VILLAGE OF PEMBERTON WATER SYSTEM PERFORMANCE ASSESSMENT

Village of Pemberton

A review and inventory of the existing water system with emphasis on the performance of the source aquifer.

2020

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Design Criteria – Village of Pemberton Bylaw 677, 2011

Per Capita Demand	
Average daily domestic Flow	455 litres/capita/day
Maximum daily domestic flow	910 litres/capita/day
Peak hour domestic flow	1,820 litres/capita/day
Design Pressures	
Minimum pressure at peak demand	300 kPa (44 psi)
Maximum allowable pressure	850 kPa (123 psi)
Minimum pressure for Fire Flow plus max day demand	150 a (22 psi)

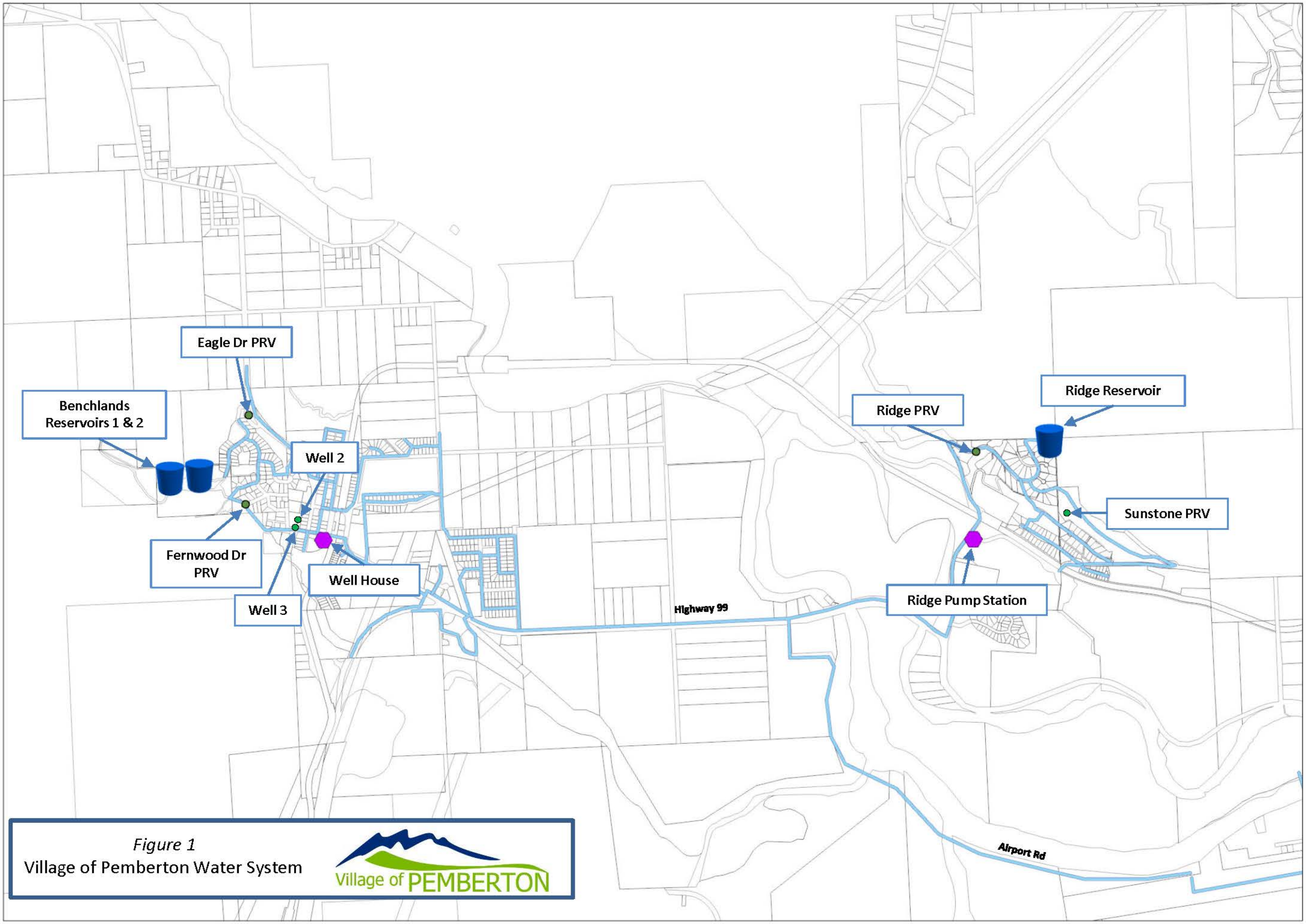


Figure 1
Village of Pemberton Water System

Village of PEMBERTON

1 Introduction

1.1 Background

The Village of Pemberton, under the authority of Vancouver Coastal Health, operates two water systems: the Village system, and the Industrial Park system and in addition supplies water to the Pemberton North Water System (**PNWS**) which is owned and maintained by the Squamish Lillooet Regional District. The main Village system withdraws water from the Pemberton Creek Fan Aquifer through two 300mm (12") diameter wells which supply the current Village population of approximately 3,100 as well as the water demands of the **PNWS**. The Industrial Park system is separate from the Village system and is supplied with metered water from the neighboring Lil'wat Nation through a water use agreement. This report describes the results of a study to determine the performance of the Village water system with emphasis on the performance of the source aquifer.

1.2 Previous Studies

The following reports, studies and documents were reviewed in preparation of this report:

- Village of Pemberton Water Study, NovaTec, 1991
- Pemberton Water System Study, Binnie, 1998
- Village of Pemberton Water System Capacity Study, Associated Engineering, 2007
- Hydrogeological Assessment for Groundwater Protection Plan, Enterprise Geoscience Services Ltd., 2012
- Groundwater Recharge Assessment For Pemberton Creek Fan Aquifer, Enterprise Geoscience Services Ltd., 2015
- Alternate Water Source Assessment, ISL, 2017
- Guidance on Manganese in Drinking Water, BC Ministry of Health, 2019

1.3 Report Objectives

The main objectives of this report are:

1. Summarize and assess the existing water system and its ability to provide sufficient potable water to meet current and future demands.
2. Determine the improvements required to ensure the Village is able to maintain the ability to provide sufficient water that meets all Guidelines for Canadian Drinking Water Quality (**GCDWQ**).

2 Village Water System

2.1 Supply Source

The Village of Pemberton's water source is comprised of 2 active wells that withdraw water from the Pemberton Creek Fan Aquifer; Well 2, located in Foughberg Park; and Well 3, located in Pioneer Park. Well 1, located in the well house, is currently isolated from the system and is included here for reference in regards to water quality which is discussed in Section 5.4 of this report. Table 1 summarizes the relevant information for each well.

