REPORT

Assessment of Groundwater at Risk of Containing Pathogens (GARP), Railway Well Field, Parksville, BC

City of Parksville, Parksville, BC

Submitted to:

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Distribution List

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Hydrogeological investigations and groundwater assessments are dynamic and inexact sciences. They are dynamic in the sense that the state of any hydrological system is changing with time, and in the sense that the science is continually developing new techniques to evaluate these systems. They are inexact in the sense that subsurface conditions are not known between the specific investigation locations, and there is invariably a lack of complete information both spatially and temporally about the geological and hydrogeological conditions.

The hydrogeological services performed as described in this report were conducted in a manner consistent with the level of care and skill normally exercised by other members of the engineering and science professions currently practising under similar conditions, subject to the quantity and quality of available data, the time limits and financial and physical constraints applicable to the services. Unless otherwise specified, the results of previous or simultaneous work provided by sources other than WSP and quoted and/or used herein are considered as having been obtained according to recognised and accepted professional rules and practices, and therefore deemed valid. WSP makes no warranty, expressed or implied, and assumes no liability with respect to the use of the information contained in this report at the subject site, or any other site, for other than its intended purpose. If new information is discovered in the future, WSP should be requested to re-evaluate the conclusions of this report and provide amendments as required prior to any reliance upon the information presented herein.

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1.0 INTRODUCTION

As requested by the City of Parksville (the City), WSP Canada Inc. (WSP), formerly Golder Associates Ltd. Member of WSP (Golder)[1], conducted an assessment of the City's seven existing production wells (the "Railway Wells") at the Railway Well Field (the Site) to be groundwater at risk of containing pathogens (GARP), herein referred to as the "GARP Assessment". WSP conducted the GARP Assessment as per our proposal titled "Proposal for Professional Services for Assessment of Groundwater at Risk of Containing Pathogens (GARP), Railway Well Field, Parksville, BC" and dated 22 June 2022 (Proposal No. CX22532310-001-P-Rev0). Our proposal was developed based on the requirements of the City's Request for Proposal (RFP) File No. 2240-20-GARP.

The GARP Assessment was conducted in accordance with the procedures outlined in the BC Ministry of Health (MoH, 2017) Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP) (the "GARP Guidance Document") and Engineers and Geoscientists BC (EGBC, 2019) Professional Practice Guidelines for Assessment of Groundwater at Risk of Containing Pathogens (GARP) (the "GARP Professional Practice Guidelines"). WSP also conducted a preliminary review of the existing drinking water treatment process considering the BC MoH (2015) Drinking Water Treatment Objectives (Microbiological) for Ground Water Supplies in British Columbia (the "DWTO Document").

The information presented in this report should be interpreted and used in accordance with the limitations and considerations set out in WSP's *Study Limitations*, provided at the beginning of this report.

2.0 OBJECTIVE AND SCOPE OF WORK

The objective of the GARP Assessment was to screen and assess each of the Railway Wells (i.e., Railway #1, #2, #3, #4, #5, #6 and #7)[2] according to the criteria outlined in the MoH GARP Guidance Document and to provide a professional opinion regarding whether the well is considered to be GARP.

The scope of work for this GARP Assessment included the following:

- compile and conduct a desktop review of relevant background information available from provincial databases and provided by the City
- conduct capture zone analysis to estimate 200-day time-of-travel zones for the Railway Wells
- conduct a Site visit with City staff to supplement the background information and assess the wellhead conditions and adjacent land uses; a second Site visit was also conducted by WSP to supplement the Site visit that was conducted with City staff
- analyse the results and conduct a Stage 1 hazard screening and Level 1 preliminary hydrogeological investigation supplemented with more detailed elements that are consistent with Level 2 or 3 investigations, as per the GARP Guidance Document
- conduct a preliminary review of the existing water treatment process, considering the results of the GARP Assessment and the DWTO Document, herein referred to as the Preliminary Review of Groundwater Treatment Practices
- prepare a factual report that presents the results of the GARP Assessment and provides conclusions and recommendations

[1] Work conducted, including documents issued, prior to 1 January 2023 is referenced as "Golder"; subsequent work referenced as WSP.

[2] Railway #8, which is located approximately 800 m northwest from the Railway Well Field, was not included in the GARP Assessment.

3.0 METHODS

For the GARP Assessment, WSP compiled and reviewed the following information:

- water well records (i.e., well logs) and construction drawings provided by the City
- information and water quality data provided by the City
- reports prepared by consultants and subcontractors
- land use, topographic and geospatial data available through public sources, including Google Earth™
- aquifer mapping information available online on the BC Ministry of Environment and Climate Change Strategy (ENV) Groundwater Wells and Aquifers (GWELLS) database
- water resources information available online on the Regional District of Nanaimo (RDN) Interactive Map and Water Resource Information System (RDNMap)
- analysis of chlorine contact time for groundwater from the Railway Wells presented by the City

WSP conducted capture zone analysis to delineate 200-day time-of-travel zones for the Railway Wells; a capture zone is defined as the portion of an aquifer from which groundwater is derived by a pumping well and time-of-travel zones are sub regions of the capture zone from which groundwater is derived in a fixed portion of time. For the purposes of the GARP Assessment, a time-of-travel zone of 200 days was selected to be consistent with the considerations for virus transport that are outlined in the GARP Guidance Document. However, it is noted that 200 days is a conservative estimate of the travel time required to achieve up to a 4-log inactivation of viruses, as this value is based on a relatively low groundwater temperature of 5°C and does not account for filtration, adsorption or degradation of viruses.

WSP conducted the capture zone analysis using a three-dimensional (3D) regional-scale numerical groundwater flow model that WSP developed for the French Creek Water Region.[3] The model, which was developed for the Phase 3 Refined Water Budget project that WSP is conducting for the RDN, was constructed with the FEFLOW 3D finite element code to simulate the complex hydrogeological setting and calibrated to conditions in the dry and wet seasons; further details are presented in the draft report by Golder (2022). With the permission of the RDN, for the purposes of the GARP Assessment, WSP simulated simultaneous pumping of all the Railway Wells at the average pumping rates that the City applied during the dry season of 2022; the pumping rates are presented in Table 1 in Section 4.1.1. As a result, the time-of-travel zones are considered to be conservative (i.e., reflect relatively larger areas than those representative of annual pumping conditions) because the pumping rates are highest during the dry summer months. In addition, the combined 200-day time-of-travel zone for the well field is larger than the sum of the zones when the wells are pumped individually.

WSP conducted a Site visit with City staff on 27 February 2023 to supplement the information from the desktop review and assess current wellhead conditions and land uses at the Railway Well Field and the surrounding area.

[3] The RDN and the City provided approval to use the model for the purposes of the GARP Assessment via email correspondence dated 28 November 2022.

Ms. Barbara Silenieks, Utilities Technician and Mr. Scott Churko, Chief Operator, Distribution of the City accompanied Mr. Mark Bolton of WSP during the Site visit, which included assessment of the following:

- the wellhead conditions at each of the City's wells at the Railway Well Field, including the well casing at and above grade, the well cap and cover and general ground conditions at the wellhead; however, as discussed in Section 4.1, at the time of the Site visit, snow cover limited the view of ground conditions at the well field on 27 February
- conditions at the well field and adjacent to each of the Railway Wells
- general conditions and land uses in the estimated 200-day time-of-travel zone and surrounding area
- general layout and treatment process at the Springwood Water Complex (the "Water Complex"), where groundwater from the Railway Wells is treated prior to entering the City's water supply distribution network

WSP conducted brief supplemental Site visits to document ground conditions at the Site when there was no snow cover during a precipitation event on 6 April 2023 and during clear conditions on 7 April 2023.

WSP analysed the results from the desktop review, capture zone analysis and Site visits. Based on the results, WSP screened each of the Railway Wells against the 13 hazards identified in the GARP Guidance Document, assessed those hazards that were considered to be present, and provided an opinion to support a GARP Determination (Stage 2) by Island Health.

WSP also conducted a preliminary review of the chlorination practices that the City currently applies to the groundwater from the Railway Wells to assess whether the CT[4] is sufficient to meet the microbiological water quality objectives outlined in the DWTO Document, including 4-log removal of viruses before reaching the first user.

