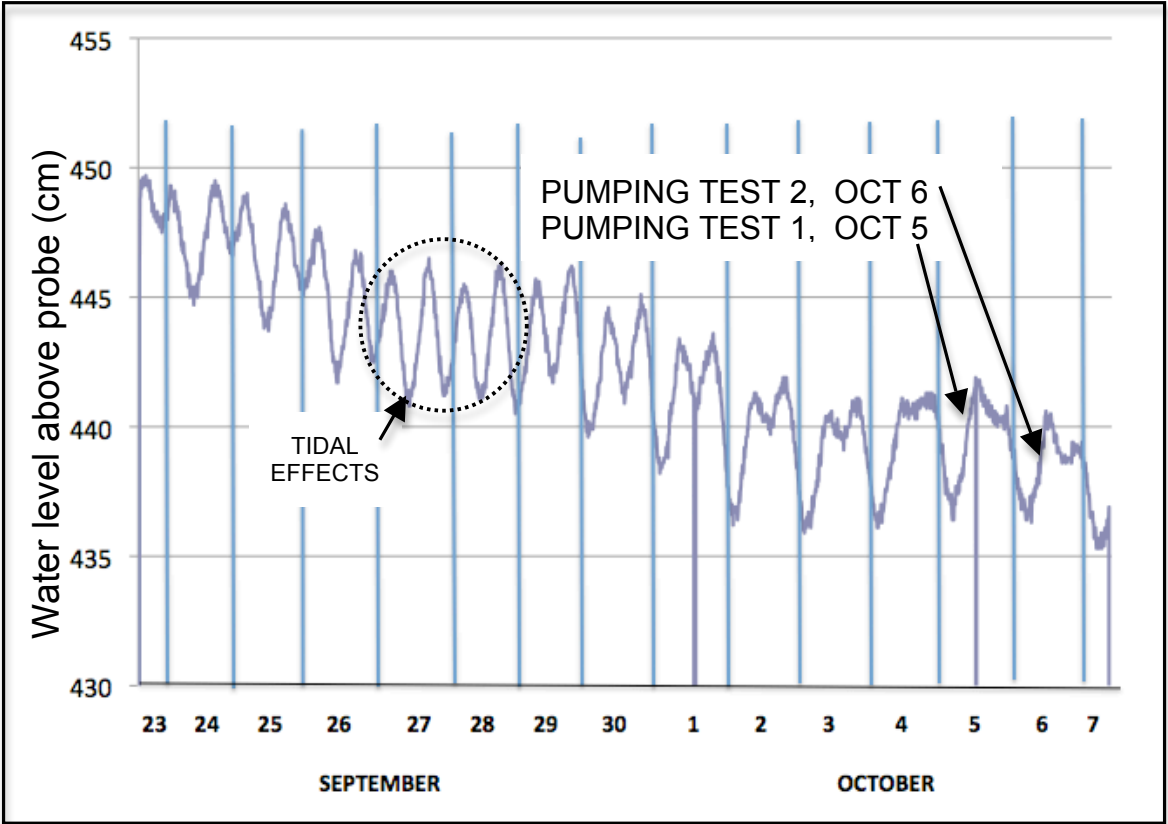


Figure 7. Water levels in observation well site 17, (WID 23229).

## WATER QUALITY RESULTS

Based on the laboratory results of the October 6, 2015 samples (Table 4) the water quality of the central well (WID 23227) met or exceeded the *Guidelines for Canadian Drinking Water* (Federal-Provincial-Territorial Committee on Drinking Water, 2015) for all parameters tested except for total coliforms at 11 CFU/100mL. No E.coli was detected. Previous bacteriological reports for samples taken from a tap at the kitchen showed elevated coliforms of 142, 23 and 4.8 MPN/100mL in September 2015, June and August 2014 respectively, indicating that presence of coliforms may be problematic.

Red Williams subsequently acidized and chlorinated the well on October 26 and 27, 2015. The well was then pumped to remove several well volumes and resampled on October 28, 2015 for bacteriological analysis. Two samples were delivered to Maxxam Analytics laboratory in Saanich within 24 hours of sampling. Results of this last sampling showed totals coliforms of 3 and 1 CFU/100ml with E. Coli in both samples at <1 CFU/ml. A copy of the analytical laboratory report from Maxxam Analytics is provided in Appendix C. Table 5 summarizes the results of the recent bacteriological testing for the central well (WID 23227). The periodic source of the coliforms is not known and could be due to grey water discharge in the vicinity of the well and/or natural sources such as decaying vegetation in nearby wetland areas.

Based on the most recent chemical and physical tests (Table 4), the groundwater accessed by the central well can be classified as a calcium-magnesium-bicarbonate type, low in overall mineralization with total dissolved solids of 265 mg/L. Low mineralization may indicate that the well is situated close to a local groundwater recharge area. A previous analysis in May 2001, showed elevated iron and manganese levels above the *Guidelines for Canadian Drinking Water*. These elevated levels for these parameters do not appear in the most recent testing.