Table 1 – Village Well Information

Well	Year of Construction	Diameter (mm)	Depth (m)	Rated Flow (L/s)	Notes
1	1992	200 (10")	29	28.8	Isolated from distribution due to declining yield and poor water quality.
2	1997	300 (12")	41.8	76	Current backup well.
3	2007	300 (12")	46	50	Current duty well.

Figure 2- Well locations

Well 1

Constructed in 1992, by 1997 Well 1's performance began to decline due to what is believed to be the colonization of naturally occurring iron bacteria in the well causing fouling and decreased flow. In 1997 and again in 2001 it was re-developed using high pressure water jet and acidization[1] which resulted in temporary minor improvements in productivity. It was utilized as a backup well until 2007 when it was isolated from the system due to excessive iron and manganese concentrations.

Well 2

Well 2 was constructed in 1997 to serve as a backup well and in short order became the duty well due to the declining performance of Well 1. It was utilized as the duty well until 2014 when iron and manganese levels began rising leading to aesthetic issues for operations staff who began using Well 3 as the duty well with its better water quality. It was redeveloped in 2014 in an attempt to restore performance with only a temporary improvement. In 2019 the Government of Canada implemented a Maximum Acceptable Concentration (**MAC**) of 0.12 mg/L for manganese which Well 2 has exceeded. It is currently the sole backup well and is periodically operated for maintenance purposes only.

Well 3

Well 3 was constructed in 2007 to replace Well 1 as the backup well and served as the backup until 2014 when Well 2's water quality began to decline. It is the current duty well and until 2020 provided water that met all **GCDWQ** targets. *In 2018 manganese levels began to increase and the most recent results from February 2020 show that manganese levels have now exceeded the **GCDWQ** Aesthetic Objective of 0.02 mg/L. Water quality will be discussed further in Section5.4– Aquifer Water Quality.*

2.2 Treatment

Current water treatment consists of soda ash conditioning (since 2017) to increase the pH of the well water from approximately 6.5 to 7.0 in order to minimize corrosivity. The Village also chlorinates (since 2009) using sodium hypochlorite for both primary disinfection and to maintain a minimum free chlorine residual of 0.2 mg/L at the farthest ends of the distribution system.

2.3 Reservoirs

The distribution system includes 3 reservoirs totaling 4,551 m^3 of water storage. Table 2 summarizes the relevant information for each reservoir.

[1] Technical Briefing #4 – Water Supply Assessment New Village Production Well, Golder Associates, 2007.

Table 2 - Reservoir Information

Reservoir	Year Constructed	Type	Capacity (m^3)	Top Water Level Elevation (m)
Benchlands Reservoir 1	2002	Circular Concrete Tank	1,640	290.5
Benchlands Reservoir 2	2014	Circular Steel Tank	1,490	290.5
Ridge Reservoir	2017	Circular Steel Tank	1,421	357.6

The total required storage volume is determined based on the following formula from the MMCD Design Guidelines referenced by VoP Bylaw 677, 2011:

Required Storage = A + B + C, where: <u>*Village*</u>

A = Fire Storage -- *(2 hours at 150 L/s for Schools)*

B = Equalization Storage = 25% of Maximum Day Demand ------- *(MDD = 3,700 m^3)*

C = Emergency Storage = 25% of (A+B)

The required storage based on current water consumption rates is 2,506 m^3 which leaves 2,045 m^3 to accommodate future growth. Figure 3 summarizes the Village's water storage.

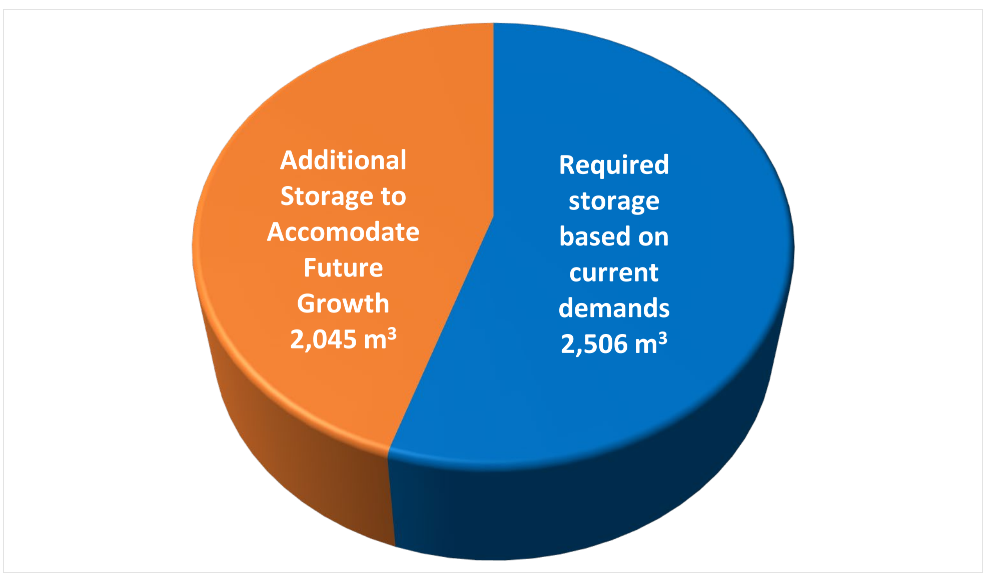


Figure 3- Existing storage capacity based on MMCD Design Guidelines

The amount of storage indicates ample capacity to accommodate future growth below the elevation of the existing reservoirs. Using the Village's per capita demand design value of 910 L/c/d for MDD shows that current storage capacity can accommodate a total population of approximately 10,000.

2.4 Backup Power

The Village does not currently have a backup power generator for its wells. In the event of a power failure of significant time, the reservoirs will provide enough water to last between 1.5 to 3 days depending on seasonal water demands. A project has been identified in the Village of Pemberton five year financial plan to design and construct a back-up generator for the well house in 2021.

2.5 Distribution System

The distribution system is comprised mainly of PVC water piping with some sections of asbestos cement piping that are scheduled for replacement. All recently installed mains have been PVC with diameters ranging between 50mm and 300mm (2" to 12"). The distribution system extends from the Benchlands reservoirs eastwards to the Sunstone Development, southwards to the WWTP on Airport Road and northwards to the **PNWS**.

2.5.1 Pressure Zones

There is a total of four distinct pressure zones within the Village water system that are governed by the water levels in the reservoirs and the setpoints of the four Pressure Reducing Valve (**PRV**) stations. Operations staff have set the PRVs to reduce pressure such that the maximum pressure (coincident with the lowest elevation) in each pressure zone is 620 kPa (90 psi).