[4] CT value is the product of the concentration of a disinfectant (e.g., free chlorine) and the contact time that the disinfectant has with the water being disinfected.

4.0 RESULTS AND DISCUSSION

A description of the general setting of the Railway Well Field and treatment that is applied to the groundwater is provided in Section 4.1. The results of the GARP Assessment are presented in Table A-1, APPENDIX A and discussed in Section 4.2. The results of the Preliminary Review of Groundwater Treatment Practices are presented in Section 4.3.

4.1 Site Setting and Well Operations

The City currently operates seven supply wells at the Railway Well Field (i.e., Railway #1, #2, #3, #4, #5, #6 and #7). The Railway Well Field is located along the southern border of the municipality, northeast from the intersection of Highway 19 and Highway 4A, as presented on Figure 1. The Railway Well Field is bisected by the E&N Railway, which is currently not in service; Railway #1, #2, #3 and #4 are located north of the railway line (referred to as the North Railway Wells) and Railway #5, #6 and #7 are located south of the railway line (referred to as the South Railway Wells; Figures 1 and 2). In the area of the Railway Well Field, ground surface generally slopes towards the north (Figures 1 and 2).

Along the railway line, the area is cleared and generally undeveloped; the Arrowsmith Potter's Guild store is located in the former railway station building, west of the Railway Wells (Photos B-1 and B-2, APPENDIX B), and a fenced compound that is used by the E&N Railway is located in the central portion of the well field, as shown in Photo B-3 (APPENDIX B), and on Figure 2. The City (2023a) reported that the compound is currently used for storage and there is no subsurface infrastructure (i.e., utilities or storage tanks) associated with the compound. It is understood that up until approximately 2001, maintenance activities had previously occurred in the compound when chemicals and fuels may have been used and stored; however, the compound is reported to have been used only for storage since 2001. Vehicular access to the Railway Well Field is controlled by locked gates that are located west of the well field to the north and south of the railway line (Photos B-2 to B-4, APPENDIX B). Walking trails extend through the area of the well field where the Railway Wells are located. Undeveloped land is located north of the well field and residential properties are located to the east and south of the well field (Figure 2).

Detailed diagrams of the wellhead completion for Railway #4 and #7 that were prepared by Koers & Associates Engineering Ltd. (1995 and 1997, respectively) are provided in APPENDIX C to illustrate wellhead completion at the Railway Wells. Each well at the Railway Well Field is protected by a locked steel kiosk that is located within a locked, fenced compound (Photos B-5 and B-6, APPENDIX B). Each kiosk is secured on a concrete slab. The tops of the concrete slabs are graded away from the kiosk walls (Photo B-7, APPENDIX B and wellhead drawings, APPENDIX C). The tops of the concrete slabs are completed above surrounding ground surface (Photo B-7, APPENDIX B); the tops of the concrete were observed to be similar at each well and was measured during the Site visit to be approximately 8 cm (3-inch) higher than ground surface at Railway #7.

The kiosks for Railway #1, #2, #4, #6 and #7 are approximately 1.2 m in height, 2.2 m long and 0.8 m wide (Photos B-5 to B-7, APPENDIX B). The kiosks for Railway #3 and #5 are approximately 1.8 m in height, 3.5 m in length and 1.0 m in width (Photo B-8, APPENDIX B). The larger kiosk at each of these two well locations includes a second chamber; the additional chamber at the Railway #5 kiosk contains electrical controls for the three South Railway Wells and the additional chamber at the Railway #3 kiosk contains electrical controls for the four North Railway Wells as well as Supervisory Control and Data Acquisition (SCADA) controls for operation of the seven wells at the Railway Well Field.

Within each kiosk, distribution pipe is connected to the well casing with a commercially manufactured steel flange that is sealed with a gasket. The distribution pipe is equipped with an air release valve, a flow meter, check valve, pressure gauge and gate valve to control flow rates (Photo B-9, APPENDIX B and wellhead drawings, APPENDIX C). During the Site visit, no annular space was visible between the well casings and the concrete floor. The concrete floor in the kiosks is graded away from the well casing towards a drain (Photo B-10, APPENDIX B). The drawings provided in APPENDIX C indicate that the drains, which are reported to be completed with rodent screen and grate, discharge to daylight. The locations where the drainpipes discharge were not confirmed during the Site visits and are assumed to be behind the fenced compounds.

During the Site visit on 27 February 2023, City personnel advised that corrosion that was observed in some of the kiosks on the outer well casing and other metal parts resulted from moisture and condensation, particularly during the summer (Photo B-10, APPENDIX B). On 27 February, space heaters were operating in the kiosks to prevent freezing and accumulation of condensation. The City also advised that as maintenance work is being done at the wellheads, the flanges are being replaced with stainless steel components and gaskets are being replaced, as has been done for Railway #2 (Photo B-11, APPENDIX B).

The pumps in wells at the Railway Well Field are operated by the SCADA system and turn on and off in response to water levels in Reservoir No. 2 at the Water Complex, discussed below. The City advised that applications have been submitted to the Province to license the groundwater use from the Railway Wells, but a decision by the Province is still pending.

The flow rate for each well is manually controlled at the wellhead with a gate valve. During the Site visit, the City indicated that flow rates are typically manually adjusted twice a year, once during the dry season and once during the wet season. Groundwater from the Railway Wells flows in a dedicated 250 mm PVC water main from the well field to the Water Complex, located approximately one km northwest from the well field (Figure 1). This dedicated line is connected to a hydrant to enable flushing at the well field and Railway #8, located approximately 800 m northwest from the Railway Well Field (Figure 1).

APPENDIX D presents a diagram of the infrastructure at the Water Complex, as provided by the City (2023b). Groundwater from both the Railway Well Field and the Springwood Well Field, located immediately west of the Water Complex, flows into Reservoir No. 2. When the wells at the Railway and Springwood Well Fields are turned on, the pump in Well No. 1, located in the Water Complex compound, also turns on. Groundwater from Well No. 1 is chlorinated at the wellhead to a concentration of approximately 0.25 mg/L (City, 2023a) (Photo B-12, APPENDIX B). Water then flows from Reservoir No. 2 through Reservoir No. 1, which is baffled to prevent short-circuiting, to the pump station. At the pump station, water is chlorinated again and analysed prior to being transferred to Reservoir No. 4 (Photos B-13 and B-14, APPENDIX B). Water then flows from Reservoir No. 4 to the distribution system. Further description of the groundwater treatment process is provided in Section 4.3.

4.1.1 Summary of Well Construction and Operation Details

A summary of well construction details for the Railway Wells is presented in Table 1 and discussed below. Copies of available water well records (i.e., well logs) and engineering drawings for the Railway Wells are provided in APPENDIX E.

In general, the Railway Wells are completed with 4.6 m (15 ft) long screens set with the tops of the screens at depths of 17.9 to 29.2 m below ground surface (bgs). The screens of the Railway Wells are completed in fine to medium grained sand deposits that are interpreted to be the Quadra Sand Aquifer, described below. The City provided WSP with daily minimum and maximum geodetic elevations of the groundwater levels that were collected with the SCADA system in 2022 for Railway #1, #2, #3, #4 and #5. The system was not recording water levels in Railway #6 and #7 accurately in 2022. Therefore, water level data were provided from 2016 for Railway #6 and 2020 for Railway #7. The daily maximum depths to water were calculated based on the elevation of the kiosk floor at each wellhead and the results are presented in APPENDIX F.