Table 4. Summary of water quality analyses.									
Parameters/Site and Sampling Date	WID 23277 pumped well sample	WID 23277 pumped well sample	WID 23277 (tap sample)	WID 23277 (tap sample)	WID 23277 (tap sample)	WID 23277 (tap sample)	WID 23277 (tap sample)	Canadian DW Guideline 2014	Units
	Oct 6/15	Oct 28/15	Sept 26/15	Jul 09/13	Jun 08/14	Aug 04/14	May 13/01		
<b>PHYSICAL TESTS</b>									
True Colour	<5.0						5	15	TCU
Conductivity	420						304		µS/cm
Total Hardness (CaCO <sub>3</sub> )	131						51		mg/L
pH	8.23						6.91	6.5-8.5	pH units
Total Dissolved solids (TDS)	265						209	500	mg/L
Turbidity	1.7						52.0		
<b>DISSOLVED ANIONS</b>									
Alkalinity (Total as CaCO <sub>3</sub> )	198						154		mg/L
Alkalinity (PP as CaCO <sub>3</sub> )	<0.50								
Bicarbonate	241								mg/L
Carbonate	<0.50								mg/L
Hydroxide	<0.50								mg/L
Chloride	12.1						7.8	250	mg/L
Fluoride	0.193						0.22	1.5	mg/L
Nitrate (N)	<0.010						0.33	10	mg/L
Nitrite (N)	<0.010						0.005	1	mg/L
Sulphate	14.7						11.3	500	mg/L
<b>TOTAL METALS</b>									
Aluminum	55.5							100	µg/L
Antimony	<0.50							6	µg/L
Arsenic	3.04							10	µg/L
Barium	2.9							1000	µg/L
Beryllium	<0.10								
Bismuth	<1.0								
Boron	84							5000	µg/L
Cadmium	<0.010							5	µg/L
Chromium	<1.0							50	µg/L
Cobalt	<0.50								µg/L
Copper	9.16							1000	µg/L
Iron	79.3						4140	300	µg/L
Lead	0.6							10	µg/L
Manganese	14.2						93	50	µg/L
Mercury	<0.010							1	µg/L
Molybdenum	<1.0								µg/L
Nickel	<1.0								µg/L
Selenium	<0.10							50	µg/L
Silicon	12400						15800		µg/L
Silver	<0.020								µg/L
Strontium	109								µg/L
Thallium	<0.050								µg/L
Tin	<5.0								µg/L
Titanium	<5.0								
Uranium	0.29							20	µg/L
Vanadium	<5.0								µg/L
Zinc	9.1							5000	µg/L
Zirconium	<0.50								
Calcium	29.2						16.2		mg/L
Magnesium	14.0						5.72		mg/L
Potassium	0.310						1.47		mg/L
Sodium	43.4						47.4	200	mg/L
Sulphur	4.0								mg/L
<b>MICROBIOLOGICAL</b>									
Total Coliforms	11	3, 1	142*, <1	0	23	4.8	<1	<1	CFU/100 mL
Escherichia Coli (E.Coli)	<1	<1, <1	<1		<1	<1		<1	CFU/100 mL
Fecal Coliforms			<1	0			<1	<1	CFU/100 mL

Red font indicates exceedances.  
\* before chlorinating well

Table 5. Summary of bacteriological sampling of central well (WID 23227).

Sampling Date	E. coli (CPU/100ml)	Total Coliforms (CPU/100ml)	Comments
September 26, 2015	<1	142	kitchen tap before chlorination
September 26, 2015	<1	<1	kitchen tap after well chlorination
October 6, 2015	<1	11	after pumping
October 28, 2015	<1, <1	3, 1	after well acidizing, chlorination and pumping

## CONCLUSIONS

1. The maximum daily requirements or maximum day demand (MDD) that would likely occur at the retreat centre is estimated at 2839 liters/day or 625 Imperial gallons day which would serve a maximum of 30 persons accommodated on site.
2. There are three bedrock wells on the retreat centre properties. Two of the wells are not currently being used. A central well, designated (WID 23227) that currently supplies the retreat centre was pump tested on October 6, 2015 for 12 hours at a constant rate of 8.07 L/min. The other wells on the property were used as observation wells during the test. Based on the results of this testing the potential long-term well yield of the well is estimated at 2.826 L/min (4069 L/day) with a 70% safety factor. This calculated yield exceeds the estimated water supply requirements of 2839 L/day by 43%.
3. No discernable pumping effects were observed in the two observation wells monitored during the October testing. Based on these monitoring results use of the central well at a rate of 1.972 L/min (2839 L/day) would have no measureable effect on any of the neighbouring wells or surface water sources in the region.
4. Water quality testing of the central well (WID 23227) indicates that the water meets or exceeds *Guidelines for Canadian Drinking Water* (Federal-Provincial-Territorial Committee on Drinking Water, 2015) for all parameters tested except for total coliforms. Total coliforms of 3 and 1 CFU/100mL were reported for two samples after chlorination of the well. No E.coli was detected. The source of the coliforms is not known and could be due to grey water discharge in the vicinity of the well and /or natural sources such as decaying vegetation in nearby wetland areas. Previous occurrences of coliform bacteria have been effectively reduced by well chlorination.

5. Based on the most recent chemical and physical testing, the groundwater accessed by the central well can be classified as a calcium-magnesium-bicarbonate type, low in overall mineralization with total dissolved solids of 265 mg/L. Low mineralization may indicate that the well is situated close to a local groundwater recharge area.

## RECOMMENDATIONS

The following recommendations are provided for consideration.

1. All potential sources of contamination in the vicinity of the central well such as grey water discharge from the kitchen, the existing outdoor shower and the outhouse (pit latrine) should be removed and any remaining excavation filled in with clean fill, such as sand and gravel, glacial till or clay, with no boulders.
2. When put into operation for the new facilities, the central well (*WID 23227*) should be equipped with a totalizing flow meter and records should be kept of the total amount of water produced each month. These records should also be reviewed on an annual basis to ensure that no excessive water demands are being placed on the well.
3. The other two wells at the centre should be retained as observation wells and water levels in these wells taken and compiled on a minimum monthly basis. Wells that are no longer being used, for example, would need to be deactivated or closed in compliance with the *Ground Water Protection Regulation* (Ministry of Environment, 2015c). This would require filling the well with clean materials such as sand, clay and an effective sealant.
4. As a precautionary measure against any future potential sources of coliform bacteria, water from the existing well source should be treated with an appropriately designed and maintained ultraviolet irradiation (UV) or chlorination treatment system.
5. Water quality from the well should be monitored for bacteria and chemical quality on a regular basis (minimum of once a year) and as directed by the local health authority to detect any changes that might occur with time that may require additional treatment.