291 m Pressure Zone – The two Benchlands reservoirs share a top water level of 290.5 m which represents the Hydraulic Grade Line (HGL) of this pressure zone. It services a large portion of the Benchlands just below the reservoirs.

265 m Pressure Zone – This is the main pressure zone that encompasses the downtown core and extends east to Pemberton Farm Road East and includes the **PNWS**. It is fed from the 291 m Pressure Zone via two **PRV**s; one located on Fernwood Dr. and the other on Eagle Dr and which are both set to reduce the HGL to 265 m.

358 m Pressure Zone – The Ridge booster pump station boosts water from the 265 m Pressure Zone to the Ridge Reservoir which has a top water level of 357.6 m. This pressure zone services the Ridge Development exclusively.

265 m Sunstone Pressure Zone – The Sunstone Development is fed water from the 358 m Pressure Zone via a PRV set to reduce the HGL to 265 m. It is anticipated that this zone will merge with the Village 265 m Pressure Zone during future water main looping.

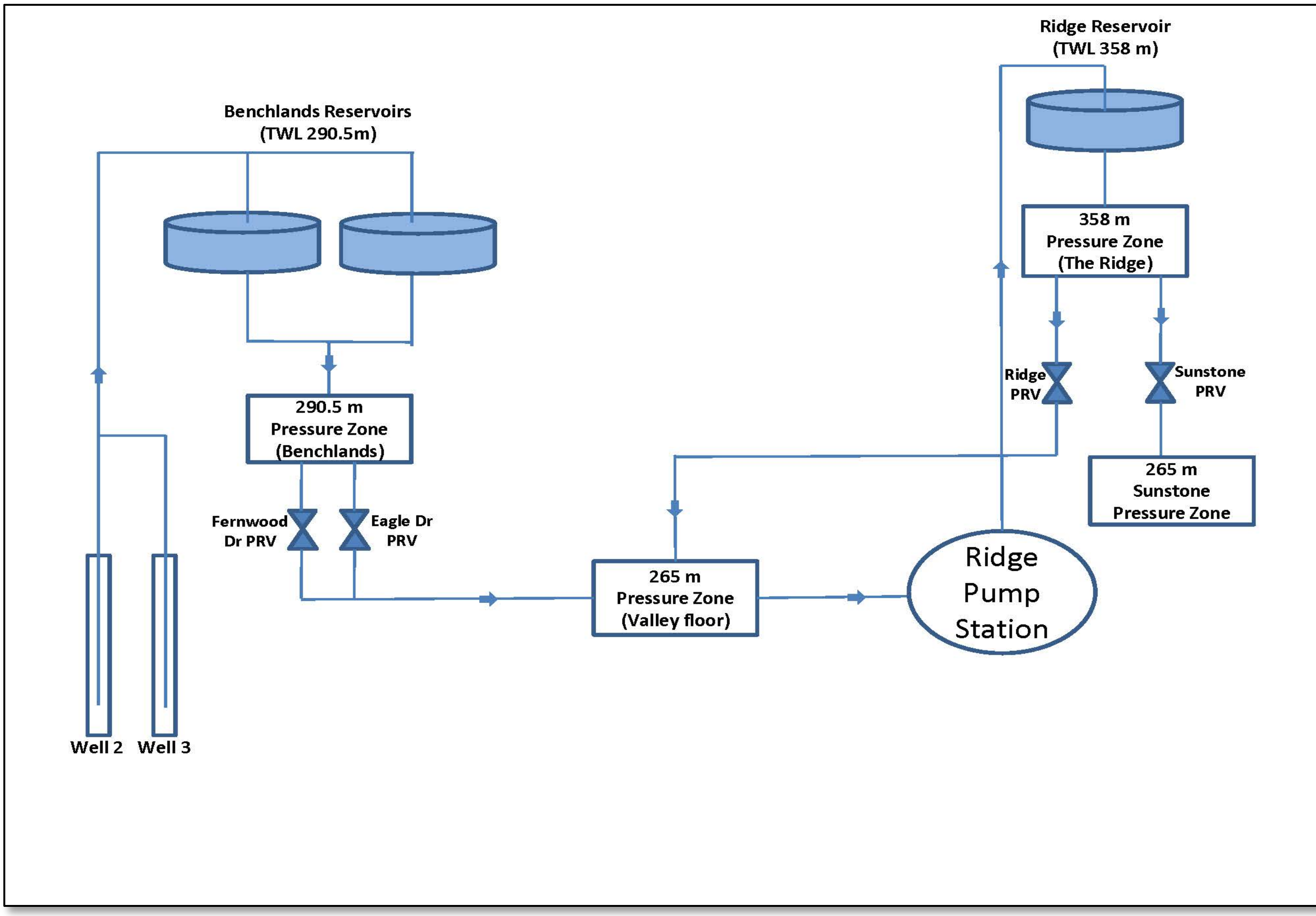


Figure 4- Village water system and pressure zones.

2.5.2 The Ridge Booster Pump Station

The Ridge booster pump station was constructed in 2017 to pump water up to the newly constructed Ridge Reservoir. The pump station also includes chlorine dosing equipment to boost chlorine levels, as this is the far end of the water system and experiences low chlorine residuals due to chlorine decay. The pump station is connected to the Ridge Reservoir via a dedicated water main.

2.5.3 Fire Protection

The Village owns and maintains a total of 95 fire hydrants spread throughout the community that provide fire flow for fire suppression activities. The Village's reservoirs are designed to include sufficient capacity for fire protection of buildings as large as schools.

3 Village Population Trends

3.1 Historic Population

The Village has experienced considerable growth over the years increasing from an approximate population of 550 in 1991 to 2,574 in the most recent 2016 Census. The data indicates that from 1991 to 2006 the Village grew at a relatively steady rate averaging 100 people per year and has slowed in recent years to an average of 50 people per year from 2006 to 2016.

3.2 Future Population

On average between 1991 and 2016, the Village grew at a rate of 80 people per year and extrapolating this growth rate indicates the Village will likely have a population of approximately 4,750 in the year 2040. Using the equation of the best fit line shows the current estimated 2020 population to be 3,100 which will be used for the purposes of this report in the absence of any recent census data. Previous studies of the Village have had a tendency to overestimate future population using exponential growth models however over the previous 25 years the data appears to more closely follow a linear trend.

There are also a number of significant residential developments currently under construction or planned for construction in the next 5 - 10 years that will presumably increase the Village population. For the purposes of this report, it will be assumed that population will increase at a linear rate as historically observed, as shown in Figure 5, but the system capacity will be assessed based on build-out of current and future planned developments.