Table 1: Summary of Well Construction and Operation Details, Railway Well Field

Railway Well No.	Year Drilled	Well Tag No.[a]	Well ID Plate No.[a]	Well Casing		Total Well Depth (m bgs)[d]	Well Screen Details			Surface Seal (Y/N) and Depth (m bgs)[h,i]	Aquifer Deposits[j]	2022 Minimum Depth to Static Water Level (m bgs)[k]	2022 Dry Season Pumping Rate (m^3/day)[l]
				Diameter[b]	Stick-up (m ags)[c]		Top of Screen (m bgs)[d,e,f]	Bottom of Screen (m bgs)[d]	Slot Size[g]				
#1	1990	107055	13765	203 mm (8-inch)	0.25	30.8	24.8	30.8	0.305 mm (0.012-inch) to 0.381 mm (0.015-inch)	N	sand	18.4	186
#2	1994	107041	13758	203 mm (8-inch)	0.25	32.3	26.2	32.3	0.305 mm (0.012-inch) to 0.381 mm (0.015-inch)	Y – 4.0	fine sand	8.3[m]	317
#3	1994	107046	13767	203 mm (8-inch)	0.25	25.1	20.6	25.1	0.254 mm (0.010-inch) to 0.305 mm (0.012-inch)	Y – 4.0	fine sand	15.1	122
#4	1995	107092	13760	203 mm (8-inch)	0.27	22.5	17.9	22.5	0.381 mm (0.015-inch)	Y – 4.1	medium grained sand	15.3	130
#5	1996	107094	13761	203 mm (8-inch)	0.30	35.6	29.1	35.6	0.330 mm (0.013-inch) to 0.381 mm (0.015-inch)	Y – 4.6	fine sand	16.5	201
#6	1996	107096	13762	203 mm (8-inch)	0.35	36.0	29.6	36.0	0.330 mm (0.013-inch) to 0.381 mm (0.015-inch)	Y – 4.5	fine sand	8.8	343
#7	1997	107099	13763	203 mm (8-inch)	0.30	33.4	26.7	33.4	0.406 mm (0.016-inch)	Y – 4.5	fine sand	8.9	207

Notes:

a. Well Tag No. (WTN) and Plate ID No. assigned on ENV WELLS database

b. dia = diameter, measured in millimetres (inches)

c. casing stickup measured as meters above ground surface (mags) in the kiosk at the wellhead, as measured during Site visit on 27 February 2023; stickup values reported on well logs at the time of drilling may not reflect current conditions

d. m bgs = metres below ground surface: as reported on engineering drawings or well logs (for wells with no associated engineering drawing); note minor discrepancies exist between some engineering drawings and associated well logs but do not affect the results of this GARP Assessment

e. note that engineering drawings refer to top of well screen assembly when indicating "Top of Well Screen"; well screen assemblies include riser pipe in addition to screened sections and therefore overestimate the length of the well screen

f. discrepancies noted in engineering record for Railway #7; therefore, information from well log were considered for the GARP Assessment

g. screen slot size reported in millimetres (inches)

h. well reported to have been constructed with a surface seal: Y/N = yes or no; depth that surface seal extended to in metres below ground surface (m bgs) at the time of drilling, as reported on well log

i. well log indicates that 254 mm (10-inch) diameter outer casing was advanced to a depth of 3.5 m bgs and removed following construction; however, no information is provided to indicate that the well was completed with a surface seal. In the absence of this information, it is conservatively assumed that Railway #1 was not completed with a surface seal

j. aquifer deposits in which well is screened

k. minimum depth to static water level reported in water level data provided by the City of Parksville (2023c), estimated as approximate metres below ground surface (m bgs) relative to the kiosk floor at the wellhead

l. average pumping rate during dry season 2022, as provided by the City of Parksville (2022); these data were used for capture zone analysis described in Sections 3.0 and 4.1.3

m. anomalous water elevation data are inferred to reflect errors in the data and do not represent actual groundwater levels

4.1.2 Aquifer Setting

The area of the Railway Well Field is mapped by ENV (2022) as being underlain by Aquifer 216. This aquifer, which consists of sand and gravel deposits of the Quadra Sand unit, is mapped by Fyles (1963) and Natural Resources Canada (2015) as being overlain by surficial deposits generally described as a marine veneer of varied stony or boulder gravel, gravel, sand, silt, clay and stony loam deposits that are less than 1 to 1.5 m thick and discontinuous. The marine surficial deposits are mapped as being underlain by Quadra sediments directly, or by till that is described as boulder diamictons of a sandy to clayey matrix (Natural Resources Canada, 2015). In the vicinity of the Railway Well Field, there is some uncertainty regarding the thickness and composition of the deposits that overlie the Quadra Sand, as both maps are regional in scale. The information on the well logs provided in APPENDIX E describe the surficial sediments that overlie the Quadra Sand deposits as compact silt to silty sand and gravel that extend to depths ranging from 3.1 (Railway #7) to 9.1 m bgs (Railway #4); the well log for Railway #1 does not provide information regarding the stratigraphy encountered during drilling.

Although ENV (1996) originally classified Aquifer 216 as IB on the Aquifer Classification Work Sheet, indicating a heavy level of development and moderate vulnerability to contamination from surface sources, the aquifer is now classified as IIB on the WELLS database, reflecting a moderate level of development. The vulnerability classification of moderate reflects the generally confined nature of the aquifer; however, as noted above, the thickness and composition of the confining deposits are interpreted to be variable. Although the ENV (1996) Aquifer Classification Work Sheet notes that the aquifer is unconfined in the southern part of the aquifer, south of the railway, review of the well logs for the Railway Wells suggests that confining deposits are present in the area of the Railway Well Field.

4.1.3 Capture Zone Analysis

The extent of the 200-day time-of-travel zone that WSP estimated for the Railway Well Field using the dry season pumping rates for 2022, as presented in Table 1 in Section 4.1.1, is presented on Figure 3. The zone, which is considered to be conservative due to the factors discussed in Section 3.0, extends to the residential properties located along Maple Crescent, east of the North Railway Wells, and along Wildgreen Way, south of the South Railway Wells. The 200-day time-of-travel zone extends west to approximately Highway 4A and south past Highway 19. The results of the capture zone analysis provided input to the GARP Assessment, as discussed in Section 4.2.2.

4.2 GARP Assessment

4.2.1 Water Quality Hazards (Hazard Categories A1 – A2)

Hazard A1: Microbiological Test Results

WSP reviewed microbiological water quality data provided by the City for groundwater samples that were collected from the Railway Wells from 2010 to 2023. Excerpts in well completion reports that were provided by the City also indicated that samples collected at the time of drilling were reported with no detectable concentrations of microbiological parameters, but the corresponding analytical laboratory data were not available for review. A summary of the available microbiological data, plus reported turbidity values and concentrations of iron and manganese, are provided in Table G-1, APPENDIX G.

The City generally collects raw groundwater samples from one or two Railway Wells per year for microbiological analysis. Samples were collected at different times of the year and are inferred to collectively reflect a range of operating conditions and seasonal variations. Results for a total of 17 samples are presented in Table G-1, each reported with no detectable coliform bacteria and no detectable Escherichia coli (*E. coli*) bacteria. Based on these results, Hazard A1 was screened as being not present for the Railway Wells.

Although these results demonstrate that the groundwater from the Railway Wells were consistently reported with no detectable microbiological parameters, it is recognized that no more than four samples are presented for each Railway Well. Continued sampling over a range of operating and seasonal conditions will increase the data set and the confidence in the results.

Hazard A2: Turbidity

The results of turbidity monitoring that the City has conducted for the Railway Wells are also presented in Table G-1, APPENDIX G. The 17 turbidity results ranged from less than 0.1 to 0.34 nephelometric turbidity units (NTU). It is noted that the turbidity results were reported by the laboratory and not measured directly at the wellhead at the time of sampling. These results therefore may be conservative (i.e., potentially biased high), as metals can precipitate out of solution during transport to the lab, potentially increasing the turbidity of the samples.

These results demonstrate that the turbidity of the groundwater from the Railway Wells has consistently been less than the maximum value of 1 NTU that is specified in the GARP Guidance Document; however, similar to the microbiological parameters, continued sampling will increase the confidence in the data set. In particular, sampling during the wet season when precipitation and surface water runoff are greatest will demonstrate groundwater quality during conditions that are inferred to represent a higher risk.

Based on the information reviewed, Hazard A2 was screened as being not present for the Railway Wells.

4.2.2 Well Location (Hazard Categories B1 – B4)

Hazard B1: Setbacks from Sources of Contamination

As described in Section 4.1, the immediate area of the Railway Well Field is undeveloped. The Railway Wells are located at distances greater than the setback requirements in the BC Health Hazards Regulation (HHR; BC Reg 216/2011, OC 575/2011 amended by BC Reg 186/2020), including the following:

- 30 m from a probable source of contamination
- 6 m from a private dwelling
- 120 m from a cemetery or dumping ground

WSP also conducted a search of Environmental Remediation Sites on the iMapBC database (Province of British Columbia, 2022). The results identified no records at the Railway Well Field; the nearest site identified was the “Springford Property (Buckerfields)” (Regional File No. 26250-20/3206, Environmental Remediation Site ID 63714013), located over 250 m west and inferred cross-gradient from Railway #3, and located outside the 200-day time-of-travel zone for the Railway Wells (Figure 3). The City also had no records of spills or contamination in the area. Therefore, Hazard B1 is considered to be not present for the Railway Wells.

