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POWERHOUSE SPRINGS
WELL PROTECTION PLAN

Prepared for

DISTRICT OF SQUAMISH

ENGINEERING AND PARKS DEPARTMENT

Prepared by

PITEAU ASSOCIATES ENGINEERING LTD.

PROJECT 2841 **MAY 2014**

EXECUTIVE SUMMARY

A Well Protection Plan has been developed for the seven municipal water supply wells operating at the Powerhouse Springs well field. This is done in general accordance with steps laid out in the Province's "Well Protection Toolkit," which are as follows:

1. Define the Well Protection Area
2. Identify Potential Contaminants
3. Develop Management Strategies and Contingency Plans
4. Implement, Monitor, and Evaluate the Plan

At the outset of this work, there was limited regional scale information about the Ring Creek aquifer, which is the source of groundwater to the Well Field. Therefore, the first objective was to define the aerial extent of the aquifer and identify predominant recharge sources, based on geological site reconnaissance, geochemical and isotopic analysis, and a hydrogeological water balance utilizing pertinent climate and hydrological data. The resulting conceptual model was incorporated into a numerical groundwater flow model, which was used to define well capture zones for the Well Field under current operating conditions. This preliminary work, is summarized in Piteau's report entitled "Hydrogeological Assessment for Well Protection" dated May 2014.

The Well Protection Plan presented herein defines a Groundwater Protection Zone (or GPZ), based on the one-year capture zone defined in the Hydrogeological Assessment. Land use activities within the Groundwater Protection Zone are reviewed, and associated hazards to groundwater quality and quantity are identified. The level of risk associated with each hazard is evaluated, and management options to mitigate these risks are suggested. These options were further refined based on feedback received from various stakeholders / user groups that attended a workshop on September 28, 2013. This Well Protection Plan also outlines contingency measures for possible contamination scenarios.

Our vision is that this document will assist the community in making land management decisions that are cognizant of the value and vulnerability of their water resource, and that it will be reviewed and modified on a regular basis as land use and community needs change over time.

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1. INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

The District of Squamish relies on the Powerhouse Springs well field (the Well Field) as their main source of potable water. The Well Field was developed incrementally between 1997 and 2007. An Environmental Assessment (EA) certificate for the extraction of up to 255 L/s was granted by the Province in 1999, and an operating permit was issued in 2002. Development of a Well Protection Plan (WPP) was a condition of the operating permit, as well as a requirement of the EA certificate.

Supplemental water sources include surface water intakes on Mashiter Creek and the Stawamus River. As these are subject to high turbidity at certain times of year which interfere with the effectiveness of disinfection, the District of Squamish's objective is to use surface water as a back-up source only.

This WPP follows on investigative work conducted in Piteau Associates Engineer Ltd.'s (Piteau) Hydrogeological Assessment for Well Protection, henceforth referred to as the Hydrogeological Assessment, wherein the regional characteristics of the Ring Creek Aquifer (the Aquifer) were conceptualized and a numerical model was utilized to estimate well capture zones, and the effects of variations in aquifer recharge. In this document, a Groundwater Protection Zone (GPZ) is proposed, and hazards to groundwater quality and quantity within and adjacent to this zone are identified. Mitigation strategies addressing the risks to groundwater quality both are presented, regulatory and non-regulatory, as well as response measures to be taken in the event of a contamination event. This WPP outlines a program for monitoring groundwater quality and quantity, and recommends regular review of the effectiveness and pertinence of the plan in light of upgradient land use activities.

1.2 WELL PROTECTION PLANNING COMMITTEE

The Well Protection Planning Committee (WPPC) is an important component of the WPP. It is composed of representatives from various land user groups, regulatory bodies, and common stakeholders in the groundwater resource. Individuals from the following groups attended a well protection planning workshop on September 25, 2013, were given an opportunity to review the draft Well Protection Plan, and/or have been involved in subsequent discussions:

- District of Squamish (Operations Manager – Bob Smith, A.ScT.; Municipal Engineers – Jenni Chancey and David Roulston P.Eng.; Planner – Elaine Naisby)
- Squamish Nation (Paul Wick)
- Ministry of Forests, Lands, and Natural Resource Operations (Resource Manager – Scott Shaw-MacLaren; Crown Land Authorizations – Danielle Dodd; Natural Resources Forester – Jodie Krakowski; Water Resources Officer – Mike Simpson)
- Ministry of Environment (Water Stewardship Division)
- Squamish Lillooet Regional District (Planning member, Council Member – Moe Freitag)
- Vancouver Coastal Health (Local Drinking Water Officers Cindy Watson and Len Clarkson)
- Sea to Sky Forestry Society (President – Mike Wallace)
- Garibaldi Springs Water Company (Cascadia Consulting Consultant – Peter Gordon)
- Squamish Dirt Bike Association (Members – Juliane Knoll, Ed Alder, and Peter Ald)
- Squamish Climate Action Network (CAN) (Members – Brad Ray and Star Morris)
- Skookum Run of River Power Inc. (Project Manager – Rhonda Rolland)
- Squamish Offroad Cycling Association (Brandi Wilson)

The WPPC helped shape the WPP and identified areas requiring further consideration. They will also play a valuable role in implementing the WPP by facilitating education between policy makers and land users, and by participating in annual meetings to review well protection activities and update the WPP.

2. GROUNDWATER SOURCES

2.1 POWERHOUSE SPRINGS WELL FIELD

The Well Field is located approximately 5 km from the Town Centre, at the foot of the Ring Creek Lava Flow (Fig. 1). The Well Field consists of seven operating wells, ranging in depth from 25 to 45m, and operated at instantaneous pumping rates of between 15 and 35 L/s. Average monthly withdrawals from the Well Field range from 110 to 160 L/s, with the highest withdrawal rates occurring during the months of July and August. The EA Certificate allows for a combined instantaneous withdrawal of up to 255 L/s from the Well Field. Pertinent construction details and current average pumping rates are summarized in the table below:

Well ID	Year Commissioned	Diameter (mm)	Depth of Well Screen (m-bgl)	Maximum Pumping Capacity (L/s)	Average Annual Pumping Rate (L/s)
PW-1	2002	387	27.0 – 33.2	46 - 56	10
PW-2	2002	387	23.8 – 30.3	27 - 43	10
PW-3	2002	387	35.4 – 41.1	27 - 43	10
PW-4	2005	203	27.6 – 30.8	17 - 24	15
PW-5	2008	387	19.8 – 24.0	34 - 39	25
PW-6	2008	387	22.3 – 26.0	42 - 47	25
PW-7	2008	387	24.5 – 30.0	77 - 105	35
				Total	**130**

Groundwater produced by the Well Field is generally soft (< 100 mg/L TDS) and exhibits a calcium-sodium bicarbonate-sulphate chemistry. Samples from the combined discharge stream are collected annually for complete potability testing, and weekly for bacteriological analysis (*E. coli* and total coliforms). To date, no public health concerns have been identified with respect to water quality.

2.2 RING CREEK AQUIFER

The Well Field draws water from the Aquifer, which is comprised of glacial outwash and alluvial sediments that filled an ancestral paleochannel. These sediments are approximately 50m in vertical thickness and are made up of medium to coarse sand and gravels interrupted in places

by silty horizons. The Aquifer is very permeable, with calculated transmissivity values on the order of 2 x 10^{-2} m^2/s.

To the west of the Well Field, the Aquifer is truncated by the east wall of the Mamquam River valley, and numerous springs exist where the water table intercepts ground surface. Flow in Powerhouse Creek is largely made up of this groundwater discharge. Total flows from the Aquifer are estimated to be about 800 L/s and vary less than 20% over the year, based on historical and recent flow gauging of creeks and monitoring of well pumping rates and water levels.

To the east of the Well Field, the Aquifer is capped by the Ring Creek Lava flow (the Lava Flow), which flowed along the ancestral Mamquam River valley shortly after the most recent period of deglaciation approximately 9,500 years before present. We interpret that the Aquifer underlies the core of the Lava Flow, extending 6.5 km east to the confluence of the Mamquam River and Skookum Creek, and possibly further up the valley. The width of the aquifer is about 500m wide in the vicinity of the Well Field and may widen to 1,500m up the valley.

The primary sources of water recharge to the Aquifer are interpreted to be seepage from Ring Creek and Skookum Creek (approximately 69% averaged annually). Areas where seepage is most likely to occur are highlighted on Fig. 1. A lesser component of recharge is derived from rainfall and snowmelt that infiltrates the more heavily jointed levees and surficial breccia on the margins and top surface of the Lava Flow, respectively (approximately 31%). Analyses of environmental isotopes in ground and surface water samples support the interpreted provenance of the well water, and also indicate that it is relatively young, having spent less than 15 years within the flow system since falling as precipitation.

2.3 WELL CAPTURE ZONES

A regional-scale numerical groundwater flow model was developed using the USGS MODFLOW code and Groundwater Vistas as the pre- and post- processing interface. The model was used to define groundwater Time of Travel (TOT) boundaries to the Well Field (well capture zones), and test how these might be sensitive to partitioning of recharge between various sources (Ring Creek, Skookum Creek, and direct infiltration). Model-estimated groundwater travel times between Ring Creek and the Well Field, and between Skookum Creek and the Well Field, ranged

from nine months to two years, and from three to seven years, respectively. These travel times are conservative in that they do not include any time for water to travel vertically downward into the aquifer from the recharge surface (i.e., creek bottom or top of Lava Flow).

The three-month, one-year, and five-year TOT boundaries extend approximately 800m, 2.5 km, and 8 km from the Well Field, respectively, and are shown on Fig. 1. To account for uncertainties with respect to the actual footprint of the Aquifer, capture zone boundaries have been extended to the mapped extent of alluvial and glaciofluvial sediments at the Skookum-Mamquam confluence and on the north side of Ring Creek, respectively.

2.4 GROUNDWATER PROTECTION ZONE

This WPP proposes that the model-defined one-year capture zone be designated GPZ, wherein land use activities are strictly monitored and mitigation measures to protect groundwater are exercised. This area covers approximately 304 ha and extends about 2.5 km east of the Well Field. Land use activities and water resource use would be monitored more at an awareness level within the five-year capture zone, which covers an area of about 1,200 ha.

At the request of Peter Gordon, representative of Cascadia Consulting on behalf of the Garibaldi Springs Water Company Ltd. (see Section 3.3), the boundary of the GPZ adjacent to Powerhouse Creek has been extended approximately 100m northward (to south boundary of the adjacent Woodlot) to include the entire Powerhouse Creek surface catchment. This area is underlain by a thin soil layer over granite, and could become geotechnically unstable and release sediment to the creek if the vegetative cover is disturbed (Skermer, 2012). Since the creek is the groundwater discharge area for the Aquifer, protection of this area falls within the mandate of this plan.