## CLOSURE

This report was prepared in accordance with generally accepted engineering, hydrogeological and consulting practices. It is intended for the prime use of Crystal Mountain Society, in connection with its purpose as outlined under the scope of work for this project. This report is based on data and information available to the author from various sources at the time of its preparation and the

findings of this report may therefore be subject to revision. Data and information supplied by others has not been independently confirmed or verified to be correct or accurate in all cases. Any errors, omissions or issues requiring clarification should be brought to the attention of the author. The author retains full copyright of the material contained in the report. The author and Hy-Geo Consulting accepts no responsibility for damages suffered by any third party as a result of any unauthorized use of this report.

Respectfully submitted:


Alan P. Kohut, PEng  
Senior Hydrogeologist

Hy-Geo Consulting

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**APPENDIX A**

**Water Well Records,  
Crystal Mountain Properties**









Report 1 - Detailed Well Record

<p>Well Tag Number: 56583</p> <p>Owner: CRYSTAL MOUNTAIN ENT</p> <p>Address: DIVINA DRIVE</p> <p>Area:</p> <p>WELL LOCATION:</p> <p>COWICHAN Land District</p> <p>District Lot: 90 Plan: 31200 Lot: 9</p> <p>Township: Section: Range:</p> <p>Indian Reserve: Meridian: Block:</p> <p>Quarter:</p> <p>Island: GALIANO</p> <p>BCGS Number (NAD 83): 092B093332 Well: 20</p> <p>Class of Well:</p> <p>Subclass of Well:</p> <p>Orientation of Well:</p> <p>Status of Well: New</p> <p>Licence General Status: UNLICENSED</p> <p>Well Use: Private Domestic</p> <p>Observation Well Number:</p> <p>Observation Well Status:</p> <p>Construction Method: Drilled</p> <p>Diameter: 6.0 inches</p> <p>Casing drive shoe:</p> <p>Well Depth: 280 feet</p> <p>Elevation: 0 feet (ASL)</p> <p>Final Casing Stick Up: inches</p> <p>Well Cap Type:</p> <p>Bedrock Depth: 9 feet</p>	<p>Construction Date: 1986-09-30 00:00:00</p> <p>Driller: Island Well Drilling</p> <p>Well Identification Plate Number:</p> <p>Plate Attached By:</p> <p>Where Plate Attached:</p> <p>PRODUCTION DATA AT TIME OF DRILLING:</p> <p>Well Yield: 6 (Driller's Estimate) Gallons per Minute (U.S./Imperial)</p> <p>Development Method:</p> <p>Pump Test Info Flag:</p> <p>Artesian Flow:</p> <p>Artesian Pressure (ft):</p> <p>Static Level: 55 feet</p> <p>WATER QUALITY:</p> <p>Character:</p> <p>Colour:</p> <p>Odour:</p> <p>Well Disinfected: N</p> <p>EMS ID:</p> <p>Water Chemistry Info Flag:</p> <p>Field Chemistry Info Flag:</p> <p>Site Info (SEAM):</p> <p>Water Utility:</p> <p>Water Supply System Name:</p> <p>Water Supply System Well Name:</p> <p>SURFACE SEAL:</p> <p>Flag:</p> <p>Material:</p> <p>Method:</p> <p>Depth (ft):</p>
---	--

Lithology Info Flag:	Thickness (in):
File Info Flag:	
Sieve Info Flag:	WELL CLOSURE INFORMATION:
Screen Info Flag:	Reason For Closure:
	Method of Closure:
Site Info Details:	Closure Sealant Material:
Other Info Flag:	Closure Backfill Material:
Other Info Details:	Details of Closure:

Screen from	to feet	Type	Slot Size	
Casing from	to feet	Diameter	Material	Drive Shoe

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From	0 to	9 Ft.	STONEY BROWN CLAY
From	9 to	11 Ft.	BROWN SANDSTONE
From	11 to	28 Ft.	GRAY SANDSTONE WITH BROWN SANDSTONE LENS
From	28 to	36 Ft.	GRAY SANDSTONE
From	36 to	48 Ft.	SHALEY SANDSTONE
From	48 to	125 Ft.	GRAY SANDSTONE WITH SHALEY SANDSTONE LEN
From	125 to	130 Ft.	SHALEY SANDSTONE
From	130 to	136 Ft.	VERY SHALEY SANDSTONE
From	136 to	142 Ft.	GRAY SANDSTONE
From	142 to	200 Ft.	GREY SANDSTONE WITH SHALEY SANDSTONE LEN
From	200 to	245 Ft.	GREY SANDSTONE
From	245 to	280 Ft.	GRAY SANDSTONE WITH SHALEY SANDSTONE LEN

**Information Disclaimer**

The Province disclaims all responsibility for the accuracy of information provided. Information provided should not be used as a basis for making financial or any other commitments.

**APPENDIX B**

**PUMPING TEST RESULTS**

## Pumping Test Data for Central Well (WID 23227)

**Project:** Crystal Mountain Retreat Centre  
**Client:** as above]  
**Location:** Galiano Island  
**Date of Test:** 06-Oct-15  
**Test Conducted by:** Red Williams Well Drilling  
**Pumped Well:** WID 23277  
**Pumping Rate:** 8.07 L/min (0.135L/s)  
**Static Water Level:** 13.290 m.

**Reference:** all readings from top of sounding tube  
**Stick up:** 36 cm  
**Observation Wells:** WID 23228 and WID 23229  
**Pump Start Time:** 9:00 AM  
**Pump End Time:** 9:00 PM  
**Analysis by:** A. Kohut, P.Eng.