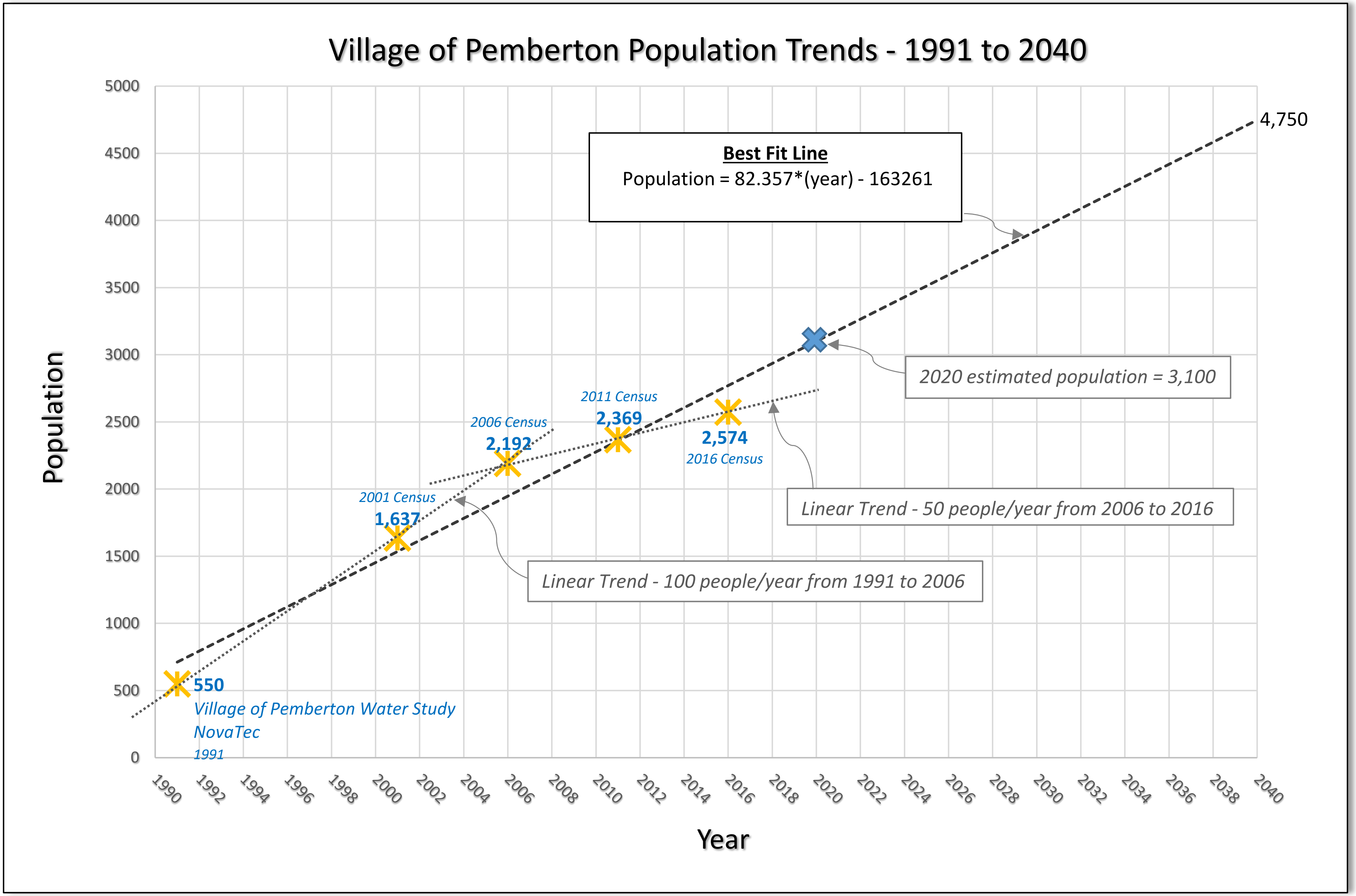


Figure 5 - Village Population Trends

4 Water Demands

4.1 Historical Demands

Figure 6 on the following page shows the daily water consumption of the Village water system from 2010 to 2020. The peaks represent consumption during the summer months and the troughs represent demand during the winter months. Water consumption increased steadily from 2010 until 2015 when a major leak was identified and repaired resulting in an immediate and substantial decrease in consumption. Records indicate the leak was responsible for a daily loss upwards of 500 m^3 or 500,000 L.

From 2016 to 2020 water consumption has remained remarkably consistent and has declined to a small extent despite a growing population. This decline can be attributed to factors such as the repairing of leaks as well as the effectiveness of water conservation measures such as summer lawn watering restrictions and increased use of water efficient appliances. It is anticipated that with increasing population, water consumption rates will again show an increasing trend in future years.

Due to the significant water leak that was repaired in 2015 impacting previous data, only data from 2016 onward was used in determining the average and maximum day consumption rates for the Village water system. Note that these values include the demands of the **PNWS**. Table 3 summarizes the Average Day and Maximum Day demands for the years 2016-2019.

Table 3 - Village Water Demands

Year	Average day demand (m^3/day)	Max day demand (m^3/day)	Peaking Factor
2016	1,847	3,696	2.0
2017	1,880	3,579	1.9
2018	1,799	3,570	2.0
2019	1,838	3,527	1.9

The maximum day demand from 2016-2019 was 3,696 m^3 on July 28, 2016. For the calculations found in this report, the rounded value of 3,700 m^3/day (42.8 L/s) will be used as the present-day Max Day Demand (**MDD**) and the 2017 average of 1,880 m^3/day (21.9 L/s) will be used for the Average Day Demand (**ADD**). The estimated sustainable aquifer withdrawal rate (2,600 m^3/day or 30 L/s) shown in Figure 6 is discussed in more detail in Section 5.2 – Aquifer Recharge Rate and is shown here to illustrate current demands with respect to aquifer capacity.