3. LAND USE ACTIVITIES

The following sections describe land use activities within the five-year capture zone of the Well Field, which includes the GPZ.

3.1 FORESTRY OPERATIONS

Timber harvesting activities have occurred in the near vicinity of the Well Field as recently as 2011. Cutblocks RI161 and MA100 were harvested between 2007 and 2008 (Fig. 1). These blocks have been fully replanted and will be ineligible for harvesting for the next 80 years[1]. An active managed licence is held on Woodlot W1930, located above Ring Creek approximately 2 km from the Well Field. Harvesting has taken place in this area since December 2012[2]. Woodlots 0028A, 0028B, and 0028C, located south, north, and west of the Well Field, respectively, are located outside of the GPZ.

Extensive logging has also taken place historically on and adjacent to the Lava Flow further upgradient from the Well Field. This region lies within the BC Timber Sales (BCTS) operating area, wherein they issue Timber Sales Licences for specific cut blocks that typically have a two-year term. Until such licences are issued, Ministry of Forests, Lands, and Natural Resource Operations (MFLNRO) have little information on what harvesting activities are planned within the BCTS operating area. Any harvesting on lands owned by First Nations groups would also not be reported to MFLNRO.

Figure 1 presents a map of current Forest Tenures in the study area. BCTS cutblocks that are planned, but with no timeline for development, or that are sold but not yet logged, are outlined in orange. Lands with Licences to Cut (issued mostly between 2009 and 2011) or comprising active cutblocks are outlined in green. Historical cutblocks which have reached “free growing” status (i.e., wherein seedlings have reached a minimum height and density) are not shown on this figure. Planned and recently sold cutblocks lying within the five-year capture zone of the Well Field comprise an area of approximately 110 ha (1.1 km^2).

[1] Personal comm. with Mr. Shaotang Deng, planning forester with BC Timber Sales, December 7, 2012.
[2] Personal comm. with Ms. Jodie Krakowski, Natural Resources Forester with MFLNRO, December 3, 2012.

A search of the DataBC's web mapping tool (imapBC) indicates that there are currently no other forestry held tenures within the GPZ or five-year capture zone of the Well Field. These include Special Use Permits which may be held for Quarry sites, access roads, and other purposes.

3.2 RUN-OF-RIVER POWER PROJECTS

The Skookum Power Project (SPP) is a run-of-river hydroelectric project located on the lower reaches of Skookum Creek. The project was initiated by Sea to Sky Power Corporation, a subsidiary of Run of River Power Inc., and was recently bought by Concord Green Energy Inc., a member of Concord Pacific Group of companies. The facility is designed to deliver approximately 25 MW to the energy grid. Commercial operation of the facility is planned for the beginning of 2014.

The SPP facility consists of an intake, penstock, powerhouse, and tailrace, together with access roads and a transmission corridor. A maximum of 9.9 m^3/s of flow will be diverted from Skookum Creek with an intake at an elevation of 805 m-geod. This water will be channeled through a 6,300m long penstock to the power plant located at 458 m-asl. Power generated at the plant will be relayed via approximately 20 km of 138 kV transmission line to BC Hydro's Cheekye substation. An Interim Licence for the SPP powerline Right-of-Way (covering a total area of 804 ha) covers a large portion of the GPZ. An Investigative Use Licence for the Upper Pitt River run-of-river project covers a larger area (2745 ha) and overlaps the SPP powerline Right-of-Way.

The approximate routing of the SPP transmission line between the Power Plant and cut block MA100 is shown on Fig.1. Harvesting was conducted under an Occupant License to Cut along this 9 km long section. Most of this route follows former FSR 9244-01 (now a mountain biking trail referred to as the "Ring Creek Rip"). A forest service access road for vehicles (e.g., 4WD trucks) has been reopened along this corridor for maintenance inspections and required clearing and brushing.

3.3 GARIBALDI SPRINGS WATER COMPANY LTD.

The Garibaldi Springs Water Company Ltd. (formerly Alava Spring Water Company Ltd.) is a small spring water supplier operating in the headwaters area of Powerhouse Creek. They have constructed an intake and cistern at approximately 160m elevation and a 0.7 km pipeline to divert water to a tanker loading base near the Mamquam River bridge. This infrastructure can handle flows of approximately 29 L/s (400 USgpm), and flows at the intake have been estimated to be between 70 and 75 L/s (Nelson Environmental, 1997; Piteau, 1997). When there is no filling taking place at the loading base, the pipeline outlet is blocked and water entering the cistern decants into the creek. As this operation simply reroutes spring water that naturally discharges into Powerhouse Creek, it is not considered to have any impact on groundwater flows in the Well Field area.

Garibaldi Springs Water Company Ltd. (Garibaldi Springs) holds three conditional water licenses to divert 227 m^3/day, 454 m^3/day, and 3,864 m^3/day (a total of 4546 m^3/day or 52.6 L/s) from the creek for the industrial bottling of water. The licenses were issued in December 2009, and have priority dates of 1995, 2002, and 2002, respectively. They also hold a 2.2 ha License of Occupation in the headwaters area, and a 0.687 ha area Statutory Right-of-Way (*Land Title Act*) along the routing of their diversion infrastructure. Water sourced from the springs meets strict guidelines set out by NSF International, which certifies spring water suppliers throughout the United States. Along with the District of Squamish (the District), they are also considered stakeholders in the groundwater resource with an equal interest in protecting the Aquifer from negative impacts.

3.4 RURAL RESIDENCES ON RING CREEK FOREST SERVICE ROAD (FSR)

Approximately 20 residential dwellings have been constructed along the Ring Creek Forest Service Road about 5 km east of the Well Field on the north side of Ring Creek (Fig. 1). Communications with residents indicate that they obtain potable water from surface water sourced further to the east, and that sewage effluent is discharged to ground via outhouses or small septic fields. No water wells were identified in this area on MFLNRO's Water Well database. As residents are not serviced by BC Hydro, most rely on wood stoves for heating, and some may use heating oil or propane.

3.5 RECREATION

The Lava Flow area is frequented by many recreational users, including hikers, dog-walkers, mountain bikers, dirt bikers, and recreational hunters. The southern portion of the Lava Flow extending 5 km east of the Well Field is within the District's municipal boundary (Fig. 1), and the remainder is on Crown land. Hunting is permitted on Crown lands outside Garibaldi Provincial Park.[3]

The Lava Flow area offers over 22 km of single track trails and deactivated logging road spurs. These are authorized by a License of Occupation for commercial recreation covering 87 ha. The popular "Ring Creek Rip" and "Powerhouse Plunge" trails are Forest Recreation trails managed by the Recreational Branch of MFLNRO. The Ring Creek Rip was originally authorized as a FSR, and will be maintained as such to facilitate future logging activities in the area. There are four main access points to the Lava Flow trails: Powerhouse Road, the Carpenter's Son Bridge and Darwin's Crossing off of the Ring Creek FSR, and the 9-mile Bridge on the Mamquam FSR (Fig. 2). Most of the trails within the GPZ are used by mountain bikers and dirt bikers. ATV-friendly trails are located in other areas of the Lava Flow.

The Mamquam FSR and Ring Creek FSR are active logging roads that are accessible to the public. Vehicles (e.g., 4WD trucks) can now drive across most of the Lava Flow along the SPP transmission corridor service road (which overlaps with the Ring Creek Rip FSR), starting either from Powerhouse Road at the west end, or from the "Top of the Rip" FSR at the east end. To prevent through-passage of vehicles, an approximate 500m section of this road has been deactivated[4] starting about 2 km east of the Well Field.

[3] Personal communication with Mike Wallace, President of the Squamish Valley Rod & Gun Club, October 31, 2013

[4] Personal communication with Ed Alder, member of the Squamish Dirt Bike Association, November 22, 2013

4. GROUNDWATER POLLUTION HAZARDS AND RISKS

This section presents an inventory of potential groundwater pollution hazards associated with current land use activities at the Well Field, within the GPZ, and within the five-year capture zone. The relative risk associated with these hazards has been evaluated according to the relation:

RISK = (RISK LEVEL OF CONTAMINANT) x (EXPOSURE POTENTIAL)

where:

Risk Level of Contaminant is the potential harm that can result from human exposure to a contaminant in the drinking water. This takes into account the toxicological aspects of the potential contaminants such as acute and chronic exposure effects. Maximum allowable concentrations specified in guidance documents for drinking water quality provide a rough sense of the toxicity of various contaminants.

Exposure Potential is the likelihood that individuals consuming the groundwater will be exposed to contaminants of concern. Exposure can only occur where contaminants are able to enter an aquifer and migrate to a point of groundwater extraction, and depends on a variety of factors:

- location of the source relative to the established well capture zone(s);
- aquifer vulnerability (e.g., confined, un-confined, karst);
- amount of contaminant present (or potentially present) and storage practices;
- duration of the activity of concern in the source area, and when it occurred;
- mobility of the contaminant(s) in groundwater; and
- potential for attenuation of contaminants in groundwater as a result of biodegradation, dilution, absorption onto sediment and other processes.

Table I includes a column denoting the relative risk associated with each potential groundwater pollution hazard, based on the above criteria. This is discussed in more detail in the following sections.

The BC Site Registry was queried for potential groundwater pollution hazards (contaminated sites) within the five-year well capture zone. This database includes properties where contaminated sites investigations and possibly remediation have been completed. No sites were identified in the queried area.

4.1 HAZARDOUS SUBSTANCES IN WELL FIELD AREA

Two control buildings have been constructed within the Well Field area. The main control building, located just east of PW-4, is located within a paved, fenced compound. Within this building is the water treatment station, where (up to eight) 200 L drums of liquid sodium hypochlorite are stored. This room has a concrete floor and floor drains which provide secondary containment in the event of a spill.

A diesel-powered generator is located on the south side of this building to serve as a back-up power source in the event of a power failure. It is approximately 10 years old and holds approximately 1,000 L of diesel fuel. It is double-walled but has no secondary containment or leak detection instrumentation.

The risk to groundwater quality associated with the storage of sodium hypochlorite and diesel in the Well Field area is considered to be medium, given their close proximity to Wells PW-1 and PW-4 in this more vulnerable (uncapped) portion of the Aquifer. These wells are relatively protected by their deep completions (screened intervals > 27m below grade) in a predominantly horizontal groundwater flow regime.