Hazard B2: Flood Risk

The Railway Well Field is not located within the natural boundary of a surface water body; the nearest surface water body is Shelley Creek 2, located over 600 m south from the well field (Figure 2). In the area of the Railway Well Field, land surface generally slopes towards the north. The area of the well field area is not prone to flooding and the City indicated that water does not pond near the wellhead, as observed on 6 April 2023 during a precipitation event. The area around each well at the Railway Well Field is graded to direct surface water away from the wellhead (Photo B-6; APPENDIX B). Furthermore, as presented on the well logs (APPENDIX E) and summarized in Table 1, the well intakes for the Railway Wells range from depths of 17.9 to 29.6 m bgs for Railway #4 and #6, respectively. These depths are greater than the minimum depth of 15 m bgs that is specified in the GARP Guidance Document. Hazard B2 is, therefore, screened as being not present for the Railway Wells.

Hazard B3: Hydraulic Connection to Surface Water

As discussed above and illustrated on the well logs provided in APPENDIX E, the tops of the screens for the Railway Wells are at depths greater than 15 m bgs. The Railway Well Field is also not located within 150 m of permanent or intermittent surface water bodies or drainage ditches. As discussed above, surface water does not pond in the area of the wellfield. Furthermore, at each of the Railway Wells ground surface is graded to direct surface water away from the wellhead. Based on these results, Hazard B3 is considered to be not present at the Railway Well Field.

Hazard B4: Viruses

In the area of the Railway Well Field, private residences are serviced by individual septic systems. If these systems are not maintained and/or operating as intended, they may represent a potential source of enteric viral contamination to the subsurface. The wells at the Railway Well Field are located at distances of less than 100 m from the adjacent residences; these distances are less than the 300 m specified in the GARP Guidance Document. Also, as presented on the Figure 3, the 200-day time-of-travel zone for the Railway Wells extends beneath the adjacent residential properties. Therefore, Hazard B4 is present for the wells at the Railway Well Field.

Surficial deposits in the area of the well field that are described in Section 4.1.2 to extend to depths of 3.1 to 9.1 m bgs and generally comprise compact silt to silty sand and gravel may provide some protection to the underlying aquifer. Furthermore, as presented in Table 1, the unsaturated zone (i.e., depth to static water level) beneath the Railway Well Field is estimated to be greater than 8 m in thickness. These conditions are inferred to provide some protection to the aquifer through mechanism such as natural filtration and inactivation of viruses; however, the thickness and composition of the confining deposits are interpreted to be variable. Furthermore, other wells that were identified on the WELLS database as being present in the area of the Railway Well Field could provide preferential pathways for migration of contaminants to the aquifer if not closed properly. Therefore, based on the information provided, the Railway Wells were conservatively assessed as being at risk for Hazard B4.

It is noted that chlorination can achieve a 4-log removal of viruses, as required in the DWTO Document, provided that the CT is sufficient. The water treatment practices that the City is currently applying to groundwater from the Railway Well Field are discussed further in Section 4.3.

4.2.3 Well Construction (Hazard Categories C1 – C4)

The GARP Guidance Document recognizes that wells that were constructed before the BC Ground Water Protection Regulation (GWPR; BC Reg. 39/2016, includes amendments up to BC Reg. 75/2021) came into force on 1 November 2005 may not meet the minimum construction requirements of Part 3, Division 3 (Surface Seals) and Division 5 (Wellhead Completion), as these requirements were not made retroactive. If a well does not meet the well construction standards outlined in the GWPR, then it is considered to be GARP unless further assessment indicates that the well is considered to be at low risk for the well construction hazard(s). Depending upon site specific conditions, it may be possible to retrofit a well to meet the standards.

Hazard C1: Surface Sealing

Hazard C1 was screened as being present for each of the wells at the Railway Well Field. The well log for Railway #1 indicates that the well was constructed with a 254 mm (10-inch) diameter outer casing that was advanced to a depth of 3.5 m bgs and removed following construction of the 203 mm (8-inch) diameter well (APPENDIX E); however, no information is available indicating whether the well was completed with a surface seal. In the absence of additional information, it is assumed that Railway #1 was not completed with a surface seal and the well is, therefore, conservatively assessed as being at risk for Hazard C1. It is noted that Railway #1 was constructed in 1990, prior to introduction of the GWPR in 2005.

As summarized in Table 1 and documented on the well logs (APPENDIX E), the rest of the wells at the Railway Well Field were constructed with surface seals that extended to depths of 4.0 m bgs (Railway #2 and #3) to 4.6 m bgs (Railway #5). Although these lengths are less than the minimum length of 5 m that is specified in Part 3, Division 3 of the GWPR, the seals extend through surficial deposits that are inferred to be confining. Furthermore, as discussed in the following sections, the kiosks that cover the wells and grading that directs surface water away from the wellheads provide protection to these wells. Therefore, Railway #2 through #7 were assessed as being at low risk for Hazard C1.

Hazard C2: Well Caps and Covers

The wellhead for each of the Railway Wells is completed with a distribution pipe that is bolted to a commercially manufactured steel flange that is attached to well casing and sealed with a gasket (Photos B-7, B-9, B-10 and B-11, APPENDIX B). These completions, combined with the wellhead conditions further discussed below (i.e., wellhead within a locked kiosk and locked, fenced compound) are interpreted to satisfy the requirements of Part 4 of the GWPR and prevent persons, animals, foreign matter or water from entering the wells. Hazard C2 was, therefore, screened as being not present for the Railway Wells.

Hazard C3: Floodproofing of Wells

The Railway Wells are each located in a locked kiosk that prevents unauthorized access to the well and migration of standing water to the wellhead. The concrete slab floors of the kiosks are approximately 0.08 m (3 inches) above surrounding grade and graded to direct water away from the well casing towards a floor drain. The floor drains are located at distances from the well casing of approximately 0.20 m (8 inches) at Railway #4 to 0.57 m (22.5 inches) at Railway #5. Detailed records provided in APPENDIX C for Railway #4 and #7 indicate that the floor drains discharge to daylight; the discharge location is inferred to be behind the concrete slab but was not located during the Site visits. Furthermore, the wellhead drawing for Railway #4 includes a note indicating that during backfilling of electrical conduits and the watermain, the contractor placed bentonite sealant around the well casing and on the surface of the watermain trench for a distance of 4 m from the well. Other wells at the Railway Well Field are inferred to be completed in a similar manner but detailed records were not available to confirm this.

Based on the conditions of the wellheads and immediate surroundings, the wellhead completions for the Railway Wells are interpreted to meet the floodproofing requirements outlined in Part 7, Section 63 of the GWPR and Section 16 of the Drinking Water Protection Act (DWPA), and Hazard C3 was screened as not being present for these wells.

Hazard C4: Wellhead Protection

The casing stick-up (above the kiosk floor) for four of the Railway Wells was less than the minimum requirement of 0.3 m that is specified in the GWPR, at values of 0.25 m (Railway #1, #2 and #3) and 0.27 m (Railway #4). Therefore, Hazard C4 was considered to be present for Railway #1, #2, #3 and #4. However, since the each well is protected in a secured kiosk, within a fenced compound, and water within a kiosk would drain away from the well casing, the wellhead conditions for the Railway Wells are interpreted to satisfy the requirements outlined in Part 3, Division 5 and Part 7 of the GWPR and prevent surface water and foreign matter from entering the well. Therefore, the Railway Wells are considered to be at low risk for Hazard C4.

4.2.4 Aquifer Type and Setting (Hazard Categories D1 – D3)

Hazard D1: Shallow Wells

As summarized in Table 1 and presented on the well logs in APPENDIX E, the intake depths for the Railway Wells range from 17.9 m bgs (Railway #4) to 29.6 m bgs (Railway #6), greater than the minimum requirement of 15 m bgs specified in the GARP Guidance Document. Furthermore, as discussed in Section 4.2.2, surficial deposits in the vicinity of the Railway Well Field and the unsaturated zone that is estimated to be greater than 8 m in thickness are also inferred to provide protection to the Railway Wells. Therefore, Hazard D1 was screened as being not present.