### Drawdown Data:

### Recovery Data:

Time (minutes)	Water Level (metres)	Drawdown (metres)	Time t (minutes)	Time t' (minutes)	Water Level (metres)	t/t'	Residual Drawdown (metres)
0.5	13.34	0.05	720.5	0.5	33.560	1441.0	20.27
1	13.39	0.1	721	1	33.349	721.0	20.06
1.5	13.453	0.163	721.5	1.5	33.130	481.0	19.84
2	13.558	0.268	722	2	32.914	361.0	19.62
2.5	13.641	0.351	722.5	2.5	32.720	289.0	19.43
3	13.726	0.436	723	3	32.520	241.0	19.23
3.5	13.798	0.508	723.5	3.5	32.320	206.7	19.03
4	13.852	0.562	724	4	32.160	181.0	18.87
4.5	13.93	0.64	724.5	4.5	31.920	161.0	18.63
5	14.036	0.746	725	5	31.740	145.0	18.45
6	14.31	1.02	726	6	31.380	121.0	18.09
7	14.485	1.195	727	7	31.050	103.9	17.76
8	14.59	1.3	728	8	30.720	91.0	17.43
9	14.675	1.385	729	9	30.403	81.0	17.11
10	14.763	1.473	730	10	30.098	73.0	16.81
12	15.108	1.818	732	12	29.506	61.0	16.22
14	15.503	2.213	734	14	28.960	52.4	15.67
16	15.884	2.594	736	16	28.452	46.0	15.16
18	16.245	2.955	738	18	27.967	41.0	14.68
20	16.57	3.28	740	20	27.518	37.0	14.23
25	17.287	3.997	745	25	26.448	29.8	13.16
30	17.89	4.6	750	30	25.783	25.0	12.49
35	18.422	5.132	755	35	24.622	21.6	11.33
40	18.884	5.594	760	40	23.878	19.0	10.59
45	19.3	6.01	765	45	23.317	17.0	10.03
50	19.69	6.4	770	50	22.670	15.4	9.38
55	20.051	6.761	775	55	22.235	14.1	8.94
60	20.383	7.093	780	60	21.776	13.0	8.49
70	20.977	7.687	790	70	21.045	11.3	7.75
83	21.652	8.362	800	80	20.467	10.0	7.18
90	21.979	8.689	810	90	19.985	9.0	6.69
100	22.405	9.115	820	100	19.57	8.2	6.28
110	22.673	9.383	830	110	19.21	7.5	5.92
120	23.7	10.41	840	120	18.895	7.0	5.60
150	24.164	10.874	870	150	18.113	5.8	4.82
180	25.262	11.972	900	180	17.526	5.0	4.24

Time (minutes)	Water Level (metres)	Drawdown (metres)	Time t (minutes)	Time t' (minutes)	Water Level (metres)	t/t'	Residual Drawdown (metres)
210	26.357	13.067	950	230	16.749	4.1	3.46
240	27.133	13.843	1000	280	16.204	3.6	2.91
270	27.885	14.595	1050	330	15.784	3.2	2.49
300	28.56	15.27	1100	380	15.444	2.9	2.15
330	29.158	15.868	1200	480	14.96	2.5	1.67
360	29.697	16.407	1300	580	14.664	2.2	1.37
390	30.182	16.892	1400	680	14.442	2.1	1.15
420	30.603	17.313	1500	780	14.217	1.9	0.93
450	30.99	17.7	1600	880	14.085	1.8	0.79
480	31.328	18.038	1670	950	14.006	1.8	0.72
540	32.063	18.773	1720	1000	13.958	1.7	0.67
600	32.73	19.44					
660	33.299	20.009					
720	33.795	20.505					

Note: Data in red font from transducer.