4.2 GARIBALDI SPRINGS OPERATIONS

To the best of our knowledge, Garibaldi Springs do not handle or store any hazardous substances within their License of Occupation or Statutory Right-of-Way. However, should they decide to expand or re-construct their diversion infrastructure, operation of heavy machinery in these areas may result in accidental spills of fuel and hydraulic oil. The associated risks to groundwater quality is considered to be low, since Garibaldi Springs operates in an area of groundwater discharge from the Aquifer. Any contaminants released in this area would be expected to flow away from, rather than towards, the Well Field.

4.3 HAZARDOUS LIQUIDS ASSOCIATED WITH FORESTRY OPERATIONS

Operators of logging machinery have the potential to accidentally release fuel and hydraulic oil into the subsurface. MFLNRO offer “management directions” committed to maintaining the quantity and quality of surface and groundwater for sustaining aquatic ecosystems and community water supplies (MFLNRO, 2008). Holders of Woodlot licences, Forest Licences, and Timber sales under the BC Timber Sales program are required to develop a Site Plan outlining measures to protect forest resource values, including water, riparian areas, fisheries, wildlife, recreation, cultural heritage etc. This Site Plan must be signed and sealed by a Professional Forester.

BC Timber Sales have set out detailed Environmental Field Procedures (EFP’s) for licensees, permittees, and contractor workers responsible for fuel handling within their operating areas (BCTS, 2012). These incorporate legislation requirements, industrial standards, and best management practices pertaining to fuel handling, storage, and transportation. The EFP’s define procedures specific to the volume of fuel in question, from jerry cans (<230 L) to stationary skid tanks (>3,000 L), and minimum spill kit requirements. Additional pollution prevention and control measures are also set out for high-, medium-, and low-risk fuel handling scenarios.

It is our understanding that large fuel storage tanks are rarely utilized in harvested areas owing to problems with fuel theft. Current practice is to transport small quantities (<450 L) of fuel to the work site on an as-needed basis using pick-up trucks.

Risks to groundwater quality associated with timber harvesting activities are judged to be low, given the moderate quantities of hazardous liquids utilized, the distances of harvested blocks from the Well Field, and the protection afforded by the Lava Flow cap in most areas.

4.4 SKOOKUM POWER PROJECT (SPP) TRANSMISSION CORRIDOR MAINTENANCE

The transmission corridor servicing the SPP is now complete. The pole structures used to support the transmission line are Douglas fir treated with pentachlorophenol at an off-site facility. In general, any pentachlorophenol leached from these poles during rainfall and snowmelt, is not expected to travel more than a few meters in the subsurface, due to degradation by aerobic and anaerobic microbial organisms.

The project's Operational Environmental Management Plan (OEMP, Barkley Project Group Ltd., 2011) outlines guiding principles for the long-term maintenance of the corridor, including the use of mechanical control treatments such as girdling and mowing wherever possible, and avoidance of chemical herbicides. To prevent contamination of soils and waterways by petroleum products (e.g., gasoline, diesel, lubricating oil, waste oil), vehicles and machinery will be kept in good working order and free of leaks, will carry spill response kits and a fire extinguisher, and will not be refueled within 30m of a stream, wetland, or waterway.

SPP is also required to follow BC Hydro guidelines during maintenance works, which stipulate that:

- No storage or handling of flammable or explosive material, and no refueling of vehicles or equipment be carried out within BC Hydro's right-of-way, without prior written authorization from BC Hydro.
- No storage, manufacturing, disposal, treatment, generation, use, transport, remediation, or release of Hazardous Materials be carried out within BC Hydro's right-of-way, without prior written authorization by BC Hydro. These "Hazardous Materials" include explosives, radioactive materials, pollutants, pesticides, herbicides, contaminants, hazardous, corrosive or toxic substances, special waste or wastes including chlorobiphenyls[5].

Spills of hazardous liquids (hydraulic oil, fuel) from service vehicles, and the potential application of pesticides / herbicides along the corridor present a potential risk to groundwater quality.

This risk is judged to be low given the small quantities of fuel carried by service vehicles during periodic maintenance, and unlikelihood that pesticides/herbicides will be applied along the corridor.

4.5 PATHOGENS FROM SURFACE WATER

Surface water is highly susceptible to contamination from waterborne pathogens. Pathogens are disease-causing organisms such as bacteria, viruses, and protozoan parasites such as Cryptosporidium and Giardia lamblia. These are typically found in the intestinal tract of infected

[5] Email correspondence from SPP project manager Rhonda Rolland, March 27, 2014.

humans or animals, and are passed on by sewage effluent and animal waste. Common indicators of the presence of pathogens are total coliform bacteria, fecal coliform and *Escherichia coli* (*E. coli*).

Groundwater that is under the direct influence of surface water, or GWUDI, is hydraulically connected to nearby surface waters and is susceptible to contamination if subsurface filtration is inadequate to effectively remove pathogens. The estimated time of travel from the surface water body to the well intake can be used as an indicator of risk. A modelling study conducted by Yates et al. (1985) estimated that the average time of travel in the subsurface required to achieve a 4-log inactivation of viruses is 200 days (6.6 months). This survivability is a function of the type of pathogen and physical and chemical subsurface conditions.

An assessment of the potential for groundwater withdrawn by the Well Field to be at risk of containing pathogens sourced from Powerhouse Creek or Ring Creek (the closest surface water sources) was undertaken as part of the Hydrogeological Assessment.

Groundwater from the Powerhouse Well Field was determined to be at low risk of containing pathogens derived from surface water for the following reasons:

- model-estimate travel times between Ring Creek and the Well Field exceeding 200 days;
- our interpretation that Powerhouse Creek is a receiving surface water body (i.e., an expression of groundwater discharge), and that Well Field withdrawals would not induce a reversal of flow (i.e., induce recharge from the creek);
- Microscopic Particulate Analysis results for a raw well water sample indicating an absence of particulates indicative of GWUDI; and
- The 2009 to 2013 record of bacteriological water quality at the Well Field. Raw water samples collected weekly over this period indicated a consistent absence of total coliform and *E. coli* bacteria. Two of the three exceptions (total coliform detects) out of the 244 samples tested, are likely to be sampling errors.

4.6 RESIDENTIAL SEPTIC SYSTEMS ON RING CREEK FSR

Sewage effluent discharged by the residences on Ring Creek FSR constitutes a potential hazard to groundwater quality. Associated potential contaminants include nutrients, pathogens, chemicals present in garden fertilizers and household cleaning products, and pharmaceutical products.

The residences along Ring Creek FSR lie within the Squamish Lillooet Regional District (SLRD), outside the District's municipal boundaries. Under the *Public Health Act's* Sewerage System Regulation effective in May 2005, an authorized person must, after construction of a sewerage system, provide the local health authority (Vancouver Coastal) a signed letter certifying that the system was constructed in accordance with standard practice. These must be consistent with the Ministry of Health's "Sewerage System Standard Practice Manual," which provide design guidelines to ensure adequate microbial breakdown of organics under various hydraulic loading scenarios. The authorized person must also provide the owner with copies of the plans, letter, and maintenance plan. Subsequently, it is up to the owner to ensure that the sewerage system is maintained in accordance with this plan. It is our understanding that there are no regular inspections of system performance required under the *Act*. As most Ring Creek FSR residences were constructed prior to 2005, the standards applied to the on-site sewage systems could vary widely from the current standard. Although records of these installations are maintained at Vancouver Coastal Health, regular inspections or audits are not carried out unless associated with a complaint or known discharge event.

Most contaminants associated with household sewage are expected to be microbially broken down before leaving the drain field; however, others such as nitrates, inorganic salts, heavy metals, bacteria and viruses, and pharmaceuticals are more persistent. The most likely pathway for these contaminants to reach the Well Field is through shallow overburden sediments into Ring Creek, and then seepage from Ring Creek into the Aquifer. In this scenario, dilution with surface water in Ring Creek and/or groundwater sourced from other areas is expected to reduce contaminant concentrations below detectable levels.

Based on the above, the risk to groundwater quality associated with the Ring Creek FSR residential septic systems is judged to be low.

4.7 RECREATION

The trail network on the lower portion of the Lava Flow is a popular destination for hikers, mountain bikers, and dirt bikers. More recently, four-wheel drive vehicles have been able to access the area along the SPP transmission corridor. Dirt bikes and ATV's carry very small amounts of fuel (tank sizes typically less than 30 L and 20 L, respectively).

Trail building and maintenance activities on Crown lands require authorization from MFLRNO, as per Sections 56 and 57 of the *Forest and Range Practice Act*. Many of the trails are constructed by hand, and some using small machines (e.g., bobcat, mini-excavator). Quantities of fuel and hydraulic oil carried by these machines are relatively small (less than 30 L and 5 L, respectively). MFLNRO do not point to or enforce environmental field procedures to prevent environmental contamination during trail construction (e.g., fuel handling procedures, spill response plans); but can attach conditions to trail building authorizations in sensitive areas (e.g., community watersheds)[6]. Trail standards have been developed by the District to encourage sound trail design, construction, and maintenance, and adherence to environmental best practices pertaining to stream crossings and riparian setbacks, erosion and stormwater control, and protection of fish habitat. These are enforceable on Crown lands within District boundaries, and can be referenced as part of an MFLNRO trail building authorization.

Increased access to the Lava Flow by the general public increases the potential for unlawful land use practices, including illegal dumping / burning of hazardous waste and refuse, as well as the accidental starting of forest fires. Illegal dumping of old cars has historically occurred along the Mamquam FSR near Raffuse Creek[7]. The service road along the SPP transmission line corridor is also vulnerable to such activities. Collisions between private vehicles and logging trucks on FSR's may also potentially release fuel, hydraulic oil, and other hazardous liquids into the environment.

The risk to groundwater quality associated with the accidental release of hazardous liquids by recreational users is considered to be low, given the small quantities involved, and the protection afforded by the Lava Flow cap in most areas.

[6] Personal communication with Alistair McCrone, Recreation Officer with MFLNRO, April 3, 2014.
[7] Personal communication with Scott Shaw-MacLaren, Resource Manager with MFLNRO, September 25, 2013.

4.8 FOREST FIRES

Fire retardant chemicals are often applied aerially to suppress forest fires. They are generally made up of ammonium-phosphate or sulphate-based compounds mixed with dyes, thickeners, flow conditioners, corrosion inhibitors, and water. Compounds found in “Phos-check,” a commonly used retardant made of diammonium sulphate and ammonium phosphate, are claimed to be biodegradable and/or readily absorbed by vegetation. Fire suppressants are applied as foams and are made up of sodium and ammonium salts, alcohol, ether, and sulphates. These generally have a high solids content, hence are less mobile than chemicals in liquid form.