Hazard D2: Vulnerable Aquifers

As discussed in Section 4.1.2, Aquifer 216 is classified by the Province as IIB, indicating a moderate level of development and moderate vulnerability to contamination from surface sources. It is further noted that well logs for the Railway Wells suggests that confining deposits are present in the area of the Railway Well Field. Therefore, Hazard D2 was screened as being not present for the Railway Wells.

Hazard D3: Karst

The Railway Wells are not completed in a karst bedrock aquifer. Therefore, Hazard D3 is not applicable to the YWD wells.

4.2.5 Summary and Discussion

As discussed in Table A-1 in APPENDIX A and summarized in Table 2, below, three hazards were identified as being present for each of the Railway Wells, related to the proximity of the septic systems on adjacent residential properties that could be a source of viruses (Hazard B4), and well construction aspects including the lengths of the surface seals (Hazard C1) and wellhead protection (Hazard C4).

Table 2: Summary of Results of Preliminary GARP Assessment[a], City of Parksville Railway Wells

Well	Hazards Screened as being Present[b]	Results of Hazard Assessment
Railway #1	B4, C1, C4	At risk of containing pathogens (GARP)
Railway #2	B4, C1, C4	GARP-viruses only
Railway #3	B4, C1, C4	GARP-viruses only
Railway #4	B4, C1, C4	GARP-viruses only
Railway #5	B4, C1	GARP-viruses only
Railway #6	B4, C1	GARP-viruses only
Railway #7	B4, C1, C4	GARP-viruses only

Notes: a. Details of Preliminary GARP Assessment provided in Table A-1, APPENDIX A

b. Hazards identified as being present according to criteria outlined in BC GARP Guidance Document

c. Hazards that were considered present were further assessed for the likelihood of being considered "At Risk" (i.e., water source potentially GARP) or "At Low Risk"

Based on the results of the GARP Assessment, Railway #1 is assessed as being at risk of containing pathogens (i.e., GARP). This assessment is based on the conservative assumption that Railway #1 was not completed with a surface seal. As discussed in Section 4.2.3, it is noted that the well was constructed with an outer casing to a depth of 3.5 m bgs; it is likely that a surface seal was installed when the outer casing was removed. Based on the current well completion (i.e., kiosk and infrastructure), it is anticipated that further investigation of the annular space around the casing for Railway #1 would not be practical.

The wellhead conditions at Railway #1 and the limited development in the immediate vicinity are anticipated to provide protection to the well. Total coliform and *E. coli* bacteria have not been detected in samples from Railway Well #1 and turbidity has been reported to be 0.11 and 0.25 NTU, consistent with a low risk of microbiological contamination to the well; however, a limited number of samples have been reported for Railway #1. Implementation of a more frequent water quality sampling program would build a larger dataset and increase the confidence in the results.

The chlorination that the City applies to groundwater from the Railway Well Field would provide a barrier to bacteria and viruses, provided that there is adequate CT (discussed further in Section 4.3), whereas protozoa are more resistant to chlorination.

Although Railway #2 through #7 were constructed with sanitary seals with lengths less than the 5 m that required in the GWPR, the seals, in combination with other factors including the presence of deposits overlying the aquifer and the kiosks and fenced compounds around the wells, are interpreted to provide adequate protection. Furthermore, based the wellhead completions, casing stick-ups that are less than the minimum requirement of 0.3 m that is specified in the GWPR are interpreted to represent a low risk. Therefore, Railway #2 through #7 are considered to be GARP-viruses only.

4.3 Preliminary Review of Groundwater Treatment Practices

4.3.1 Chlorination Practices

The City currently applies one form of treatment to the groundwater supply from the Railway and Springwood Well Fields (City, 2023d). Chlorination takes place at two locations. One of these is at Well No.1, located at the Water Complex (APPENDIX D). This well and the associated chlorination system operate whenever one or more of the City's production wells are in operation. The water from the Railway Wells is mixed with Well No.1 water in a pipe upstream of Reservoir No.2, providing chlorination to Railway Well water as it enters Reservoir No.2. From Reservoir No.2, water flows into Reservoir No.1. Water is then pumped from Reservoir No.1 via a chlorination building, the second location at which chlorination takes place, to Reservoir No.4 from where it enters the distribution system.

According to information provided by the City (2023d), the target chlorine concentration for water in Reservoir No.2 is 0.25 mg/L, and 0.75 mg/L to 1.0 mg/L for water leaving Reservoir No.4.

The City (2023d) provided a document that presents the City's calculations of the CT (product of chlorine concentration and contact time of water and chlorine) for water at the Water Complex. CT is an important parameter in water treatment. To demonstrate that adequate inactivation of pathogens is achieved, the available CT (CT_a) must be at least equal to the minimum required CT (CT_r) . For inactivation by chlorine, the CT_r depends on the type of pathogen to be inactivated, the desired inactivation level, water temperature (the lower the temperature, the higher the CT_r), and the pH of the water. For virus inactivation, pH normally is not an issue as the CT_r does not change within the pH range of 6 to 9; however, the inactivation of Giardia is highly pH dependent, with lower pH values resulting in lower CT_r. For the calculation of CT_a, the degree of short circuiting possible within a retention volume such as a reservoir or pipe must be accounted for. This is done with the help of a baffling factor which varies from 0.1 (mixed flow) to 1 (plug flow).

Cryptosporidium cannot be inactivated by the chlorine concentrations typically used in potable water treatment. Consequently, should Railway #1 be considered GARP, an additional form of treatment or disinfection normally would be required, as outlined in the DWTO Document. Providing treatment or disinfection for the Cryptosporidium inactivation level normally also results in the required inactivation of Giardia. Consequently, chlorination would then only be necessary to achieve the required virus inactivation level and to impart the water with a chlorine residual.

Based on the CT calculation provided by the City, it is expected that the CT_r for viruses can be readily achieved. However, this statement is subject to the comments made below regarding the methods used for calculating the available CT and a detailed assessment should be carried out to confirm the results. The detailed assessment should consider the validity of the assumptions used and also account for the recommendations outlined by Koers (2022) that included operational changes. Also, it appears that cross connections exist that may allow untreated or insufficiently treated groundwater to enter the distribution system. If a more detailed investigation confirms this preliminary assessment, modifications such as appropriate piping changes, installation of backflow prevention devices and double-blocking valve features, would be required.

To be conservative, the City did not consider the CT upstream of the second chlorination location identified above and only estimated the CT that can be achieved by:

- the pipe connecting Reservoirs Nos.1 & 4, measured from the point of chlorination to Reservoir No.4
- Reservoir No.4 itself
- the main from Reservoir No.4 to the property line of the Springwood Compound

Based on a review of the City's CT calculation, WSP notes the following:

1) For the entire lengths of the 300 mm and 400 mm pipes described above, a baffling factor of 1 was used. According to the Colorado Department of Public Health and Environment (CDPHE, 2014), only pipe segments with a length to diameter ratio of at least 40 qualify for this baffling factor. This requirement is considered to be a refinement of the USEPA requirement for calculation of the CT on which Canadian requirements are based. Consequently, for 300 mm and 400 mm pipe, only pipe segments with a minimum straight length of about 12 m and 16 m, respectively, qualify for a baffling factor of 1. Shorter pipe lengths also contribute to CT; however, the baffling factor would have to be appropriately de-rated. For the 300 mm and 400 mm pipes considered in the CT calculation, about 14% and 34%, respectively, of the overall pipe lengths do not meet the L/D≥40 criterion.

2) For the calculation of the volume of the pipe sections, the inner diameter (ID) not the nominal diameter should have been used.

3) The 400 mm pipe from Reservoir No.4 to the Water Complex property line not only conveys groundwater but also water from the Englishman River Water Treatment Plant (WTP). Further, the outflow of water from Reservoir No.4 is not controlled. One of the purposes of reservoirs is to meet the instantaneous demand, which can be considerably higher than the average or even the maximum day demand. Consequently, the peak hourly flow of the water in the 400 mm pipe should have been used in the calculation, not the rate at which the Reservoir No.1 pumps deliver water to Reservoir No.4.