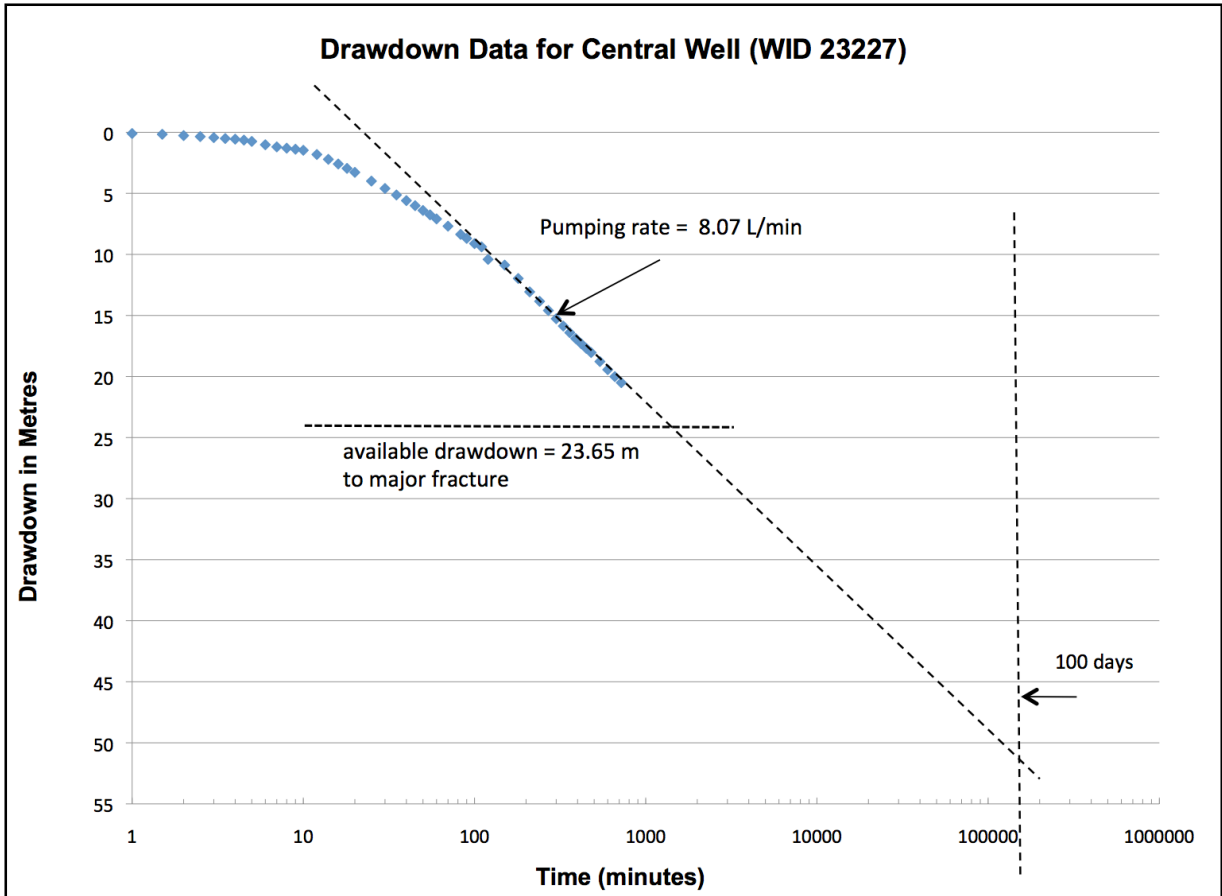


Figure 1. Drawdown graph for central well, pumped October 6, 2015.

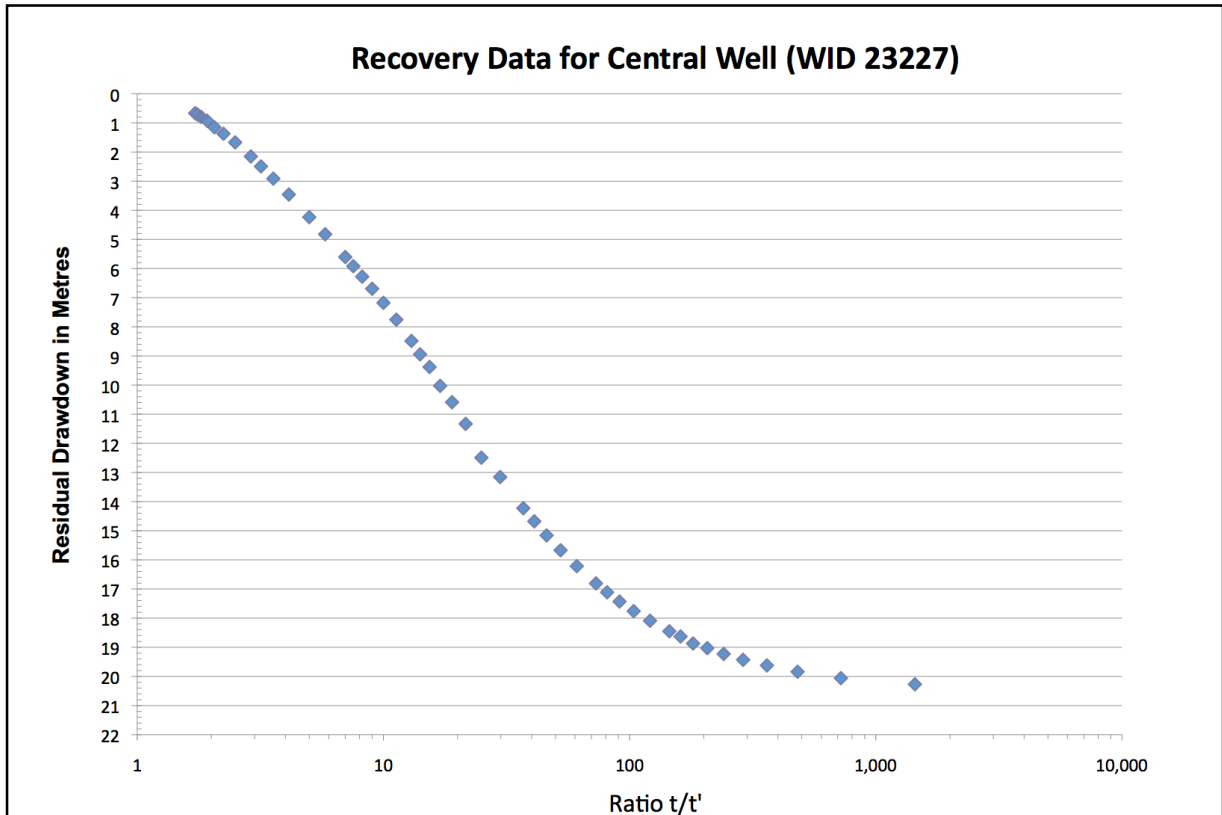


Figure 2. Recovery graph for central well, pumped October 6, 2015.



## **APPENDIX C**

### **Water Quality Analyses**

Your C.O.C. #: WI000401

**Attention: Al Kohut**

Hy-Geo Consulting  
1041 Laburnum Rd  
Victoria, BC  
Canada V8Z 2M9

**Report Date: 2015/10/20**

Report #: R2061237

Version: 1 - Final

**CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B588378**

**Received: 2015/10/07, 11:06**

Sample Matrix: Water  
# Samples Received: 1

Analyses	Quantity	Date		Laboratory Method	Analytical Method
		Extracted	Analyzed		
Alkalinity - Water	1	2015/10/17	2015/10/17	BBY6SOP-00026	SM 22 2320 B m
Anions in Water by Ion Chromatography (1, 2)	1	N/A	2015/10/07	VIC SOP-00020	Based on SM-4110B
True Colour (Single Wavelength) (1)	1	N/A	2015/10/09	VIC SOP-00010	Based on SM-2120 C
Conductance - water	1	N/A	2015/10/17	BBY6SOP-00026	SM 22 2510 B m
Hardness Total (calculated as CaCO3)	1	N/A	2015/10/20	BBY7SOP-00002	EPA 6020a R1 m
Mercury (Total) by CVAf	1	2015/10/16	2015/10/18	BBY7SOP-00015	BCMOE BCLM Oct2013 m
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	N/A	2015/10/20	BBY7SOP-00002	EPA 6020A R1 m
Elements by CRC ICPMS (total)	1	N/A	2015/10/20	BBY7SOP-00002	EPA 6020A R1 m
Nitrate + Nitrite (N) (calculated) (1)	1	N/A	2015/10/16	VIC-SOP-00005	Based SM-4500 NO2 E
pH Water (3)	1	N/A	2015/10/17	BBY6SOP-00026	SM 22 4500-H+ B m
Total Dissolved Solids (Filt. Residue) (1)	1	N/A	2015/10/15	VIC SOP-00008	Based on SM 2540C
Total coliform and E. by MF (Chromocult) (1)	1	N/A	2015/10/07	VIC SOP 00112	Based on SM-9222
Turbidity (1)	1	N/A	2015/10/09	VIC SOP-00011	Based on SM - 2130

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

\* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Victoria

(2) Anions in Water by Ion Chromatography: The samples were received and analyzed in Maxxam Victoria. The data was processed and approved in Maxxam Burnaby.

(3) The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

**Encryption Key**

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Debbie Nordbruget, Project Manager

Email: DNordbruget@maxxam.ca

Phone# (250)385-6112

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This report has been generated and distributed using a secure automated process.

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

**RESULTS OF CHEMICAL ANALYSES OF WATER**

Maxxam ID					NI0755		
Sampling Date					2015/10/06 16:25		
COC Number					WI000401		
	UNITS	MAC	AO	OG	WID 23227	RDL	QC Batch
<b>CONVENTIONALS</b>							
Dissolved Nitrate (N)	mg/L	<b>10</b>	-	-	<0.010	0.010	8065824
Dissolved Nitrite (N)	mg/L	<b>1</b>	-	-	<0.010	0.010	8065824
<b>Misc. Inorganics</b>							
Dissolved Chloride (Cl)	mg/L	-	250	-	12.1	0.50	8065824
Dissolved Fluoride (F)	mg/L	<b>1.5</b>	-	-	0.193	0.010	8065824
Dissolved Sulphate (SO4)	mg/L	-	500	-	14.7	0.50	8065824
Alkalinity (Total as CaCO3)	mg/L	-	-	-	198	0.50	8078038
Alkalinity (PP as CaCO3)	mg/L	-	-	-	<0.50	0.50	8078038
Bicarbonate (HCO3)	mg/L	-	-	-	241	0.50	8078038
Carbonate (CO3)	mg/L	-	-	-	<0.50	0.50	8078038
Hydroxide (OH)	mg/L	-	-	-	<0.50	0.50	8078038
<b>MISCELLANEOUS</b>							
True Colour	Col. Unit	-	15	-	<5	5	8073503
<b>Nutrients</b>							
Nitrate plus Nitrite (N)	mg/L	-	-	-	<0.010	0.010	8069236
<b>Physical Properties</b>							
Conductivity	uS/cm	-	-	-	420	1.0	8078041
pH	pH	-	6.5:8.5	-	8.23	N/A	8078042
<b>Physical Properties</b>							
Total Dissolved Solids	mg/L	-	500	-	265	10	8075415
Turbidity	NTU	see remark	see remark	see remark	1.7	0.1	8072031
RDL = Reportable Detection Limit N/A = Not Applicable							

Maxxam Job #: B588378  
Report Date: 2015/10/20

Hy-Geo Consulting

**MICROBIOLOGY (WATER)**

<b>Maxxam ID</b>			NI0755		
<b>Sampling Date</b>			2015/10/06 16:25		
<b>COC Number</b>			WI000401		
	<b>UNITS</b>	<b>MAC</b>	<b>WID 23227</b>	<b>RDL</b>	<b>QC Batch</b>
<b>Microbiological Param.</b>					
Total Coliforms	CFU/100mL	<b>1</b>	<b>11</b>	1	8073379
E. coli	CFU/100mL	<b>1</b>	<1	1	8073379
RDL = Reportable Detection Limit					