Application of fire retardants and fire suppressants can cause short-lived increases in ammonium, phosphate, and nitrate concentrations in nearby surface watercourses. Fire-fighting chemicals applied to soils having a high organic content are potentially less mobile, owing to their tendency to sorb to soil surfaces by cation exchange (Little and Calfee, 2011). If such chemicals persist in the environment, there is a potential to affect groundwater quality by direct infiltration, or seepage of impacted surface water into the Aquifer.

The Upper Mamquam watershed is designated a Community Water Supply Area MFLNRO's Sea to Sky Land and Resource Management Plan (2008), which precludes the use of chemicals to fight fires. Instead, helicopters (helitankers or helicopters carrying buckets) or air tankers (fixed wing aircraft fitted with tanks) would be used to scoop and bucket with water directly. Historic incidence of forest fires in this area is also very low.

Based on this information, the risk to groundwater quality associated with the application of fire retardants and/or suppressants on the Lava Flow is considered to be low.

5. GROUNDWATER SUPPLY HAZARDS

This section discusses processes that have the potential to affect the quantity of groundwater flowing past the Well Field. These include climate change and diversion of surface water from Skookum Creek, as discussed in the following sections.

5.1 SKOOKUM RUN-OF-RIVER POWER PROJECT (SPP)

During operation of the SPP, water depths in Skookum Creek are expected to be reduced by 8.8 cm on average (Gartner Lee Limited, 2008). Based on our understanding that Skookum Creek loses flow to the subsurface, this reduction in head in the creek could result in a reduction in aquifer recharge, particularly during the summer months when surface runoff is lowest.

We estimate that the drop in the water level in Skookum Creek could cause a 10 to 20% decrease in the vertical seepage rate from the creek into the underlying Aquifer. This in turn may cause groundwater levels in the Well Field area to drop by as much as 0.14m. Calculations and model simulations supporting this prediction are described in the Hydrogeological Assessment. Impacts of such a change on individual well productivity will depend on the amount of excess available drawdown in the well. This is the difference between the current average pumping elevation and the lowest tolerable pumping elevation above the pump. A water level drop of less than 0.14m is not expected to have a significant effect on well yields.

5.2 CLIMATE CHANGE

As a result of climate change, coastal British Columbia is expected to experience milder seasonal temperatures, and to receive less snowfall over the winter months. It is uncertain whether total annual precipitation in the region will change significantly. To address the effect of climate change on the groundwater resource, we need to determine whether the change in type of precipitation (i.e., snowmelt vs. rainfall) and its distribution over the year (e.g., more precipitation in fall and spring, less in summer) will affect total groundwater flow at the Well Field.

This question is difficult to answer with certainty. Given our conceptualization that the Aquifer is unconfined and covers a large surface area, it has the ability to store large volumes of groundwater through a small rise in the water table. This ability to act as a reservoir would effectively reduce the effect of seasonal variations in recharge on groundwater flow rates. Relatively constant water levels observed at the Well Field over the year substantiate this prediction.

Should climate change bring about a decrease in the total annual recharge received by the Aquifer, then a proportional decrease in the amount of groundwater flowing through the Aquifer may occur. The significance of this decrease is difficult to predict, but is not likely to negatively affect Well Field productivity over the next 20 years.

5.3 WELL PRODUCTIVITY DECLINE

Most wells experience a decline in well efficiency over their operational lifetimes, due to blockage of open area around the well screen by mineral encrustation, biomass, or fine sediment. Losses in well efficiency are identifiable by pumping water levels that fall over time when wells are operated at a constant pumping rate. If left too long, the water level in the well may approach the elevation of the pump intake, resulting in excessive cycling of the pump, or in extreme cases, pump cavitation and/or failure. Wells that are operated too long between rehabilitation campaigns may also experience lesser recoveries in well efficiency than wells that are serviced more frequently. Therefore, it is important that each well be monitored regularly and rehabilitated in a timely manner to maintain their optimum yields.

Wells PW-1, PW-2, and PW-3 had been rehabilitated after their first five years of operation, and not subsequently for another eight years. The remaining four wells had not been rehabilitated since they were brought on-line five to eight years prior. In September 2013, Piteau evaluated each well's performance by measuring each well's specific capacity[8] and comparing it to that measured when the well was first tested after construction. The data indicated that wells PW-1, PW-2, PW-4, and PW-5 were operating at between 30 and 60% of their original capacities, and that wells PW-3, PW-6, and PW-7 were operating at less than 20% of their original capacities,

[8] Specific capacity is the ratio of pumping rate to water level drawdown (difference between static water level and pumping water level) at that pumping rate, often expressed as L/s/m.

respectively. A historical summary of well efficiency measurements and maintenance activities are provided in the table below:

HISTORICAL SUMMARY OF WELL PERFORMANCE DECLINE

Year	PW-1	PW-2	PW-3	PW-4	PW-5	PW-6	PW-7
1998				100%			
1999	100%						
2000		100%	100%				
2001							
2002							
2003	51% 87%						
2004		37% 66%	41% 74%				
2005	67% 84%	28% 52%	27% 87%				
2006					100%		100%
2007						100%	
2008							
2009							
2010							
2011							
2012							
2013	52%	29%	11% 41%	44%	59%	19% 84%	16% 96%

Notes:

1. Percentages are percent of original specific capacity measured during initial well testing post-construction
2. Shaded cells indicate length of time that well has been in service
3. Arrow indicates rehabilitation campaign

A rehabilitation campaign was undertaken with wells PW-3, PW-6, and PW-7 in November 2013, and was successful in producing a four-fold recovery in well efficiencies. Field observations made during this program indicated that the cause of well decline was due to migration of fine sediment into the natural gravel pack surrounding the well screens. This was largely reversible using conventional redevelopment techniques (surging and bailing). Further description of the field methodology and results can be found in Piteau's well rehabilitation report (Piteau, 2014b).

6. GROUNDWATER MANAGEMENT OPTIONS

This section sets out a number of strategies to effectively mitigate risks associated with groundwater contamination hazards within the GPZ. These strategies have been selected after consultation with various stakeholders, government representatives, and groups sharing an interest in the WPP. Groundwater supply risks will be addressed at the monitoring level only (see Section 8.2).

6.1 WELL FIELD CONSTRUCTION, MAINTENANCE, AND ACCESS

Existing and future production wells, test production wells, and monitoring wells will be constructed with effective and permanent surface seals in accordance with the specifications set out in the Ground Water Protection Regulation (*Water Act*). Surface seals are necessary to prevent surface-sourced contaminants from entering the well via the disturbed annular space outside the well casing.

Existing surface seals will be maintained to ensure that any annular space that may develop as the result of any alteration, maintenance, erosion, excavation, or subsidence, is resealed.

The diesel fuel tank will be inspected on an annual basis for signs of leakage, and secondary containment added within the next five years.

6.2 GARIBALDI SPRINGS OPERATIONS

The District will establish an agreement with Garibaldi Springs that formally recognizes and protects their common interests in the groundwater resource. As part of this agreement, the District would acknowledge Garibaldi Springs' land occupancy and water diversion rights, and Garibaldi Springs would endorse adoption of the Well Protection Plan. Other items could include access requirements along Powerhouse Road, environmental protocols for maintenance and construction activities, and communications protocols.

6.3 HAZARDOUS LIQUIDS ASSOCIATED WITH FORESTRY OPERATIONS

The District will contact MFLNRO on an annual basis to identify operations that hold harvesting licences within the GPZ. Licensees would be contacted directly to request copies of their Site Plans, and for information related to the timing and duration of logging activities. Periodic access to harvested areas will be requested for a District representative to confirm that planned environmental protection measures are being implemented.

6.4 SKOOKUM POWER PROJECT (SPP) TRANSMISSION CORRIDOR MAINTENANCE

The District will ask representatives of the SPP for their anticipated schedule of corridor maintenance activities. The District will consult with SPP, BC Hydro, and MFLNRO Sea-to-Sky District regarding installation of:

- locked gates at vehicle access points at the west (Powerhouse Road) and east (Top of the Rip FSR) ends of the transmission corridor. These gates would prevent unauthorized vehicles (e.g., 4WD trucks) from entering the Lava Flow area, while permitting passage of logging trucks, dirt bikes and ATVs. These gates will require authorization by MFLNRO; and
- Signage at strategic locations to notify persons accessing the corridor that they are within the GPZ.

6.5 PATHOGENS FROM SURFACE WATER

The District will continue to promote healthy streams within the community. The provincial Riparian Areas Regulation (RAR) is enabled by section 12 of the *Fish Protection Act*. It sets out how lands may be developed within the riparian area adjacent to streams, in the interests of avoiding any harmful alteration, destruction, or disruption of fish habitat. Protection of riparian areas offers secondary benefits to groundwater flow regimes that receive water from surface water. In accordance with the RAR, the District's "Watercourse Regulations stipulates that no development (i.e., soil/vegetative disturbance, construction of structures, drainage works, trails, utilities, etc.) be permitted within the Riparian Assessment Area. This area is generally defined to be within 30m of high water mark of a stream, unless otherwise defined by a Qualified Environmental Professional. The District will invite local streamkeepers to participate in the

WPPC and ask that they report any activities along Ring or Skookum creeks that could have a negative effect on stream water quality.

Provision of public toilet facilities within the GPZ or adjacent waterbodies is not considered a priority at this time, owing to the low to medium density and seasonality of recreational use. Signs currently posted near the Well Field notify visitors that they are atop a community drinking water aquifer and ask them to use the area responsibly.

6.6 RESIDENTIAL SEPTIC SYSTEMS ON RING CREEK FSR

The District shall, in co-operation with the SLRD, plan an educational campaign to inform residents on the Ring Creek FSR of measures that should be taken to promote responsible groundwater stewardship. This includes:

- Regular inspection and maintenance of existing septic systems (e.g., pumping of septic tanks);
- Appropriate storage, handling, and disposal of hazardous liquids (including a list of local recycling/waste disposal facilities); and
- Avoiding disposal of potential pollutants that cannot be effectively broken down by the septic systems (e.g., pharmaceuticals, heavy metals, etc.).

6.7 RECREATION

The District will engage in discussions with the District Manager of the Sea-to-Sky District of MFLNRO, and recreational user groups such as the Squamish Off-Road Cycling Association (SORCA) and the Squamish Dirt Bike Association (SDBA) regarding practical ways to limit unauthorized access and irresponsible land use practices within the GPZ. These include:

- Placing signs on hiking/biking trails to notify recreational users that they are within a Groundwater Protection Zone, and asking them to identify hazardous practices (e.g., illegal dumping, forest fire risks) to the District. Suggested sign locations on the following trails are indicated on Fig. 2:
    - Powerline Road (1)
    - Powerhouse Road (2, already exist)

  - Bonsai / Blindside (3)
  - Darwin's Crossing (4)
  - Ring Creek Rip (5)

- Enlisting recreational group support for mitigation strategies such as carrying absorbent pads for vehicular leaks and doggie bags for dog excrement.