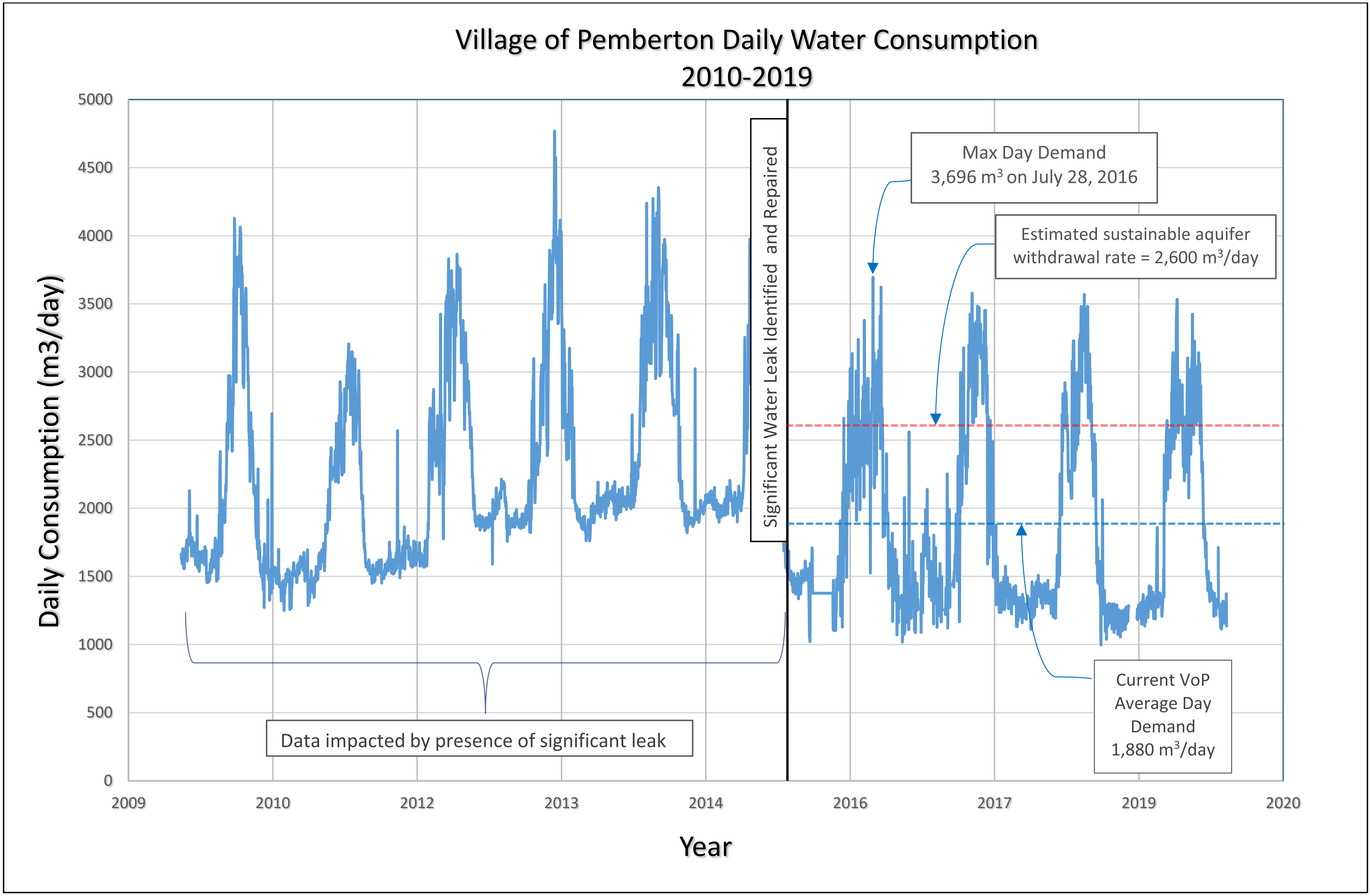


Figure 6- Daily water consumption from 2010 – 2020

4.2 Future Demands

Using the estimated population growth rate in Figure 5, along with Village design criteria for per capita water use, Table 4 shows projected Village populations along with the corresponding estimated future water use.

Table 4 - Projected future Village water demands

Year	Estimated Village population	Estimated ADD (m^3/day)	Estimated MDD (m^3/day)
2020	3,100	1,880	3,700
2025	3,510	2,067	4,073
2030	3,925	2,255	4,451
2035	4,335	2,442	4,824
2040	4,750	2,631	5,202

4.3 Per Capita Water Use

Total per capita water use, which includes residential, industrial, commercial, and other uses of water provided by the Village averaged 611 L/capita/day[1] in 2016, the last year with census data. This is above the Canadian average of 427 L/capita/day[2] indicating the potential for reducing consumption through increased water conservation efforts and or leak detection and repair.

4.4 Current and Future Development and Impacts to Water Consumption

The Village currently has several developments that are either under construction or have been completed within the previous 2 years and have not yet been substantially populated. Once populated these developments will add to the demands on the water system. Using Village Design Criteria, Table 5 summarizes the developments including their potential impacts on water consumption and assuming the average unit or lot will contribute 2.7 to the Village population as found in the 2016 census.

[1] 2016 PNWS demands deducted from Village demands.
[2] https://www150.statcan.gc.ca/n1/daily-quotidien/190611/dq190611b-eng.htm

Table 5 - Current Developments and their estimated impacts on water consumption.

Development	Population Estimate	ADD (m^3/day)	MDD (m^3/day)
The Ridge - Phase 1	119	54	108
Sunstone - Phase 1	105	48	96
Sunstone - Phase 2	108	49	98
Sunstone - Townhomes	146	66	133
Tiyata - Phase 1	51	23	47
Tiyata - Phase 2	35	16	32
Orion	122	55	111
Totals	**686**	**312**	**624**

There are also several developments currently in the planning phase and are expected to be constructed within the next 5 – 15 years. The anticipated impacts are summarized in Table 6.

Table 6 - Future developments in planning and their estimated impacts on water consumption.

Development	Population Estimate	ADD (m^3/day)	MDD (m^3/day)
The Ridge - Phase 2	65	29	59
Tiyata - Phase 3	57	26	52
Tiyata - Phase 4	32	15	29
Crestline	97	44	88
Wye Lands	216	98	197
Coombs	81	37	74
Benchlands	1215	553	1106
Totals	**1763**	**802**	**1604**

Table 7 below summarizes the impacts to water demands when both current and future developments are fully populated. The current demands and system capacity are included for comparison/reference. The system capacity is governed by the **ADD** which is an annual average while the **MDD** is a one day demand and does not impact system capacity.

Table 7 - Projected impacts to water demands when current and future developments are fully populated.

Scenario	ADD (L/s)	MDD (L/s)
Current 2020 Demands	21.9	42.8
Demands when current developments are fully populated.	25.3	50
Demands when future planned developments are fully populated.	34.6	68.6
System Capacity	**30**	**n/a**

5 Pemberton Creek Fan Aquifer

5.1 Aquifer Description

Pemberton Creek begins flowing at the base of the Ipsoot Glacier approximately 10 km west of the Village. It flows down the steep mountainous watershed before flowing out onto the Pemberton Creek alluvial fan that encompasses most of the Village's downtown core. The alluvial fan consists of cobbles, gravel, sand, and silt that have been deposited over millennia by the creek due its flattening gradient as it flows down onto the valley floor. Alluvial fan deposits vary widely over the area due to flooding events as well as changes in the creek path over the depositional history. The saturated alluvial fan deposits are what form the Pemberton Creek Fan Aquifer. The aquifer is unconfined and is considered highly susceptible to contamination by surface sources.

Several test wells have been drilled in the aquifer over the years with yields varying between 2 - 79 L/s confirming the highly variable stratigraphy of the underlying sediments. Towards the western edge of the aquifer (near the fire hall) test wells revealed cemented sand and gravel at depth which produced low yields insufficient for conversion into a municipal production well. Towards the eastern edge of the aquifer (near the railway) test wells indicate finer sands at depth contributing to low yield potential. The central portion of the aquifer where all production wells (1, 2 and 3) are located consists mainly of sand and gravel at depth, producing wells that are able to meet the demands of the Village water system.

5.2 Recharge Rate

The Pemberton Creek Fan Aquifer is primarily (~99%) recharged via leakage from Pemberton Creek with a minor contribution (~1%) from surface water sources such as snowmelt and rainfall infiltration. The 2015 report, Village of Pemberton Groundwater Recharge Assessment for Pemberton Creek Fan Aquifer by Enterprise Geoscience Services Ltd, estimated that the recharge rate of the aquifer at approximately 30 L/s. This was deduced from the observation that average water levels in Wells 2 and 3 were declining in 2014/2015 when the ADD was 30 L/s. A 2017 ISL report, Alternate Water Source Assessment, also suggested the aquifer yield to be 30 L/s based on pumping and well level records.

5.3 Aquifer Levels

Figure 7 shows the static water level for Wells 2 and 3 since 2018, when this data began being consistently collected. As expected, the summer months show a decrease in the water level of the aquifer as summer water usage exceeds the estimated 30 L/s recharge rate of the aquifer. As water usage drops below 30 L/s in the winter months the aquifer is able to recharge.