**TOT. METALS W/ CV HG FOR DRINKING WATER (WATER)**

Maxxam ID					NI0755		
Sampling Date					2015/10/06 16:25		
COC Number					WI000401		
	UNITS	MAC	AO	OG	WID 23227	RDL	QC Batch
<b>Calculated Parameters</b>							
Total Hardness (CaCO3)	mg/L	-	-	-	131	0.50	8068356
<b>Elements</b>							
Total Mercury (Hg)	ug/L	<b>1</b>	-	-	<0.010	0.010	8076829
<b>Total Metals by ICPMS</b>							
Total Aluminum (Al)	ug/L	-	-	<b>100</b>	55.5	3.0	8080659
Total Antimony (Sb)	ug/L	<b>6</b>	-	-	<0.50	0.50	8080659
Total Arsenic (As)	ug/L	<b>10</b>	-	-	3.04	0.10	8080659
Total Barium (Ba)	ug/L	<b>1000</b>	-	-	2.9	1.0	8080659
Total Beryllium (Be)	ug/L	-	-	-	<0.10	0.10	8080659
Total Bismuth (Bi)	ug/L	-	-	-	<1.0	1.0	8080659
Total Boron (B)	ug/L	<b>5000</b>	-	-	84	50	8080659
Total Cadmium (Cd)	ug/L	<b>5</b>	-	-	<0.010	0.010	8080659
Total Chromium (Cr)	ug/L	<b>50</b>	-	-	<1.0	1.0	8080659
Total Cobalt (Co)	ug/L	-	-	-	<0.50	0.50	8080659
Total Copper (Cu)	ug/L	-	<b>1000</b>	-	9.16	0.20	8080659
Total Iron (Fe)	ug/L	-	<b>300</b>	-	79.3	5.0	8080659
Total Lead (Pb)	ug/L	<b>10</b>	-	-	0.60	0.20	8080659
Total Manganese (Mn)	ug/L	-	<b>50</b>	-	14.2	1.0	8080659
Total Molybdenum (Mo)	ug/L	-	-	-	<1.0	1.0	8080659
Total Nickel (Ni)	ug/L	-	-	-	<1.0	1.0	8080659
Total Selenium (Se)	ug/L	<b>50</b>	-	-	<0.10	0.10	8080659
Total Silicon (Si)	ug/L	-	-	-	12400	100	8080659
Total Silver (Ag)	ug/L	-	-	-	<0.020	0.020	8080659
Total Strontium (Sr)	ug/L	-	-	-	109	1.0	8080659
Total Thallium (Tl)	ug/L	-	-	-	<0.050	0.050	8080659
Total Tin (Sn)	ug/L	-	-	-	<5.0	5.0	8080659
Total Titanium (Ti)	ug/L	-	-	-	<5.0	5.0	8080659
Total Uranium (U)	ug/L	<b>20</b>	-	-	0.29	0.10	8080659
Total Vanadium (V)	ug/L	-	-	-	<5.0	5.0	8080659
Total Zinc (Zn)	ug/L	-	<b>5000</b>	-	9.1	5.0	8080659
Total Zirconium (Zr)	ug/L	-	-	-	<0.50	0.50	8080659
Total Calcium (Ca)	mg/L	-	-	-	29.2	0.050	8069234
Total Magnesium (Mg)	mg/L	-	-	-	14.0	0.050	8069234
Total Potassium (K)	mg/L	-	-	-	0.310	0.050	8069234
Total Sodium (Na)	mg/L	-	<b>200</b>	-	43.4	0.050	8069234
Total Sulphur (S)	mg/L	-	-	-	4.0	3.0	8069234
RDL = Reportable Detection Limit							

Maxxam Job #: B588378  
Report Date: 2015/10/20

Hy-Geo Consulting

### GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	8.3°C
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MAC,AO,OG: The guidelines that have been included in this report have been taken from the Canadian Drinking Water Quality Summary Table, October 2014.

Criteria A = Maximum Acceptable Concentration (MAC) / Criteria B = Aesthetic Objectives (AO) / Criteria C = Operational Guidance Values (OG)  
It is recommended to consult these guidelines when interpreting your data since there are non-numerical guidelines that are not included on this report.

**Turbidity Guidelines:**

1. Chemically assisted filtration: less than or equal to 0.3 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 1.0 NTU at any time.
2. Slow sand / diatomaceous earth filtration: less than or equal to 1.0 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 3.0 NTU at any time.
3. Membrane filtration: less than or equal to 0.1 NTU in 99% of the measurements made or at least 99% of the time each calendar month. Shall not exceed 0.3 NTU at any time.

**Results relate only to the items tested.**

Maxxam Job #: B588378  
Report Date: 2015/10/20

**QUALITY ASSURANCE REPORT**

Hy-Geo Consulting

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8065824	Dissolved Chloride (Cl)	2015/10/07	NC	80 - 120	106	80 - 120	<0.50	mg/L		
8065824	Dissolved Fluoride (F)	2015/10/07	109	80 - 120	109	80 - 120	<0.010	mg/L	NC	20
8065824	Dissolved Nitrate (N)	2015/10/07	99	80 - 120	109	80 - 120	<0.010	mg/L		
8065824	Dissolved Nitrite (N)	2015/10/07	102	80 - 120	107	80 - 120	<0.010	mg/L		
8065824	Dissolved Sulphate (SO4)	2015/10/07	106	80 - 120	107	80 - 120	<0.50	mg/L		
8072031	Turbidity	2015/10/09			99	80 - 120	<0.1	NTU	0	20
8073503	True Colour	2015/10/09			100	80 - 120	<5	Col. Unit	NC	10
8075415	Total Dissolved Solids	2015/10/15			113	80 - 120	15, RDL=10	mg/L	7.8	20
8076829	Total Mercury (Hg)	2015/10/18	90	80 - 120	93	80 - 120	<0.010	ug/L	NC	20
8078038	Alkalinity (PP as CaCO3)	2015/10/17					<0.50	mg/L	NC	20
8078038	Alkalinity (Total as CaCO3)	2015/10/17	NC	80 - 120	97	80 - 120	<0.50	mg/L	0.58	20
8078038	Bicarbonate (HCO3)	2015/10/17					<0.50	mg/L	0.58	20
8078038	Carbonate (CO3)	2015/10/17					<0.50	mg/L	NC	20
8078038	Hydroxide (OH)	2015/10/17					<0.50	mg/L	NC	20
8078041	Conductivity	2015/10/17			99	80 - 120	<1.0	uS/cm	0.083	20
8078042	pH	2015/10/17			101	97 - 103			0.13	N/A
8080659	Total Aluminum (Al)	2015/10/20	NC	80 - 120	102	80 - 120	<3.0	ug/L		
8080659	Total Antimony (Sb)	2015/10/20	104	80 - 120	98	80 - 120	<0.50	ug/L		
8080659	Total Arsenic (As)	2015/10/20	98	80 - 120	101	80 - 120	<0.10	ug/L		
8080659	Total Barium (Ba)	2015/10/20	98	80 - 120	97	80 - 120	<1.0	ug/L		
8080659	Total Beryllium (Be)	2015/10/20	98	80 - 120	91	80 - 120	<0.10	ug/L		
8080659	Total Bismuth (Bi)	2015/10/20	103	80 - 120	96	80 - 120	<1.0	ug/L		
8080659	Total Boron (B)	2015/10/20					<50	ug/L		
8080659	Total Cadmium (Cd)	2015/10/20	98	80 - 120	94	80 - 120	<0.010	ug/L		
8080659	Total Chromium (Cr)	2015/10/20	95	80 - 120	101	80 - 120	<1.0	ug/L		
8080659	Total Cobalt (Co)	2015/10/20	94	80 - 120	101	80 - 120	<0.50	ug/L		
8080659	Total Copper (Cu)	2015/10/20	NC	80 - 120	102	80 - 120	<0.20	ug/L		
8080659	Total Iron (Fe)	2015/10/20	NC	80 - 120	113	80 - 120	<5.0	ug/L		
8080659	Total Lead (Pb)	2015/10/20	100	80 - 120	96	80 - 120	<0.20	ug/L		
8080659	Total Manganese (Mn)	2015/10/20	NC	80 - 120	102	80 - 120	<1.0	ug/L		
8080659	Total Molybdenum (Mo)	2015/10/20	101	80 - 120	97	80 - 120	<1.0	ug/L		
8080659	Total Nickel (Ni)	2015/10/20	95	80 - 120	102	80 - 120	<1.0	ug/L		

Maxxam Job #: B588378  
Report Date: 2015/10/20

**QUALITY ASSURANCE REPORT(CONT'D)**

Hy-Geo Consulting

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
8080659	Total Selenium (Se)	2015/10/20	97	80 - 120	99	80 - 120	<0.10	ug/L		
8080659	Total Silicon (Si)	2015/10/20					<100	ug/L		
8080659	Total Silver (Ag)	2015/10/20	101	80 - 120	97	80 - 120	<0.020	ug/L		
8080659	Total Strontium (Sr)	2015/10/20	NC	80 - 120	94	80 - 120	<1.0	ug/L		
8080659	Total Thallium (Tl)	2015/10/20	91	80 - 120	89	80 - 120	<0.050	ug/L		
8080659	Total Tin (Sn)	2015/10/20	104	80 - 120	94	80 - 120	<5.0	ug/L		
8080659	Total Titanium (Ti)	2015/10/20	87	80 - 120	109	80 - 120	<5.0	ug/L		
8080659	Total Uranium (U)	2015/10/20	104	80 - 120	97	80 - 120	<0.10	ug/L		
8080659	Total Vanadium (V)	2015/10/20	99	80 - 120	98	80 - 120	<5.0	ug/L		
8080659	Total Zinc (Zn)	2015/10/20	NC	80 - 120	106	80 - 120	<5.0	ug/L		
8080659	Total Zirconium (Zr)	2015/10/20					<0.50	ug/L		

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).



Maxxam Job #: B588378  
Report Date: 2015/10/20

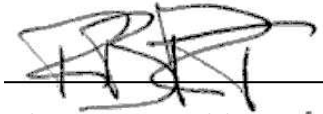
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### VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



David Nadler, AASc, Victoria Operations Manager



Rob Reinert, Data Validation Coordinator

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Your C.O.C. #: V014603

**Attention: EILEEN JENNETT**

RED WILLIAMS WELL DRILLING LTD.  
980 PRATT RD  
QUALICUM BEACH, BC  
CANADA V9K 1W5

**Report Date: 2015/10/30**

Report #: R2068261

Version: 1 - Final

**CERTIFICATE OF ANALYSIS**

**MAXXAM JOB #: B596362**

**Received: 2015/10/29, 08:00**

Sample Matrix: DRINKING WATER  
# Samples Received: 2

<b>Analyses</b>	<b>Quantity</b>	<b>Date Extracted</b>	<b>Date Analyzed</b>	<b>Laboratory Method</b>	<b>Analytical Method</b>
Total coliform and E. by MF (Chromocult) (1)	2	N/A	2015/10/29	VIC SOP 00112	Based on SM-9222

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

\* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Victoria

**Encryption Key**

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Debbie Nordbruket, Project Manager

Email: DNordbruket@maxxam.ca

Phone# (250)385-6112

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Maxxam Job #: B596362  
Report Date: 2015/10/30

RED WILLIAMS WELL DRILLING LTD.

**MICROBIOLOGY (DRINKING WATER)**

Maxxam ID			NN0484	NN0485		
Sampling Date			2015/10/28 18:35	2015/10/28 18:40		
COC Number			V014603	V014603		
	UNITS	MAC	CRYSTAL MNT. #1	NEW WELL #2	RDL	QC Batch
<b>Microbiological Param.</b>						
Total Coliforms	CFU/100mL	<1	3	1	1	8095999
E. coli	CFU/100mL	<1	<1	<1	1	8095999
RDL = Reportable Detection Limit						

### GENERAL COMMENTS

MAC: The guidelines that have been included in this report have been taken from the Canadian Drinking Water Quality Summary Table, October 2014.

Criteria A = Maximum Acceptable Concentration (MAC) / Criteria B = Aesthetic Objectives (AO) / Criteria C = Operational Guidance Values (OG)  
It is recommended to consult these guidelines when interpreting your data since there are non-numerical guidelines that are not included on this report.

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1. Chemically assisted filtration: less than or equal to 0.3 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 1.0 NTU at any time.
2. Slow sand / diatomaceous earth filtration: less than or equal to 1.0 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 3.0 NTU at any time.
3. Membrane filtration: less than or equal to 0.1 NTU in 99% of the measurements made or at least 99% of the time each calendar month. Shall not exceed 0.3 NTU at any time.

**Results relate only to the items tested.**

Maxxam Job #: B596362  
Report Date: 2015/10/30

**QUALITY ASSURANCE REPORT**

RED WILLIAMS WELL DRILLING LTD.

QC Batch	Parameter	Date	RPD	
			Value (%)	QC Limits
8095999	E. coli	2015/10/29	NC	N/A
8095999	Total Coliforms	2015/10/29	NC	N/A

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.


NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

Maxxam Job #: B596362  
Report Date: 2015/10/30

RED WILLIAMS WELL DRILLING LTD.

### VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Rob Reinert, Data Validation Coordinator

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