6.8 FOREST FIRES

The District's Community Wildfire Protection Plan (CWPP) was adopted in June of 2007 to decrease the risk of wildfire in the Squamish community and to foster preparedness in the event of a wildfire. The CWPP divides the community into Fuel Management Areas, and describes the fire hazards and risks in each. It provides recommendations for promoting Fire Smart community planning and design, and for working with the public and various stakeholders to raise awareness and mitigate fire hazards. It also maps 'values at risk', namely human and natural resources which could be damaged or destroyed by wildfire.

In consideration of ongoing efforts to reduce wildfire risk, low historical incidence of wildfires, and the understanding that only water (no chemicals) would be used to fight wildfires in the Lava Flow area, no additional mitigation strategies related to forest fires are proposed at this time.

6.9 PUBLIC OUTREACH

Raising public awareness of the groundwater resource and the importance of its protection is an important aspect of the WPP. This can be achieved using brochures, newspaper ads, posters, presentations, and other forms of communication. Online references and information sources should be kept up-to-date with groundwater resource information as it becomes available. As part of this initiative, the District will:

- Make a copy of the WPP publicly accessible on its website;
- Share the WPP and supporting Hydrogeological Assessment with the Ministry of Environment (MOE) Water Stewardship Division and request that they expand the footprint of the Ring Creek Aquifer (Number 0397), which currently covers only a 0.2 km^2 area to reflect that presented in this report; and

- Distribute a fact sheet describing the groundwater resource and outlining pollution prevention strategies for all user groups accessing the GPZ. These include spill kits for vehicular spills, doggie bags for dog excrement, and possibly a phone number to report spills, illegal dumping or unauthorized land use.

6.10 WELL OPERATION AND MAINTENANCE

In order to mitigate future declines in well performance and maximize the operating lifetime of the wells, the District will:

- Operate the wells in such a way as to minimize sediment migration towards the wells. Measures that would help in this regard include minimizing the number of start / stops per day, and dampening the energy imparted into the formation upon start-up / shut-down of the pump (e.g., using variable frequency drives, pump centralizers).
- Operate the wells at rates not exceeding their sustainable yields, which are listed in the table below:

Well	Estimated Sustainable Yield
PW-3	35 L/s
PW-6	56 L/s
PW-7	83 L/s
PW-1	44 L/s
PW-2	50 L/s
PW-4	23 L/s
PW-5	31 L/s

- Establish a budget to rehabilitate well(s) having experienced a significant loss in well performance, based on the results of well performance monitoring (see Section 8.2.3). As a general rule, a well should be rehabilitated when its specific capacity drops to less than 50% of its original (post-construction) specific capacity.
- It is anticipated that one to two days of surging and bailing will be adequate to achieve desired improvements in capacity. For cost efficiency, two to three wells could be serviced during each rehabilitation campaign.

6.11 REGULATORY INSTRUMENTS

6.11.1 Protected Community Watershed Area

Under the *Forests and Range Practices Act*, the MOE may designate an area as a community watershed, wherein water quality objectives are established and forest practices undergo additional regulation to protect water quality and quantity. The Official Community Plan (OCP) for the SLRD Electoral Area D (which extends from Furry Creek to Whistler, excluding the Squamish municipality) By-Law 1135-2013, passed in October 2013, designates the Mashiter Creek and Stawamus River watersheds, located north and south of the Mamquam River watershed, as "Community Watershed Protection Areas". Within these watersheds, "appropriately managed resource extraction, dispersed outdoor recreation, and auxiliary uses related to these activities" would be permitted, and "intensive recreation, subdivision, and rezoning of lands" would be discouraged.

The District will initiate a dialogue with the SLRD and MOE to consider designation of the GPZ as a Community Watershed Protection Area, so that the same policies may be applied to the protection of groundwater quality. For example, Site Plans prepared by holders of timber harvesting licenses in this area would be required to meet the recommendations set out in the Well Protection Plan.

6.11.2 Community Water Supply Area

The Mashiter Creek and Stawamus River surface watersheds are referenced in the "Sea-to-Sky Land Resource Management Plan" issued by the Ministry of Agriculture and Lands (MAL) in April 2008. This document provides direction for future planning and management of natural resources and resolution of land use issues along the Sea-to-Sky corridor. It also references the "Lower Mamquam (groundwater)" Community Water Supply Area. Development of an aquifer protection plan and monitoring of groundwater quality is advocated, but specific information is limited, including the spatial extent of the Aquifer. MFLNRO is responsible for compliance and enforcement of natural resources legislation in Community Water Supply Areas.

6.11.3 Municipal Community Planning

The *Local Government Act* gives local governments' authority to plan and regulate development within their jurisdictions to promote social, economic, and environmental health of their community. By establishing Development Permit Areas (DPA) in their OCPs, municipalities may exercise greater control over the design, construction, and maintenance of industrial, commercial, and residential developments. For example, the Resort Municipality of Whistler (RMOW) has designated four DPAs for Aquifer Protection in their recently revised OCP. In these areas, development applications must identify proposed land uses, local drainage measures, practices for handling dangerous goods, and spill protection measures and response plans that would be implemented to protect groundwater quality. Development permits issued in these areas require that all land alteration and building construction activities, including the transportation, storage, or use of substances that could contaminate groundwater, be carried out in a way that would not result in contamination of the aquifer. Although the DPA designations on Crown lands cannot prohibit development (as land use is ultimately decided by the Province), they can set out provisions that need to be met for such development to occur.

The District's ability to exercise control on development within the GPZ is limited by the fact that a large portion of the GPZ lies outside of current District municipal boundaries. The District will approach the SLRD and other stakeholders (e.g., First Nations) with a proposal to expand District boundaries to include GPZ, as indicated on Fig. 1. Once this is in place, the GPZ would be designated a DPA for aquifer protection, and require certain groundwater protection measures to be incorporated in land use and construction plans.

6.11.4 Crown Land Allocation – Land Reserves

A 7.7 ha area immediately surrounding the Well Field has been designated a Watershed Reserve Area under Section 17 of the *Land Act* (Fig. 1). It was first established in December 2008 for a five-year term, and a notice of continuation for another 10-year term, effective on December 18, 2013 was issued on October 16, 2013. It is an administrative instrument held by the MFLNRO which withdraws Crown land from disposition for any purpose or use other than watershed use. The only activities currently permitted within this area are groundwater withdrawals and recreational activities.

Another, more limiting Reserve designation is a Section 16 Map Reserve, which withdraws Crown land from disposition for all land use purposes. It would effectively stop all future development in the area (including those compatible with watershed use) for a maximum term of 30 years, subject to a review once every 10 years. This option is considered overly aggressive for the GPZ, given the assessed low to medium level of risk imposed by identified groundwater pollution hazards.

The District will approach MFLNRO to request that the Section 17 Watershed Reserve Area designation be expanded to include the proposed GPZ. This regulatory instrument commits MFLNRO to continuing to maintain watershed protection as a priority in reviewing applications for Crown land use in this area, and solicit input from the District in all tenure applications prior to approval.

Land uses that are not subject to authorization under the *Land Act*, such as Special Use Permits granted under forestry legislation, would also not be subject to Section 17 conditional withdrawal. Therefore, the District will also consult regularly with other branches of MFLNRO for updates on land uses within the GPZ.

6.11.5 Powerhouse Road Authorization

Under the *Land Act*, access roads and bridges on Crown lands are required to have land tenure in order to formally authorize their use and maintenance. At this time, Powerhouse Road is not legally authorized to any party, as it was originally authorized as part of a forestry tenure and not re-authorized upon retirement of that tenure. Parties that currently use the road include the District to access the Well Field, Coast Aggregates to access private land, and Atlantic Power Inc. to access their powerhouse on the Mamquam River.

The District will submit an application to Front Counter BC for tenure of Powerhouse Road for roadway purposes, with reference to that portion of the road between the Mamquam FSR and the Well Field. An agreement will be established with other users to formalize sharing of maintenance activities and costs. The District will also request a Road Use Permit for the Mamquam FSR between Highway 99 and the Powerhouse Road turnoff, from the MFNLNO Sea-to-Sky District Engineering department.

7. CONTINGENCY PLANNING

Emergencies such as large volume spills of hazardous liquids in the GPZ present a risk to groundwater quality. The risk associated with such hazards depends on the type and quantity of liquid released, and its distance from the Well Field.

The District has prepared a Water System – Emergency Response Plan (ERP) (last updated on September 19, 2013). It describes possible emergency scenarios and outlines the roles and responsibilities of first responders, namely the system Operators, their Supervisor, the Director, and the Drinking Water Officer. Response measures to be taken in response to various scenarios, such as a major spill near a well or stream, vandalism to water system infrastructure, flooding, a forest fire, or earthquake are outlined in detail. If contamination enters or is suspected of entering the water supply as a result of these events, the risk to public health will be mitigated, either by issuing a “Boil Water” notice (for microbiological contamination) or a “Do Not Drink Water” notice (for chemical contamination).

Attachments to the Emergency Response Plan include a list of emergency contacts, draft templates of “Boil Water” and “Do Not Consume” water notices, and a policy manual outlining tasks, responsibilities, and contact information in the case of a “Boil Water” notice.

Table II of this plan presents contingency measures to be taken in the event of specific spill scenarios, such as a spill of diesel from the back-up generator in the Well Field area, or a large volume (>450 L) spill of hazardous liquid on land within the GPZ. The scope and timing of response measures will depend on the assessed risk to public health, which in turn depends on the nature of the liquid spilled, the volume released, and the proximity to individual wells. Response measures will include all or some of the following actions:

1. Report, contain and clean up the spill;
2. Determine the public health significance and issue a Public “Boil Water” or “Do Not Consume” notice (immediately, in the case of a spill at the Well Field; or when a contaminant plume is within 300m of the Well Field, in the case of a more distant spill);
3. Take well(s) off-line and/or use alternate water source(s) (immediately or at a later time, as per above);

4. Delineate the plume (install monitoring wells, if needed);
5. Remediate the plume and/or monitor its mobility and persistence in subsurface (install additional monitoring wells, if needed);
6. Plan alternate water sources or additional water treatment measures; and
7. Confirm elimination of risk before removing public notice.

Table II also outlines contingency measures to be taken in the event that one or more indicator compounds of contamination is detected during routine source water quality monitoring (Section 8.1). If the contamination presents a public health risk, then a public notice would be issued immediately and well(s) taken off-line. If pathogens were identified in the groundwater, then an increase in the level of treatment (secondary to primary disinfection) could be considered. In the case of nitrate or petroleum hydrocarbon contamination, treatment options and/or alternate water sources would need to be investigated. In all cases, the source of contamination would be investigated, and clean-up and/or mitigation measures identified.