4) The required disinfection has to be achieved upstream of the first customer. The entire length of pipe to that first customer can be considered in the CT calculation, not just the length of pipe within the Water Complex as was done by the City. Depending on the length of the pipe upstream of the first customer, this could result in an increase in the CT_a. However, the calculation would have to be carried out as outlined above.

5) For Reservoir 4, the lowest reservoir water retention time should have been used. This would have to be calculated based on the lowest reservoir water level and maximum outflow. Instead, the total capacity of the reservoir and the maximum water transfer rate from Reservoir No.1 to Reservoir No.4 was used (also see Item 3, above). Note also that Koers (2022) recommended that the water from the WTP be added to the influent to Reservoir No.4. Implementation of this recommendation would cause the retention time of the water in Reservoir No.4 to decrease.

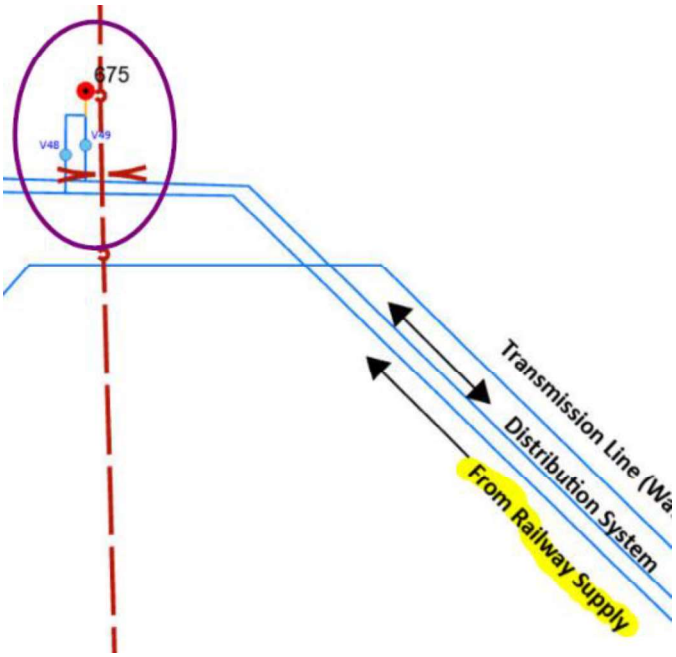
6) The CT_a was compared to the CT_r for Giardia inactivation. This would only be applicable if Cryptosporidium inactivation for some reason would not be required or would be achieved by other means that do not also result in inactivation or removal of Giardia. The Giardia CT_r selected was based on a pH of 7 and a water temperature of 10°C. It is not clear whether this is the highest water pH and the lowest water temperature.

7) The minimum required CT increases with increasing pH and decreasing temperature. This mainly would be a concern if inactivation of Giardia is to be required.

8) The lowest chlorine residual should have been used for the CT calculation. The calculation was based on a residual of 1 mg/L; however, it was reported that the residual may be as low as 0.75 mg/L.

4.3.2 Preliminary Review of Piping Arrangement

WSP also conducted a preliminary review of the piping schematic provided by the City (2023b) for the Water Complex and identified the possibility of cross connections between treated water lines and lines conveying unchlorinated water or water that may not have had sufficient chlorine contact time. An example of this is shown below (snip from the lower right side of the schematic provided by the City and presented in APPENDIX D).



Opening of Valves V48 and V49 (blue circles) at the same time could potentially allow untreated water from the Railway Wells to enter the distribution system. It is possible that the schematic simplified the actual piping arrangement or does not show all cross connection control features. However, issues such as the one identified in this section should be investigated and, if it is determined that a cross connection indeed exists, mitigated.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 GARP Assessment

Based on the results of the GARP Assessment, it is concluded that:

- Screening of the Railway Wells (i.e., Railway #1, #2, #3, #4, #5, #6 and #7) according to the criteria outlined in the MoH GARP Guidance Document identified three hazards as being present:
  - septic systems on adjacent residential properties that are located within the 200-day time-of-travel zone for the Railway Wells could be a source of viruses (Hazard B4)
  - the Railway Wells were completed with surface seals and that do not meet the minimum length of 5 m that is specified in the GWPR (Hazard C1); it is noted that the wells at the Railway Well Field were constructed between 1990 and 1997, prior to introduction of the GWPR in 2005 and, therefore, were not out of compliance with the regulations at that time
  - the casing stick-ups (above the kiosk floor) for Railway #1, #2 and #3 (0.25 m) and Railway #4 (0.27 m) were less than the 0.3 m that is specified in the GWPR (Hazard C4)
- The identified hazards were assessed as follows:
  - Hazard B4 – Viruses: Surficial deposits and the unsaturated zone above the aquifer are inferred to provide some protection to groundwater quality; however, there is uncertainty regarding the thickness, composition and extent of the surficial deposits throughout the area, and there is the potential for preferential pathways for migration of contaminants from the local septic systems to the aquifer. Therefore, the Railway Wells was conservatively assessed as being at risk for Hazard B4.
  - Hazard C1 – Surface Sealing:
    - Although the well log indicates that Railway #1 was constructed with an outer casing, no information is available indicating whether the well was completed with a surface seal. In the absence of additional information, Railway #1 was conservatively assessed as being at risk for Hazard C1.
    - The lengths of the surface seals for Railway #2 through #7 (4.0 to 4.6 m bgs) are less than the minimum requirement in the GWPR; however, the seals extend through surficial deposits that are inferred to be confining. As discussed below, the wellheads also provide protection to these wells. Railway #2 through #7 were, therefore, assessed as being at low risk for Hazard C1.
  - Hazard C4 – Wellhead Protection: Although, with the exception of Railway #5 and #6, casing stick-ups for the Railway Wells were less than the minimum requirement specified in the GWPR, each well is protected in a secured kiosk, within a fenced compound, and water within a kiosk would drain away from the well casing. Therefore, the Railway Wells were assessed as being at low risk for Hazard C4.
- Based on the above results, WSP assessed the Railway Wells as follows:
  - Railway #1: conservatively assessed as being GARP
  - Railway #2 through #7: GARP-viruses only

5.1.2 Preliminary Review of Groundwater Treatment Practices

Conclusions from the Preliminary Review of Groundwater Treatment Practices are provided below:

- The chlorination that the City currently applies at the Water Complex to groundwater from the Railway Well Field would provide one form of treatment that satisfies the virus and bacteria inactivation requirements outlined in the DWTO Document, if the CT is sufficient.
- Based on a preliminary review of the CT calculations provided by the City, it is expected that the minimum required CT (CT_r) for viruses can be readily achieved; however, the City's calculations are based on a number of assumptions that should be confirmed with a detailed assessment.
  - If, following confirmation of the City's calculations, the CT is sufficient for the inactivation of viruses, it is anticipated that the chlorination practices that the City currently uses would provide adequate treatment for the groundwater from Railway #2 through #7, as these wells are considered to be GARP-viruses only.
  - It is noted that the chlorination practices would not inactivate Cryptosporidium. Therefore, the current treatment practices at the Water Complex would not be sufficient for the groundwater from Railway #1, according to the DWTO Document; see recommendations below regarding Railway #1.
  - Groundwater from the Railway Wells mixes as it is pumped through one dedicated pipe from the well field to the Water Complex.
- Based on a review of the infrastructure drawings for the Water Complex, WSP also identified areas of potential cross connections between treated water lines and lines conveying unchlorinated water or water that may not have had sufficient chlorine contact time.

5.2 Recommendations:

WSP provides the following recommendations:

- It is recommended that the City engage in discussions with Island Health and review the results of the GARP Assessment to develop a common understanding of the Railway Wells. In particular, it is recognized that the assessment of Railway #1 is conservative, and the well could be considered GARP-viruses only if the Health Authority agrees that the wellhead conditions provide adequate protection to the well.
- If, based on the results of the discussions with the Island Health, additional lines of evidence are required to further assess Railway #1, it is recommended that the parties involved collaboratively develop a plan that will reduce uncertainty to the satisfaction of Island Health. The plan could consider refinements to the groundwater quality monitoring program such as increasing the frequency of sampling, particularly during higher risk periods such as high precipitation events, to increase the statistical confidence that the groundwater from Railway #1 is a low risk of containing pathogens. Alternatively, if Railway #1 is considered to be GARP, the City could consider providing a second form of treatment or disinfection for the water from this well such as irradiation with ultraviolet light (UV).
- A detailed assessment of the piping arrangement at the Water Complex should be undertaken to confirm site conditions and assess potential cross connections. If issues are identified, a cross connection control plan should be developed and implemented to mitigate the issues identified. The infrastructure drawings should then be updated to reflect the changes.