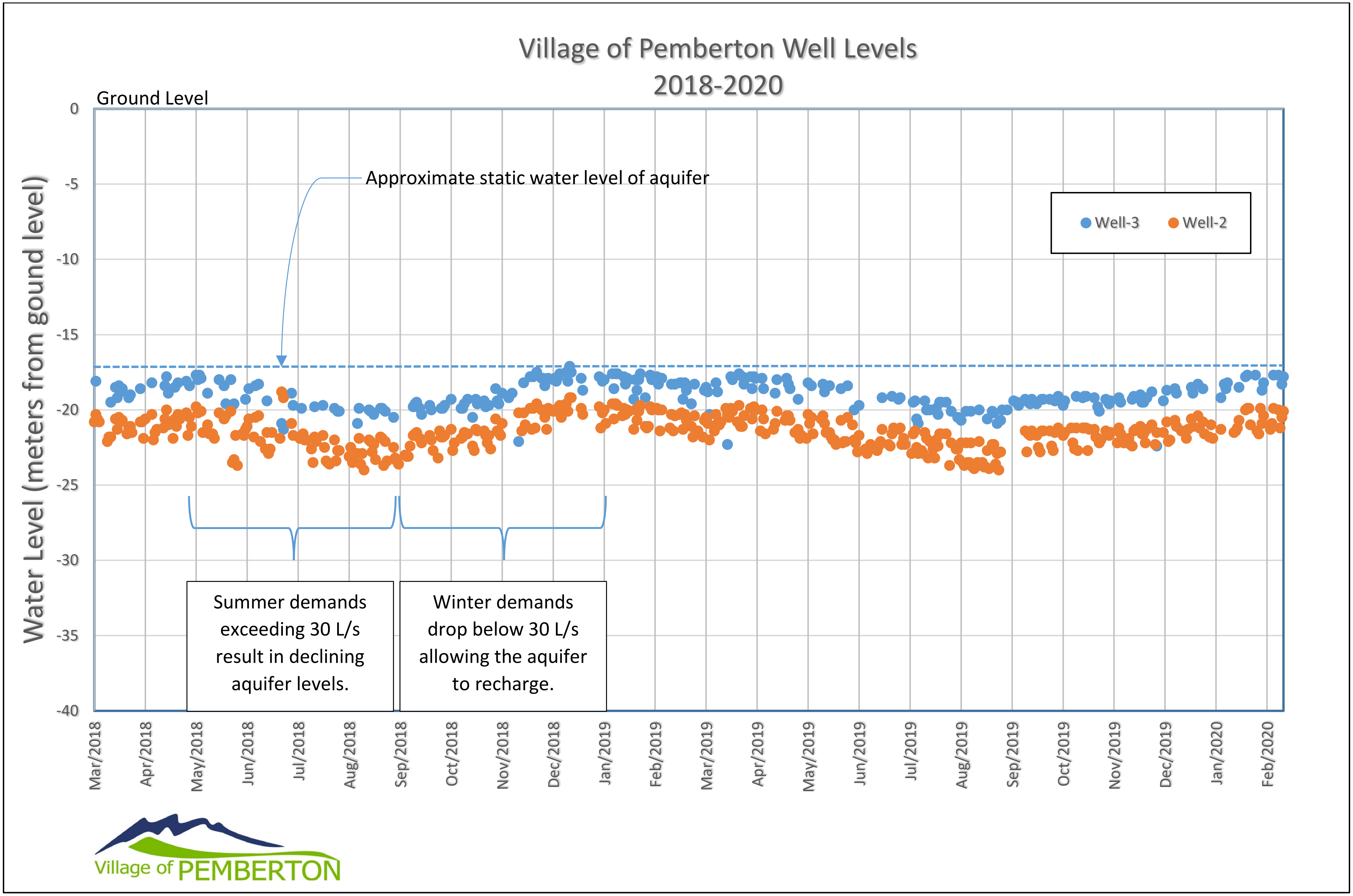


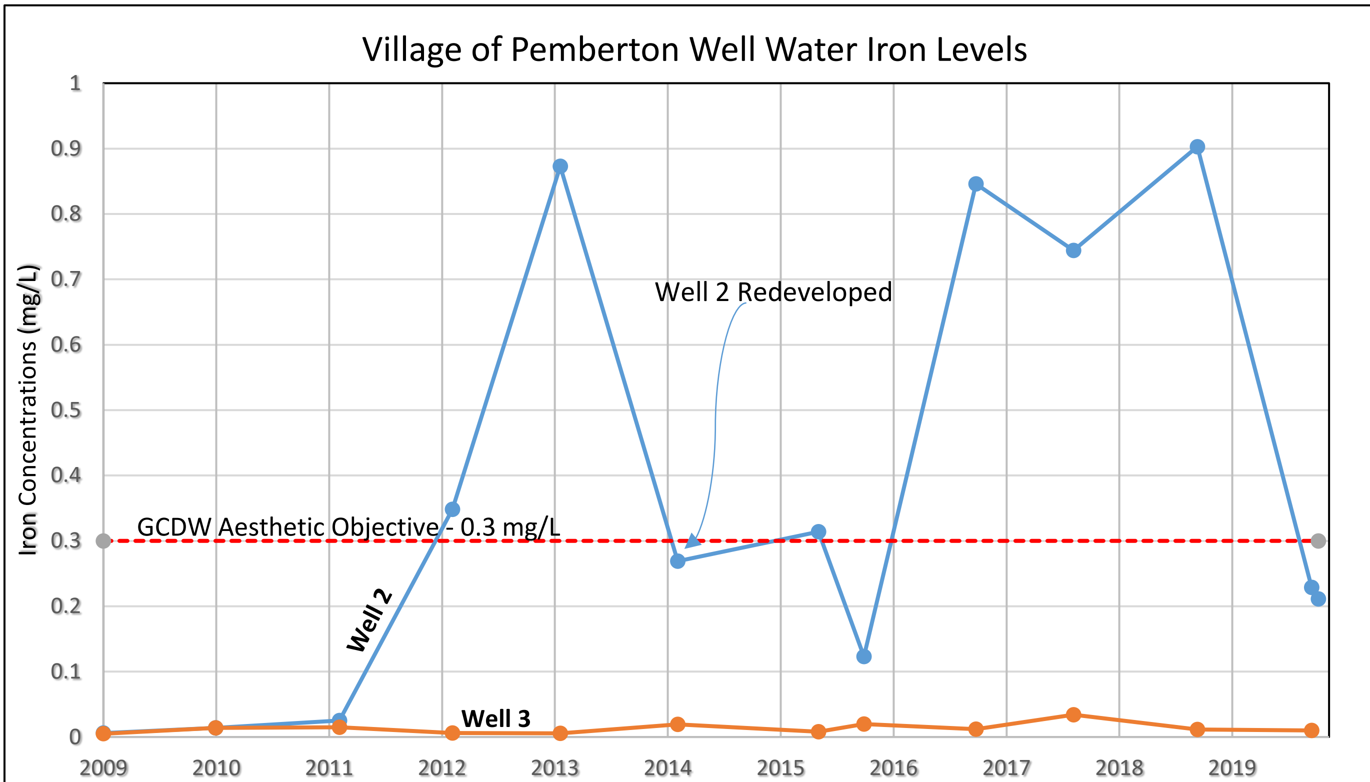
Figure 7 - VoP Well water levels

5.4 Water Quality

The Pemberton Creek Fan Aquifer produces water that is slightly acidic, is low in total dissolved solids and has shown elevated levels of iron and manganese. The presence of iron and manganese is common in groundwater wells in British Columbia and Health Canada has implemented an Aesthetic Objective (**AO**) for both iron and manganese in drinking water as both lead to staining of fixtures and appliances at higher concentrations. Manganese also has a Maximum Acceptable Concentration (**MAC**) that was implemented in 2019 due to health concerns at elevated levels which is discussed further in Section 6 – Conclusions.

Iron

Iron levels for Wells 2 and 3 clearly show the elevated levels present in Well 2 as compared to Well 3. Well 2 appears to have had negligable levels before suddenly and sharply increasing in 2011, exceeding the **AO**. Well 2 was redeveloped in 2014 resulting in a drop in iron levels that lasted two years before again surging to exceed the **AO** in 2016. The most recent results in 2020 show that iron levels have decreased back below the **AO** despite not having been redevoped or having any additional maintenance performed that can explain the decrease. Well 1, not shown on the graph due to scale, had a test result of 16.7 mg/L in 2013, the last time it was tested.



Manganese

Figure 8 - Iron levels in Village Wells

Manganese trends closely resemble iron trends for both Wells 1 and 2 with one key exception, manganese tends to appear before iron within the same well. Well 2 showed negligible manganese levels until starting to increase in 2010; two years before iron began increasing in the same well. Since 2010, manganese levels in Well 2 have not dropped below the **AO** of 0.02 mg/L and operations staff have observed the need for increased flushing when Well 2 is in use. Well 2 has also exceeded the recently introduced **MAC** at various times over the past several years before the **MAC** was introduced. As with iron levels, the most recent manganese results for Well 2 also show a decreasing trend and at present the level is below the **MAC** but above the **AO**. Well 3 manganese levels have historically been negligible, but in 2017 began to increase and in 2020 exceeded the **AO** for manganese. Considering that both Wells 1 and 2 showed similar trends of having good water quality to start with before rising iron and manganese levels exceeded **AO** and **MAC** limits, it is concerning to see the start of that trend with Well 3, the Villages main well. Well 1 was last tested in 2015 and had levels of manganese close to three times the **MAC**.

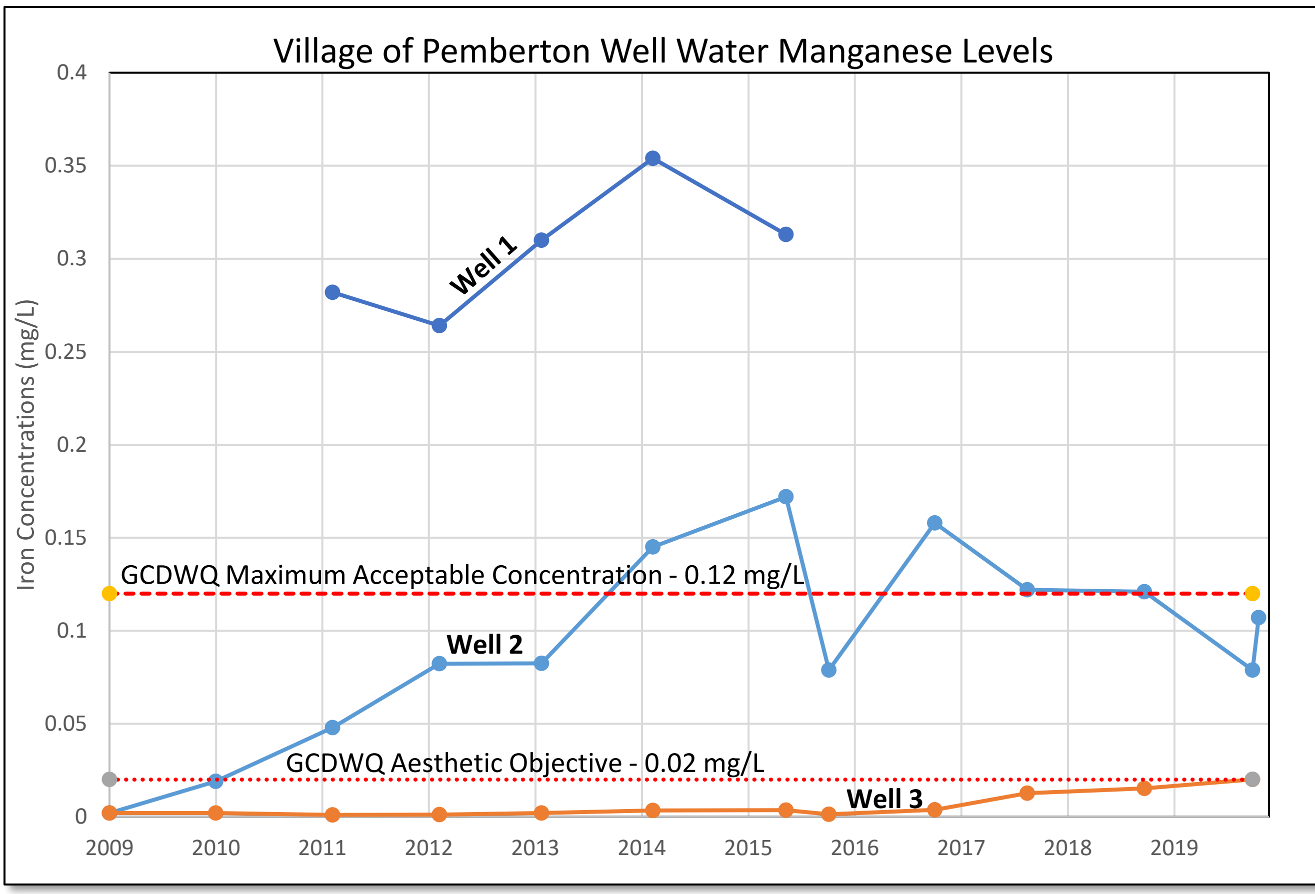


Figure 9 - Manganese Levels in Village Wells

6 Conclusions

The water supply for the Village of Pemberton is showing concerning trends with regards to increasing manganese concentrations in its well water. Historical records of the wells indicate that manganese and iron levels have tended to appear in increasing concentrations 5-10 years after well construction. This trend has been observed for Wells 1 and 2 and is now starting to show the same early signs in Well 3, the main Village well. The central concern is the level of manganese which in Wells 1 and 2 has risen above the Maximum Acceptable Concentration set out by Health Canada. Well 3 has recently exceeded the Aesthetic Objective for manganese and if it continues the same trend, in the next 4-6 years it may exceed the **MAC** requiring the Village to implement additional treatment targeting manganese to maintain the ability to provide water that meets all **GCDWQ** guidelines.

In 2019 the BC Ministry of Health issued the document "Guidance on Manganese in Drinking Water" in conjunction with the implementation of the new **MAC** for manganese. It summarized the health impacts associated with high levels of manganese and that "*measurable neurological impacts may be possible when infants and children are chronically exposed to manganese concentrations greater than the MAC*." It also stated that "*Ongoing elevated trends in manganese concentration may indicate a change in source water or watershed conditions and could be associated with changes to water chemistry or the presence of co-contaminants and warrant significant consideration.*" It is beyond the scope of this report to determine the cause of the increasing manganese levels other than to observe that it appears to be a change in source water quality over time that warrants further investigation.

Current testing of water quality including metals such as iron and manganese occurs on an annual basis for Wells 2 and 3 as required by Vancouver Coastal Health. Increasing testing to monthly will provide greater detail on the manganese and iron trends moving forward and will allow early detection of manganese levels approaching the **MAC**. Increasing testing frequency will also provide vital data that will aid in the design of any future treatment solutions. Iron bacteria is another parameter worth tracking in order to observe how their numbers fluctuate with changing iron and manganese levels.

Due to Well 2 exceeding the recently established MAC for manganese the Village decided to attempt to develop a new backup well to replace it in early 2020. Two test wells were drilled in early spring of 2020, one in Pioneer Park and the other in Foughberg Park. The Pioneer Park test well's drilling record showed fine sands at depth indicating low yield potential that would not be adequate for development into a full production well. The Foughberg Park test well showed suitable yield potential but also showed similar water quality concerns as Well 2, the well it would be replacing. These latest results indicate that the Village would be best served by implementing treatment of the existing wells rather than searching and attempting to develop another well in the small highly developed central portion of the aquifer.

The sustainable use of the Pemberton Creek Fan Aquifer also requires average annual water consumption to remain below 30 L/s. The current average consumption is 21.3 L/s and using Village design criteria, a population increase of 1,555 people will bring the ADD to 30 L/s which based on population projections will occur around the year 2040. From a development viewpoint, developments under construction and those completed within the last couple years will add to the demands of the system as they are populated. Current system capacity can accommodate these developments when fully populated. Developments that are currently in the planning phase for construction within the next 5-15 years will further add to the demands of the system must take into account how close the current system is to capacity with regards to the sustainable use of the aquifer. Although there is ample reservoir capacity, the supply source will soon be under strain and require either a new or supplemental source for future developments. There are a number of options for developing a new source that warrant further investigation as outlined in ISL's 2017 report "Alternate Water Source Assessment".

To maximize the time that the Pemberton Creek Fan Aquifer can be utilized as the sole source for the Village, water conservation efforts must be implemented in order to bring the Village's per capita water consumption down. By lowering consumption through water conservation efforts in combination with leak detection and repair, the Village can buy itself significant time before needing to develop a new source. Developing a new source is a considerable undertaking that must take into account not only water quality and quantity, but also location and ease of incorporating into the existing distribution system, which if not ideal, can dramatically increase capital costs.

The Village of Pemberton is significantly invested in its current source and to ensure its ongoing viability, options for both the treatment of manganese, and the reduction of overall consumption must be investigated. Implementing these measures will help ensure the Village is able to provide water that meets all **GCDWQ** targets while extending the time before a new source must be developed to either supplement or replace the existing source.

7 Recommendations

Considering the conclusions reached above, the following recommendations are put forth for the Village to consider with regards to the water supply system:

1. Increase the frequency of water quality testing for iron, manganese and iron bacteria for Wells 2 and 3 from annually to monthly to more closely monitor changes in WQ
2. Perform redevelopments of Wells 2 and 3 to potentially improve water quality and Well efficiency in the short term.
3. Initiate a study for the treatment of iron and manganese in Wells 2 and 3 comparing various treatment options along with their estimated capital and O&M costs.
4. Undertake a Water Source Feasibility Study to determine the most feasible option in developing a new source to replace/supplement the existing source. The study should focus on both groundwater and surface water sources and include Class D capital and operating cost estimates.
5. Investigate methods of reducing water consumption such as water conservation methods and leak detection and repair to bring down the Village's per capita water demands
6. Initiate the design and installation of a backup generator for Wells 2 and 3 to ensure the Village is able to provide water in emergency situations involving loss of power.

8 Closure

I trust this information is sufficient for meeting the Objectives of this report. If you have any questions, please do not hesitate to contact the undersigned.

Respectfully submitted,

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David Ward, P.Eng.

Village of Pemberton, Assistant Manager Operations