It is important to emphasize that once a contaminant enters the Aquifer, it is very difficult to contain or remediate, and may require several months to years to dissipate. Currently, the only alternative water source is surface water from the Stawamus and Mashiter intakes, which can adequately meet community water demand, but are faced with water quality challenges. Chlorination dosing equipment is present at each station to provide primary disinfection; however, the effectiveness of chlorination is compromised when turbidity in surface water is high (e.g., during high rainfall / runoff events). Therefore, exploration of alternate groundwater sources, which would in theory not require the same level of treatment as surface water, should be made a priority.

The District will also circulate their emergency contact information to organizations operating within the GPZ, and ask that they be included in their emergency response plans. This will expedite notification of the District in the case of a spill or other environmental emergency, so that they are informed and can provide timely support.

8. MONITORING AND EVALUATION

8.1 WATER QUALITY MONITORING

8.1.1 Water Sampling at Operating Wells

Water samples will be collected from individual production wells and from Powerhouse Creek for screening of potential contaminants of concerns (PCOCs) on a regular basis. Sampling from wells should be conducted in the spring and fall, and from Powerhouse Creek in the fall only, when surface runoff is lowest. Wells will be sampled two at a time on a rotating basis, so that each well will be sampled biannually.

The District will continue to collect water samples on a weekly basis for bacteriological analysis, and on an annual basis for more comprehensive chemical analysis. The annual analytical suite will be conducted each fall, and include PCOC's associated with land use activities within the five-year TOT of the Well Field:

Location	Timing	Parameters
Minimum two of the seven wells (PW-1 to PW-7)	Each spring	Nitrate, total metals, turbidity
Minimum two of the seven wells (PW-1 to PW-7)	Each fall	Full drinking water package (including colour, conductivity, total dissolved solids, hardness, pH, turbidity, alkalinity, chloride, fluoride, sulfate, nitrate, nitrite, total metals), BTEX, VOCs, MTBE, LEPH/HEPH (includes PAHs)
Powerhouse Creek, near source	Each fall	Nitrate

Note: HEPH – heavy extractable petroleum hydrocarbons, LEPH – light extractable petroleum hydrocarbons, PAH – polycyclic aromatic hydrocarbons, VOC – volatile organic compounds

Wells shall be sampled out on a rotating basis so that different wells are sampled each year, and all wells are sampled for the comprehensive analysis within a four-year period. A duplicate sample will be collected from one of the wells once per two years for the full suite of analyses for quality assurance / quality control.

Quantitative polymerase chain reaction (qPCR) is a biochemical technology that can be used to detect human enteric viruses in groundwater (e.g., enterovirus, hepatitis A, rotavirus). Once this method becomes more widely available, consideration will be given to adding viruses to the annual analytical suite.

8.1.2 Water Quality Sampling at Upgradient Wells

We recommend that a sentinel monitoring well be installed near the three-month travel time boundary for early detection of a contaminant plume sourced further away from the Well Field (>1 km). Siting this well within cut block MA100 would be practical, since access would be through a previously logged area along existing logging roads. A six-inch diameter monitoring well could be drilled using a dual air rotary rig. The depth to reach the Aquifer through the Lava Flow is estimated to be between 70 and 100m.

We also recommend that an additional monitoring well be drilled through the Lava Flow near the Mamquam River – Skookum Creek confluence to validate the presence of the Aquifer in this area, and to provide a means of measuring background groundwater quality further upgradient from the Well Field. Data from this well would also provide information on the hydraulic relationship between Skookum Creek and the groundwater flow regime beneath the Lava Flow. Our recent search of MFLNRO's water well database indicates that there are no wells within the five-year TOT of the Well Field.

8.2 WATER QUANTITY MONITORING

8.2.1 Aquifer Water Levels

Currently, water levels in each production well are continuously monitored; however, operating water levels are highly affected by well loss (the additional drop in water level in a pumped well due to head losses across the well screen). Observation well OW97-1 will be instrumented with a water level sensor to continually measure ambient water levels in the Well Field area.

Well water level and flow data recorded by SCADA provide valuable information on Aquifer response to groundwater withdrawals. It will also provide important baseline information on current groundwater elevations and their seasonal variability. All data will be reviewed for accuracy and archived on an annual basis. Consideration will also be given to adjusting the sampling frequency to avoid excessively large data sets that are cumbersome to manage and analyze.

Water levels will also be continuously monitored (with data loggers) in any additional monitoring well(s) installed upgradient of the Well Field. This data would be helpful in confirming the Aquifer's lateral and vertical extent, measuring the regional hydraulic gradient (and flow rates), and monitoring seasonal variations in water levels. Monitoring well(s) installed outside of the Well Field area offer the advantage of not being affected by drawdown interferences from operating wells.

8.2.2 SPP Hydrological Data Review

The District will ask that the SPP share stage and discharge data collected on Skookum Creek over the course of their operations. This data should be reviewed by a qualified hydrologist to determine monthly averages of diverted flows, and water levels. Data collected at the existing station above the Mamquam River – Skookum Creek confluence, and any additional stations installed upstream, should be included in the analysis.

8.2.3 Well Performance Monitoring

In order to determine appropriate timing of well rehabilitation campaigns, the District will undertake regularly monitoring of individual well performance. This will involve maintaining a continuous record of water levels and pumping rates for each production well, and archiving this data on an annual basis. For easier tracking of well efficiency, the SCADA system could be programmed to record well specific capacity. Adding individual flow meters to wells PW-1, PW-2, and PW-3 would be helpful in this regard. Specific capacity measurements derived from instrument data should be checked against manual measurements twice a year.

8.3 EVALUATION

Data from the above programs will be compiled into an annual Performance Monitoring Report for the Well Field. This report will include the following:

- Documentation of water quality sampling results, with comparison to applicable Guidelines for Canadian Drinking Water Quality;
- Time-series plots of aquifer water levels and surface water discharge (including SPP data), with comparison to groundwater withdrawal rates and climate (precipitation and temperature) data;
- Time-series plots of well specific capacities for tracking of changes in well efficiency. Based on this data, priority wells for rehabilitation will be identified, and a rehabilitation schedule proposed;
- A list of what management strategies were implemented, and their initial outcomes;
- A description of current and proposed future land use activities within the GPZ and five-year well capture zone;
- A summary of average diverted flows, and water levels in Skookum Creek as a result of SPP operations;
- An evaluation of whether the WPP objectives or scope should be modified to reflect changes in land use interests within the GPZ and five-year well capture zones; and
- A workplan and budget to implement groundwater management strategies and monitoring programs, including reporting, into the following year.

The report will be reviewed in an annual meeting attended by the District, their hydrogeological consultant, and the Well Protection Planning Committee. Once the report is finalized, it will be posted on the District's website. Water quality data obtained from the monitoring program can also be posted to the MOE's Environmental Monitoring System (EMS) database.

Once every five years, the Hydrogeological Assessment for Well Protection and Well Protection Plan will be reviewed and updated with any additional information pertaining to the Ring Creek aquifer. The District will establish a budget to carry out this work in consultation with a qualified hydrogeologist.

9. SUMMARY

A Well Protection Plan has been developed for the seven municipal water supply wells operating at the Powerhouse Springs well field. It delineates a Groundwater Protection Zone (or GPZ) east of the Well Field, whose footprint corresponds to the land area that contributes groundwater to the well-field within a one-year time frame. Land use activities within the GPZ and associated hazards to groundwater quality and quantity have been identified, as well as the level of risk pertaining to each hazard. Management strategies to mitigate these risks are summarized in Table I, and suggested contingency measures in response to possible contamination events are listed in Table II. The next steps in the well protection process involve implementation, monitoring, and evaluation of the WPP. Table III summarizes all recommended action items in this document, grouped in accordance with each of these tasks. We hope that this document will be adopted by the District to spearhead protection of their primary water supply, and that it will be modified and improved over time in step with its implementation, and evolving land uses and community priorities.