- Following assessment of the piping arrangement, it is recommended that the City's CT calculations be reviewed to confirm that the assumptions are correct or refined to reflect current conditions, and the corresponding CT is sufficient to meet the pathogen inactivation requirements. If the CT is calculated to be insufficient, alternative options for water treatment could be identified and assessed.
- Consistent with a multi-barrier approach to drinking water protection, it is also recommended that the well protection plan (WPP) be revisited and updated based on current conditions at the Railway Well Field and the results of the GARP Assessment, including the results of the capture zone analysis.

Signature Page

WSP Canada Inc.

Engineers and Geoscientists BC
Permit to Practice #1000200

PROFESSIONAL PROVINCE OF M. A. BOLTON # 29787 BRITISH COLUMBIA GEOSCIENTIST
Excluding Sections 4.3 and 5.1.2
27 Sep 2023

Mark Bolton, MSc, PGeo
Senior Principal Hydrogeologist

PROFESSIONAL PROVINCE OF M. P. VOGEL # 23540 BRITISH COLUMBIA ENGINEER
27 September 2023
Applies to Sections 4.3 and 5.1.2

Martin Vogel, MSChE, Dipl-Ing, P.Eng.
Principal Environmental Engineer

Jillian Sacré, MSc, PGeo
Senior Principal Hydrogeologist

MAB/MV/JPS/jts

https://golderassociates.sharepoint.com/sites/164260/project files/6 deliverables/3.0_issued/22532310-002-r-rev0/22532310-002-r-rev0-final report 27sep_23.docx

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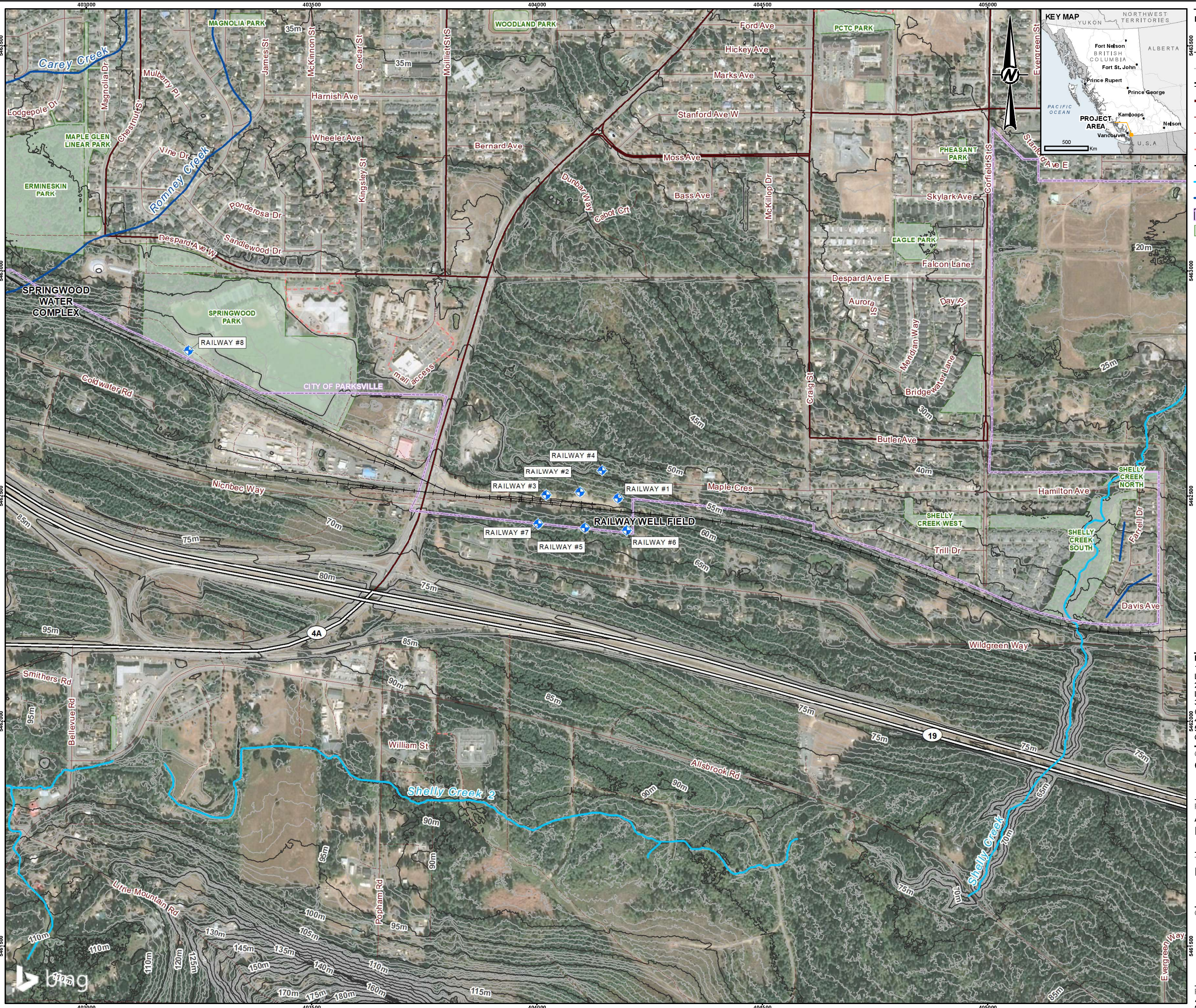

RAILWAY WELL FIELD
RAILWAY #1
RAILWAY #2
RAILWAY #3
RAILWAY #4
RAILWAY #5
RAILWAY #6
RAILWAY #7
RAILWAY #8
SPRINGWOOD WATER COMPLEX
CITY OF PARKSVILLE
Shelly Creek
Shelly Creek 2
Romney Creek
Carey Creek
SPRINGWOOD PARK
MAGNOLIA PARK
WOODLAND PARK
PCTC PARK
PHEASANT PARK
EAGLE PARK
MAPLE GLEN LINEAR PARK
ERMINESKIN PARK
SHELLY CREEK WEST
SHELLY CREEK NORTH
SHELLY CREEK SOUTH
KEY MAP
PROJECT AREA
PACIFIC OCEAN
BRITISH COLUMBIA
ALBERTA
YUKON
NORTHWEST TERRITORIES
U.S.A
Fort Nelson
Fort St. John
Prince Rupert
Prince George
Kamloops
Vancouver
Nelson
500 Km

LEGEND

- PARKSVILLE RAILWAY WELL
- CONTOUR (5m INTERVAL)
- CONTOUR (1m INTERVAL)
- ROAD - HIGHWAY
- ROAD - ARTERIAL / COLLECTOR
- ROAD - LOCAL
- ROAD - RECREATION / RESOURCE / UNCLASSIFIED
- ROAD - SERVICE
- RAILWAY
- STREAM
- WATERCOURSE
- MUNICIPALITY
- LOCAL AND REGIONAL GREENSPACE

0 170 340
1:8,500 METRES

REFERENCE(S)

1. RAILWAY DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – CITY OF PARKSVILLE.
2. ROAD, WATERCOURSE, MUNICIPALITY AND GREENSPACE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
3. STREAM DATA DERIVED FROM REGIONAL DISTRICT OF NANAIMO WATER MAP ON 2023/06/21 (HTTPS://WEBMAP.RDN.BC.CA/).
4. CONTOUR DATA DERIVED FROM LIDAR BC.
5. IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, 2023.