Respectfully submitted,

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TABLES

TABLE I

GROUNDWATER QUALITY HAZARDS, RISKS, AND MANAGEMENT STRATEGIES

SOURCE ACTIVITY	GROUNDWATER HAZARD	LOCATION WITH RESPECT TO GROUNDWATER TRAVEL TIME TO WELL FIELD	INDICATOR COMPONDS	RELATIVE RISK	RISK RATIONALE	PRIORITY	RISK MANAGEMENT STRATEGY	RESPONSIBLE PARTY	IMPLEMENTATION SCHEDULE
Well Field Operations	Liquid chlorine, Diesel	< 1 month TOT	Chloride, PHCs	Medium	Small quantities of contaminants, close proximity to Wells PW-1 and PW-4, low to high contaminant mobility in groundwater, low to medium aquifer vulnerability (no lava flow cap, groundwater flow predominantly horizontal)	Medium	New wells shall be constructed with surface seals, existing surface seals shall be maintained	DOS	Ongoing
							Equip diesel tank for back-up power generator with secondary containment. Until then, inspect annually for leakage	DOS	Within 5 years
Garibaldi Springs Operations	None currently	Downgradient of Well Field	-	Low	Use of machinery for infrastructure maintenance / expansion activities may introduce small quantities of contaminants, with low likelihood of reaching Well Field	High	Formalize an agreement between Garibaldi Springs and DOS recognizing shared interests in the groundwater resource, and outlining access, operational, and communications protocols	DOS	Within 2 years
Timber Harvesting	Hydraulic oil, Fuel	6 month to 5 year TOT, depending on location	Petroleum hydrocarbons	Low	Small quantities of fuel, close to far proximity to the Well Field, low to medium contaminant mobility, low aquifer vulnerability (lava flow cap)	Low	Request copies of Site Plans and annual updates on the timing and duration of harvesting operations within the GPZ	DOS / MFLNRO	Within 1 year
							Invite MFLNRO and forestry representatives to participate in WPPC	DOS	Ongoing
Skookum Power Transmission Corridor	Herbicides, Hydraulic oil, Fuel	< 1 month to 5-year TOT	Herbicides / pesticides, petroleum hydrocarbons	Low	Small quantities of contaminants, close to far proximity to the Well Field, low to medium contaminant mobility, low aquifer vulnerability (lava flow cap)	Low	Request that SPP share their anticipated schedule of corridor maintenance activities. Approach SPP, MFLNRO and BC Hydro re: installation of gates / signs at Lava Flow entry points for vehicles (4WD trucks).	DOS / SPP / BC Hydro / MFLNRO	Within 2 years
							Invite SPP representatives to participate in WPPC	DOS	Ongoing
Nearby Surface Water Courses	Pathogens	9 months to 2 years (Ring Creek); 3 to 7 years (Skookum Creek)	Total coliforms, fecal coliforms	Low	Long subsurface travel times, MPA results, historical bacteriological sampling results	Low	Continue to uphold provincial Riparian Areas Regulation	DOS	Ongoing
							Invite local streamkeepers to participate in WPPC and ask that they report potentially polluting activities along Ring or Skookum Creeks	DOS	Within 2 years
Residential Septic Systems on Rink Creek FSR	Septic effluent	1 to >2 year TOT	Bacteria, viruses, nitrates, inorganic salts, heavy metals, and pharmaceuticals	Low	Small quantities of contaminants, far proximity to well field, low to high contaminant mobility in groundwater, potential for dilution by Ring Creek	Low	Educate residents re: proper septic tank maintenance and responsible disposal of household hazardous liquids, pharmaceuticals	DOS	Within 2 years Distribute newsletter annually
							Invite resident representative to participate in WPPC	DOS	Ongoing
Recreational Use	Hydraulic oil, Fuel Illegal dumping	<1 month to 5-year TOT	Petroleum hydrocarbons, heavy metals	Low	Small quantities of contaminants, close to far proximity to well field, low traffic, low to medium contaminant mobility in groundwater, low to medium aquifer vulnerability	Low	Place signage notifying trail users of GPZ at strategic locations on recreational trails	DOS / MFLNRO / Recreational Groups	Within 2 years Check on signs, gate annually
							Invite User Groups to participate in WPPC, implement mitigation strategies (e.g. carrying absorbent pads for vehicular leaks, doggie bags)	DOS / Recreational Groups	Ongoing
All of the Above						Low	Request that the MOE Water Stewardship Division update the polygon which defines the areal extent of the Ring Creek Aquifer	DOS	Within 1 year
						Medium	Request that the SLRD and MOE consider the GPZ as a Community Watershed Protection Area	DOS	Within 1 year
						Medium	Consult with SLRD and stakeholders regarding expansion of District boundaries to include GPZ (see Fig. 1). If achieved, designate the GPZ as a Development Permit Area for Aquifer Protection	DOS	Within 5 years
						High	Request that Section 17 Watershed Reserve Area be expanded to include the 1-year Capture Zone	DOS	Within 6 months
						High	Submit a Land tenure application for Powerhouse Road, a Road Use Permit application for Mamquam FSR, and formalize maintenance agreement with other users of Powerhouse Road	DOS	Within 6 months

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TABLE II
CONTINGENCY RESPONSES TO POTENTIAL CONTAMINATION EVENTS

EVENT	CONTAMINANT SOURCE / ACTIVITY	CONTINGENCY ACTIVITIES	CONTACT
Reported / Observed Incidents			
Spill of diesel, lubricating oil, or other hydrocarbon in Well Field area	Diesel tank with back-up generator Machinery working in area	1. Contain / clean up the spill 2. Determine public health significance and issue public notice (if needed) 3. Take well(s) off-line and/or use alternate water source(s) (if needed) 4. Delineate plume (install monitoring well(s), if needed) 5. Monitor to determine extent and persistence of plume 6. Confirm elimination of risk and remove public notice	Environmental Health Officer Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant Remediation Specialist
Spill of sodium hypochlorite in Well Field area	Water disinfection station	1. Contain / clean up the spill 2. Determine public health significance and issue public notice (if needed) 3. Take well(s) off-line and/or use alternate water source(s) (if needed) 4. Delineate plume (install monitoring well(s), if needed) 5. Monitor to determine extent and persistence of plume 6. Confirm elimination of risk and remove public notice	Environmental Health Officer Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant Remediation Specialist
Vandalism or contamination of a well or well(s)	Various	1. Sample individual wells to determine public health significance 2. Issue public notice (if needed) 3. Take well(s) off-line and/or use alternate surface water source (if needed) 4. Monitor to determine extent and persistence of contamination	Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant Remediation Specialist
Large volume (>500L) spill of hydrocarbon or other hazardous liquid on land within GPA > 300m from Well Field	Timber harvesting, transmission corridor maintenance, recreational activities, etc.	1. Contain and clean up the spill, delineate plume (install monitoring well(s), if needed) 2. Determine public health significance 3. Monitor contaminant mobility 4. If contaminant approaches within 300m of Well Field, depending on public health significance: - Issue public notice and/or - Take well(s) off line and/or use alternate water source(s) 5. Continue to monitor and plan alternate water sources / treatment (if needed) 6. Confirm elimination of risk and remove public notice	Environmental Health Officer Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant Remediation Specialist
Large volume (>500L) spill of hydrocarbon or other hazardous liquid in Ring Creek or Skookum Creek > 300m from Well Field	Transportation of fuel or hazardous liquids along forest service roads, etc.	1. Contain and clean up the spill, delineate plume (install monitoring well(s), if needed) 2. Determine public health significance 3. Monitor contaminant mobility 4. If contaminant approaches within 300m of Well Field, depending on public health significance: - Issue public notice and/or - Take well(s) off line and/or use alternate water source(s) 5. Continue to monitor and plan alternate water sources / treatment (if needed) 6. Confirm elimination of risk and remove public notice	Environmental Health Officer Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant Remediation Specialist
Incidents Detected by Monitoring			
Pathogens in Groundwater	Contaminated surface water (Powerhouse or Ring Creek), Ring Creek Road Septic Fields, etc.	1. Determine public health significance 2. Issue public notice (if needed) 3. Take well(s) off-line and/or use alternate water source(s) and/or increase level of treatment 4. Monitor to determine source, extent, and persistence of pathogen contamination 5. Remove / mitigate pathogen source (if possible) 6. Scope alternate water source (if needed)	Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant
Nitrates in Groundwater	Ring Creek Road Septic Fields, etc.	1. Determine public health significance 2. Issue public notice (if needed) 3. Take well(s) off-line and/or use alternate water source(s) 4. Monitor to determine source, extent, and persistence of nitrate contamination 5. Remove / mitigate nitrate source (if possible) 6. Scope alternate sources (if needed)	Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant
Hydrocarbons in Groundwater	Timber harvesting, transmission corridor maintenance, recreational activities, etc.	1. Determine public health significance 2. Issue public notice (if needed) 3. Take well(s) off-line and/or use alternate water source(s) (if needed) 4. Monitor to determine source, extent and persistence of hydrocarbon contamination 5. Remove / mitigate hydrocarbon source (if possible) 6. Scope alternate sources (if needed)	Drinking Water Officer Operators, Supervisor, Director of Water System Hydrogeological / Environmental Consultant

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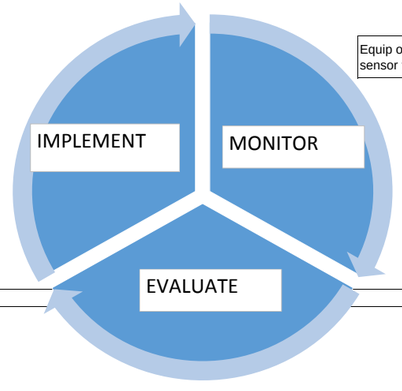
Notes:
"DOS" = District of Squamish
"SPP" = Skookum Run-of-River Power Projec
"EFPs" = Environmental Field Procedure
"PHCs" = Petroleum Hydrocarbons
1. Higher priority management strategies highlighted in yello

TABLE III
SUMMARY OF RECOMMENDATIONS IN WELL PROTECTION PLAN (2014)

	WITHIN 6 MONTHS	WITHIN 1 YEAR	WITHIN 2 YEARS	WITHIN 5 YEARS	ANNUALLY THEREAFTER
IMPLEMENT	Public Outreach: Post WPP on District Website				
	Request that Section 17 Watershed Reserve Area be expanded to the 1-year Capture Zone				Contact MFLNRO for updates on land use authorizations not subject to Section 17 mapping reserve
	Submit a land tenure application for Powerhouse Road, a Road Use Permit application for Mamquam FSR, and establish maintenance agreement with other Powerhouse Road users				
		Request that the MOE Water Stewardship Division update the footprint of the Ring Creek Aquifer			
		Request that the SLRD consider the GPZ as a Community Watershed Protection Area			
		Seek commitment to Well Protection Planning Committee from various user groups, stakeholders, regulatory officials			Meet with all members of the Well Protection Planning Committee
		Request copies of Site Plans from licensed harvesting operations within the GPZ			Contact MFLNRO for updated list of licensees within the GPZ from MFLNRO, request copies of Site Plans from licensees and information on timing and duration of harvesting activities Inspect actively logged areas to confirm implementation of environmental protection measures
		Adopt a Contingency Plan for Well Protection and distribute District emergency contact information to land users within the GPZ			Update Contingency Plan, emergency contact list as needed, explore alternate groundwater sources
			Formalize an agreement between the District and Garibaldi Springs recognizing their respective rights to the groundwater resource and outlining protocols for access, operations, and communications		
			Invite local streamkeepers to participate in WPPC and ask that they report potentially polluting activities along Ring or Skookum creeks		Contact streamkeepers for their observations
			Educate residents re: proper septic tank maintenance and responsible disposal of household hazardous liquids, pharmaceuticals		Reminder outreach (e.g., distribute annual newsletter)
			Request that MFLNRO add signs and locked gates at vehicle access points to Lava Flow via SPP transmission line corridor		Request schedule of transmission corridor maintenance activities
			Place signage at strategic locations notifying recreational trail users that they are entering GPZ		Inspect signs
				Consult with SLRD and stakeholders regarding expansion of District boundaries to include GPZ (see Fig. 1). If achieved, designate the GPZ as a Development Permit Area for Aquifer Protection	Implement DPA for Aquifer Protection as part of Official Community Plan
				Equip diesel tank for back-up power generator with secondary containment	Inspect condition of tank and inspect / maintain well surface seals
					Rehabilitate wells exhibiting appreciable decline in well performance
MONITOR		Equip observation well OW97-1 with a water level sensor to continuously monitor water levels			Sample wells in spring and fall for potential contaminants of concern
					Review water level data
					Review SCADA data for all monitored wells
					Obtain and review stage and discharge data collected at Skookum Creek by SPP
					Review well specific capacity data and prioritize wells for rehabilitation
				Install a sentinel monitoring well near the 3-month groundwater TOT boundary	Sample well for potential contaminants of concern, review water level data
				Install a sentinel monitoring well near the Mamquam-Skookum confluence	Sample well for potential contaminants of concern, review water level data
EVALUATE					Prepare a Performance Monitoring Report for the Well Field and make modifications to the WPP
				Update Hydrogeological Assessment and WPP with respect to new information, land use changes	

FIGURES

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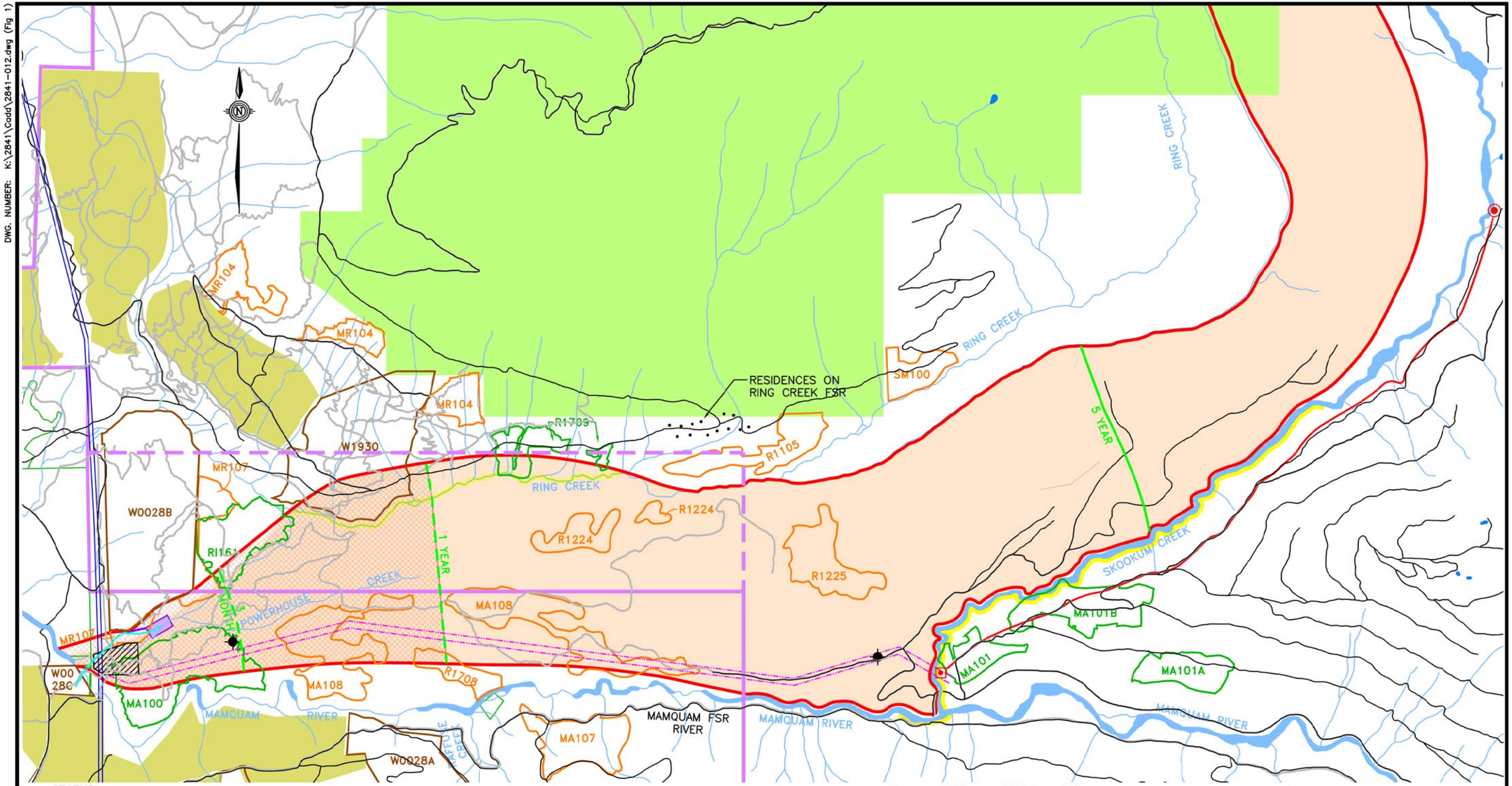

LEGEND

- ESTIMATED EXTENT OF PALEOCHANNEL SEDIMENTS
- 1 YEAR — ESTIMATED CAPTURE ZONE BOUNDARY FOR GIVEN GROUNDWATER TRAVEL TIME
- WATERCOURSES
- SQUAMISH DISTRICT MUNICIPALITY BOUNDARY
- PROPOSED EXPANSION OF DISTRICT BOUNDARIES
- GARIBALDI PROVINCIAL PARK
- SQUAMISH NATION (UNDER DISCUSSION)
- PLANNED/SOLD BCTS CUT BLOCKS (TIMBER SALE LICENCE)
- HARVESTED BCTS CUT BLOCKS (TIMBER SALE LICENCE)
- WOOD LOT (MANAGED TIMBER LICENCE)
- SPP TRANSMISSION CORRIDOR
- BC HYDRO TRANSMISSION CORRIDOR
- ROADS (GRAVEL)
- RECREATIONAL TRAILS
- PLANNED SPP PENSTOCK ROUTE
- PLANNED SPP PUMP HOUSE
- PLANNED SPP INTAKE
- SECTION 17 WATERSHED RESERVE (CROWN)
- GARIBALDI SPRINGS LICENCE OF OCCUPATION
- GARIBALDI SPRINGS STATUTORY RIGHT OF WAY
- PROPOSED GROUNDWATER PROTECTION ZONE
- PROPOSED MONITORING WELL
- INFERRED REACHES OF CREEK SEEPAGE INTO AQUIFER

0 500 1000 1500m

SCALE 1:30000

DISTRICT OF SQUAMISH
POWERHOUSE SPRINGS WELL PROTECTION PLAN
POWERHOUSE SPRINGS, SQUAMISH, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

LAND USE WITHIN STUDY AREA AND PROPOSED GROUNDWATER PROTECTION ZONE

BY:	DATE:
KT/lf	APR 14
APPROVED:	FIG:
KT	1

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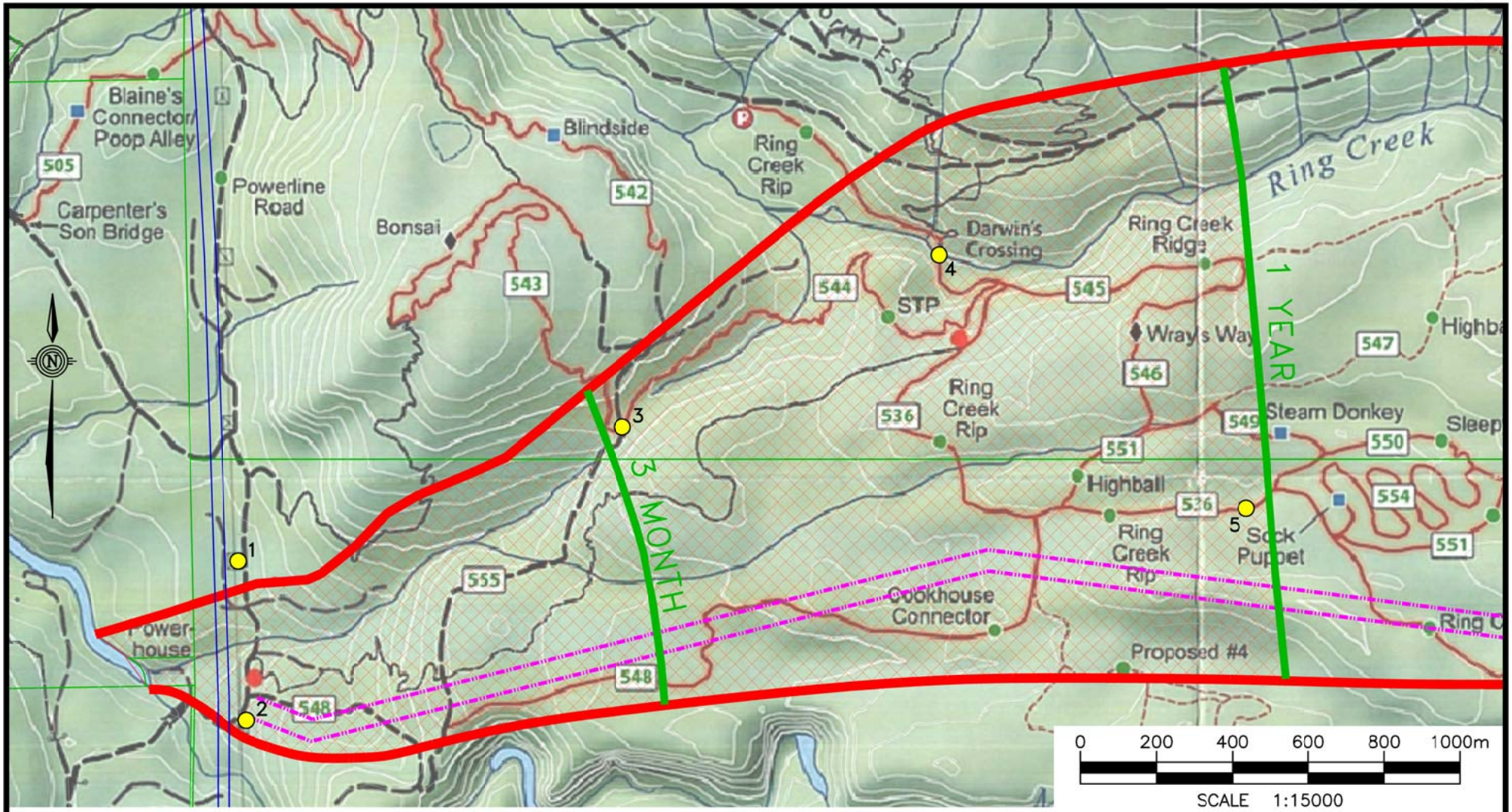

LEGEND

- ESTIMATED EXTENT OF PALEOCHANNEL SEDIMENTS
- PROPOSED GROUNDWATER PROTECTION ZONE
- 1 YEAR — ESTIMATED CAPTURE ZONE BOUNDARY FOR GIVEN GROUNDWATER TRAVEL TIME
- SPP TRANSMISSION CORRIDOR
- BC HYDRO TRANSMISSION CORRIDOR
- 1 — PROPOSED SIGN LOCATIONS AT ENTRY POINTS TO GPZ
- GRAVEL ROAD
- TRAIL (SINGLE TRACK)

DISTRICT OF SQUAMISH
POWERHOUSE SPRINGS WELL PROTECTION PLAN
POWERHOUSE SPRINGS, SQUAMISH, B.C.

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

RECREATIONAL TRAILS WITHIN GROUNDWATER PROTECTION ZONE

BY:	DATE:
KT/lf	APR 14
APPROVED:	FIG:
	2