CLIENT
CITY OF PARKSVILLE

PROJECT
ASSESSMENT OF GROUNDWATER AT RISK OF CONTAINING PATHOGENS (GARP), RAILWAY WELL FIELD, PARKSVILLE, BC

TITLE
KEY PLAN

CONSULTANT

YYYY-MM-DD	2023-09-27
DESIGNED	LH
PREPARED	MB
REVIEWED	MB
APPROVED	JS

PROJECT NO.	CONTROL	REV.	FIGURE
22532310	1000/1004	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

LEGEND

- PARKSVILLE RAILWAY WELL
- GROUNDWATER WELLS AND AQUIFERS (GWELLS)
- CONTOUR (5m INTERVAL)
- CONTOUR (1m INTERVAL)
- ROAD - HIGHWAY
- ROAD - ARTERIAL / COLLECTOR
- ROAD - LOCAL
- ROAD - RECREATION / RESOURCE / UNCLASSIFIED
- RAILWAY
- BUILDING FOOTPRINT
- PARCEL
- MUNICIPALITY

0 40 80
1:2,000 METRES

REFERENCE(S)

1. BUILDING, RAILWAY AND PARCEL DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – CITY OF PARKSVILLE.
2. GROUNDWATER WELL, ROAD, MUNICIPALITY AND GREENSPACE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
3. CONTOUR DATA DERIVED FROM LIDAR BC.
4. IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION. REDMOND, WA. 2023.

COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
CITY OF PARKSVILLE

PROJECT
ASSESSMENT OF GROUNDWATER AT RISK OF CONTAINING PATHOGENS (GARP), RAILWAY WELL FIELD, PARKSVILLE, BC

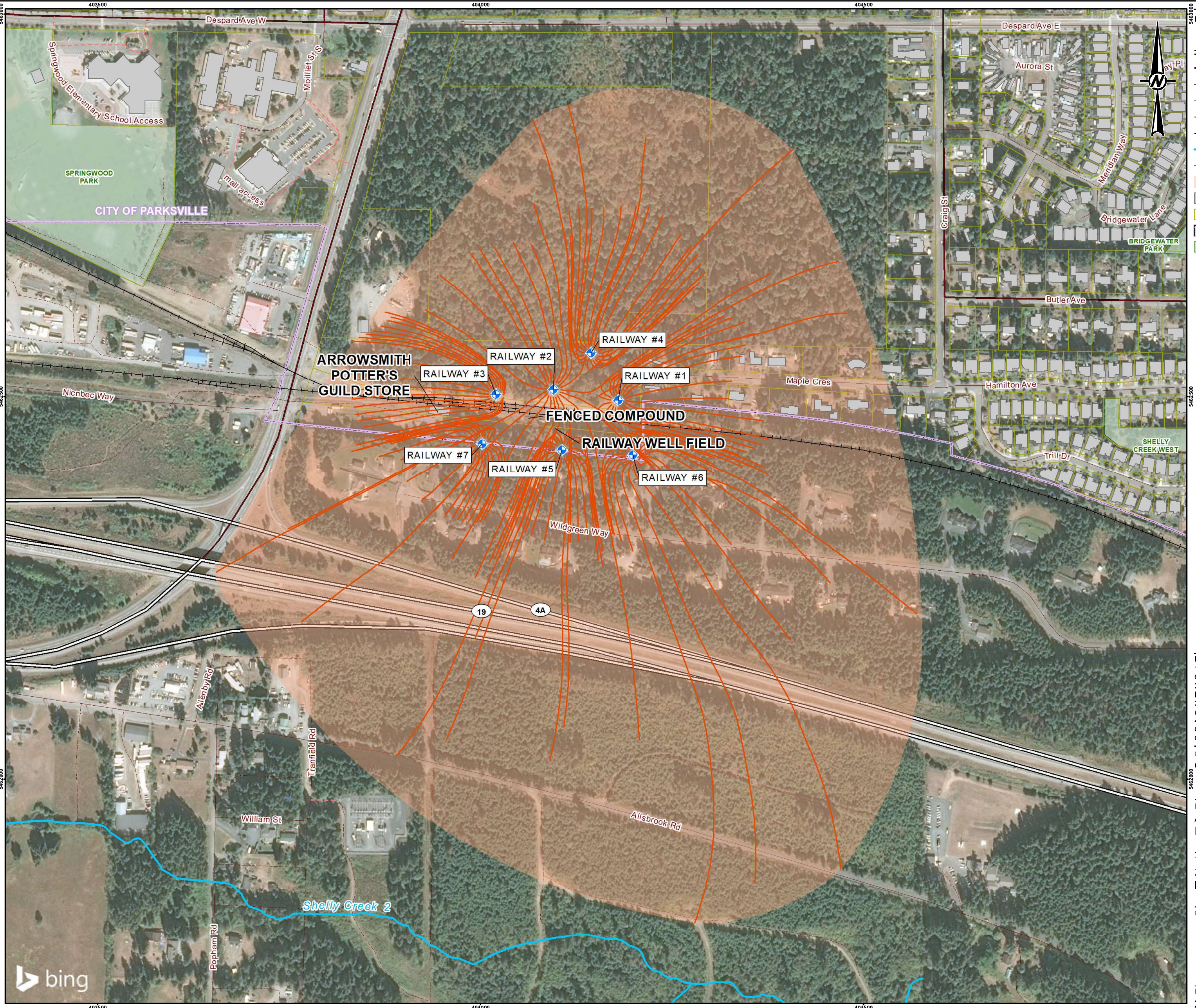
TITLE
SITE PLAN

CONSULTANT
wsp

YYYY-MM-DD	2023-09-27
DESIGNED	LH
PREPARED	MB
REVIEWED	MB
APPROVED	JS

PROJECT NO.	CONTROL	REV.	FIGURE
22532310	1000/1004	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25mm
0



ARROWSMITH POTTER'S GUILD STORE
RAILWAY #1
RAILWAY #2
RAILWAY #3
RAILWAY #4
RAILWAY #5
RAILWAY #6
RAILWAY #7
FENCED COMPOUND
RAILWAY WELL FIELD
CITY OF PARKSVILLE
SPRINGWOOD PARK
BRIDGEWATER PARK
SHELLY CREEK WEST
Despard Ave W
Despard Ave E
Springwood Elementary School Access
Moilliet St S
mall access
Aurora St
Meridian Way
Bridgewater Lane
Craig St
Butler Ave
Hamilton Ave
Maple Cres
Trill Dr
Nicnbec Way
Wildgreen Way
Allenby Rd
Tranfield Rd
William St
Allsbrook Rd
Popham Rd
Shelly Creek 2
19
4A
403500
404000
404500
5462000
5462500
5463000
bing

LEGEND

- PARKSVILLE RAILWAY WELL
- ROAD - HIGHWAY
- ROAD - ARTERIAL / COLLECTOR
- ROAD - LOCAL
- ROAD - RECREATION / RESOURCE / UNCLASSIFIED
- ROAD - SERVICE
- RAILWAY
- STREAM
- 200-DAY BACKWARD TRACKING STREAMLINES
- 200-DAY TIME-OF-TRAVEL ZONE
- BUILDING FOOTPRINT
- PARCEL
- MUNICIPALITY
- LOCAL AND REGIONAL GREENSPACE

0 100 200
1:5,000 METRES

REFERENCE(S)
1. BUILDING, RAILWAY AND PARCEL DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – CITY OF PARKSVILLE.
2. GROUNDWATER WELL, ROAD, MUNICIPALITY AND GREENSPACE DATA CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENSE – BRITISH COLUMBIA.
3. STREAM DATA DERIVED FROM REGIONAL DISTRICT OF NANAIMO WATER MAP ON 2023/06/21 (HTTPS://WEBMAP.RDN.BC.CA/).
4. IMAGERY OBTAINED FROM BING MAPS FOR ARCGIS PUBLISHED BY MICROSOFT CORPORATION, REDMOND, WA, 2023.
COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N

CLIENT
CITY OF PARKSVILLE

PROJECT
ASSESSMENT OF GROUNDWATER AT RISK OF CONTAINING PATHOGENS (GARP), RAILWAY WELL FIELD, PARKSVILLE, BC

TITLE
200-DAY TIME-OF-TRAVEL ZONES RAILWAY WELL FIELD

CONSULTANT

YYYY-MM-DD	2023-09-27
DESIGNED	LH
PREPARED	MB
REVIEWED	MB
APPROVED	JS

PROJECT NO.	CONTROL	REV.	FIGURE
22532310	1000/1004	0	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm