Associated Environmental

REPORT

City of Merritt

Source Water Assessment and Protection Plan

August 2017

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1 Introduction

1.1 PROJECT BACKGROUND

The City of Merritt (the City), which has a population of approximately 7,300 people, currently satisfies all of its potable water supply requirements via groundwater extraction from five supply wells (see Section 2 for map of locations). In 2016, the Interior Health Authority (IHA) requested that the City complete a Source Water Assessment and Protection Plan (SWAPP) for the water system as part of the City's Conditions of Permit.

In October 2016, Associated Environmental Consultants Inc. (Associated) was retained by the City of Merritt to complete the SWAPP in accordance with the BC Ministry of Health Living and Sport (MHLS) Comprehensive Drinking Water Source-to-Tap Assessment Guideline (Source-to-Tap Guideline) Modules 1, 2, 7, and 8 (MHLS 2010). This SWAPP includes all of those four modules, as required by the City's Conditions of Permit issued by IHA.

1.2 PROJECT OBJECTIVES

The overall goal of the SWAPP is to improve the safety of the drinking water system by identifying hazards and vulnerabilities in the multi-barrier system that could affect the water supply system. The objectives of developing a SWAPP are to:

- Identify hazards that may threaten the quality of the groundwater supply source.
- Rank the hazards by risk level to identify the highest priority hazards.
- Develop recommendations to either reduce the chances that the hazard will occur, or mitigate the risk from the hazard if unavoidable.
- Provide costs and timelines for the recommendations, to help the City with planning and budgeting.

1.3 PROJECT SCOPE

The Source-to-Tap Guideline provides a structured and consistent approach to evaluating risks to drinking water (MHLS 2010). It serves as a tool for water systems to: (a) develop a more comprehensive understanding of risks to drinking water safety and availability, (b) operate effectively, and (c) produce the best possible water quality. The four Source-to-Tap Guideline modules are:

- Module 1: Delineate and characterize drinking water sources
- Module 2: Conduct contaminant source ('hazard') inventory
- Module 7: Characterize risks from source to tap
- Module 8: Recommended actions to improve drinking water protection.

1.4 TECHNICAL ADVISORY COMMITTEE

The Source-to-Tap Guideline recommends assembling a multi-disciplinary Technical Advisory Committee (TAC) to identify potential hazards to the drinking water system and assess the associated risks. In

partnership with the City, Associated facilitated the formation of a TAC whose members are listed in Table 1-1.

Table 1-1
Technical Advisory Committee members

Organization	Name	Title
City of Merritt	Sasha Bird	Director of Engineering and Development
City of Merritt	Alec Macfarlane	Engineering Technologist
City of Merritt	Kevin Vilac	Senior Operator
City of Merritt	Shawn Boven	Chief Administrator Officer
City of Merritt	Darrell Finnigan[1]	Public Works Superintendent
City of Merritt	Mark Broderick	Planning and Development Services Manager
Associated	Marta Green	Hydrogeologist
Interior Health Authority	Jessy Bhatti	Environmental Health Officer, Large Water System Specialist

Notes: 1. Darrell is no longer employed by the city, but was a valuable member of the TAC during the workshops that took place in Dec 2016.

Records of meetings with the TAC are in Appendix A.

2 Module 1: Delineation and Characterization of Water Source

Module 1 includes characterizing the water source and delineating the capture zones. The key outcome of Module 1 is a definition of the capture zones for the wells during regular operating conditions. The capture zone is the area around a well that contributes water to the well. To determine this area, an understanding of the water source (including a description of the wells, well sites and the hydrogeological setting) is first required.

2.1 CHARACTERIZATION OF THE WATER SOURCE

2.1.1 Location

The city of Merritt is located in the Nicola Valley of the south-central Interior of British Columbia. Located east of the confluence of the Nicola and Coldwater Rivers, the City is set along the Nicola Valley, a thin strip of flatland set between the coastal mountains and the BC interior high plateau.

2.1.2 Climate

Climate normal data (calculated for data from 1981 - 2010) is available for Merritt STP (Climate ID: 1125079), located at an elevation of 609 m near the valley bottom. The average annual total precipitation (rain and snow) is 321.1 mm. The wettest months (including both rain and snow) are June, November, and December on average; and the driest months March and April. The Nicola Watershed is one of the drier watersheds in the province, and the Merritt area has a semi-arid climate. The Coastal Mountain Range acts as a natural barrier for precipitation coming in from the west, and the Nicola Valley is in the rain shadow. December is the month with the coldest daily average temperature (3.7°C) and July (18.8°C) is the warmest.

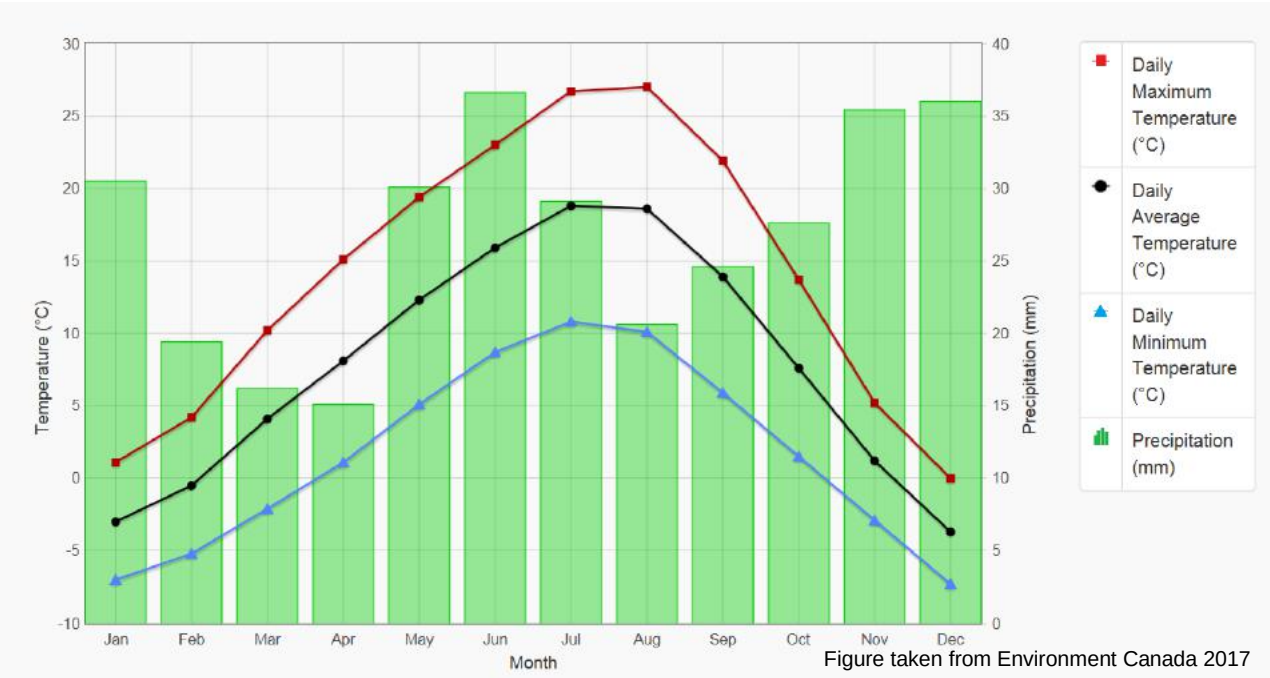

Figure 2-1
Daily average temperature and precipitation at climate station Merritt STP (1981 – 2010 Climate Normal Data)

2.1.3 Soils

Soils in the vicinity of the wells are mapped as silt loams of the Frances Series (Young et al. 1992). They are rated as poorly/imperfectly-drained, indicating a degree of filtration and natural attenuation[1] of surface contaminants. Soils farther away from the wells (300m away at the nearest point) are considered rapid or well-draining. Polygons of mapped soil types and their related ranges of infiltration rates are presented in Appendix B (Associated 2013).

2.1.4 Bedrock Geology

Two bedrock expressions are mapped underlying the Merritt area. Toward the east, the Merritt Basin is part of the Princeton Group sedimentary rocks. These tertiary period rocks are of Eocene age (between 56.5 and 35.4 million years old), and are described as sandstone, conglomerate, argillite and coal. The formation includes “Coldwater beds” and Allenby Formation of the Princeton Group. Toward the west, the Western Volcanic Facies are part of the Nicola Group volcanic rocks. These Mesozoic era rocks are of the

[1]Natural attenuation is a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater (EPA 2016).

Upper Triassic period (between 235 and 208 million years old), and consist of mafic to felsic pyroclastic rocks and flows; argillite, sandstone and local carbonate rocks (MOE 2017).

Depth to bedrock below the middle of the Merritt Aquifer is highly variable, with reports of unconsolidated sediments extending to a depth of 172m (WTN 97208- Kengard School Well) in one well, and bedrock encountered at a depth of 165m in another (WTN 97218 – Kengard Production Well) on the same property (MOE 2017).

2.1.5 Surficial Geology

Surficial materials which underlie the Merritt area are the result of this glacial, glaciofluvial, glaciolacustrine, and recent fluvial deposition. Geologic interpretation of the strata is made possible from observation of exposures along the valley margins and by interpretation of available well logs completed within the valley.

The City of Merritt is directly underlain by shallow sand and gravel strata associated with post-glaciofluvial and fluvial deposition. This surficial layer is approximately 5 to 15 metres thick, and spans the area between the two rivers, from their confluence in the west to the Coquihalla Highway in the east. The City's production wells are completed in the same deposit, but in a deeper gravel filled "trough". This trough, located at the western end of town is very narrow, extends in an east-west orientation, and down to a depth of 50 metres or more. BC MOE Observation Well No. 296 is completed in this surficial aquifer, but did not encounter this trough of coarse grained sediments. The trough location is shown on Figure 2-2.

Several irrigation wells on the River Ranch property have intersected saturated sandy gravel layers up to several metres thick below the glaciolacustrine silts to a depth of about 100 metres. These deeper gravels are interpreted to originate from glaciofluvial deposition that occurred prior to the ice damming of the valley. The total thickness of these deposits is largely unknown, but the borehole for the recently installed Kengard well encountered bedrock at a depth of 165 metres below grade. The position of these sediments suggests the potential existence of a paleo-channel which follows the present course of the Nicola River, and may extend as far east as Nicola Lake (KALA 2004).

2.1.6 Hydrogeological Setting

All but one of the City's groundwater supply wells are within the spatial extent of MOE mapped aquifer 74 IA. This is a surficial, unconfined sand and gravel aquifer that is considered highly productive and highly vulnerable to contamination. There are few registered wells outside of the mapped extent of this aquifer, but wells with the well tag numbers (WTN) 61559 near the airport and 89213 to the North towards Nicola suggest the sand and gravel aquifer likely extends towards further to the North than mapped. Due to the lack of lithological information northwest of the City it is unclear if the aquifer extends further in this direction as well.

Aquifer 74 IA is predominantly 5-10 m thick and is underlain by a discontinuous silt and clay aquitard. This aquitard exhibits a deep trough (~50 m deep) in the center of the valley (Figure 2-2). The trough is interpreted to extend from the intersection of May street and Priest Ave to the Collettville Well. The deepest

part of the trough is interpreted to be about 0.5 km wide. Fairley Park, Collettville, and the Voght Park wells are screened across the sediments in this deeper trough, while OBS 296 did not intersect it.

Below the aquitard are several discontinuous deeper aquifers, described by BC Groundwater (2011) as Deep Aquifer 1, Deep Aquifer 2, and Deep Aquifer 3. Below Deep Aquifer 3 is bedrock, with depths upwards of 170 m in the area around the City. The Kengard well is screened across Deep Aquifer 2 from 120-139 m.

The results from a 5-day pumping test on the Kengard well indicate that the deeper aquifers and the surficial aquifer are all connected to varying degrees (BC Groundwater 2011). Both the surficial and deep aquifers are hydraulically connected to the Coldwater and Nicola Rivers, but to different degrees (Bennett and Caverly 2009, BC Groundwater 2011).

2.1.7 Description of Wells and Well Sites

The City's sole source of water supply is from its five groundwater wells. The oldest well in use, Fairley Park, was drilled in 1966 and since then other supply wells have been drilled and connected to the distribution system. The most recent well, Kengard, was drilled in 2007 as the result of a deep aquifer exploration program undertaken at the City (BC Groundwater 2011). Table 2-1 summarizes the 5 wells. Available well logs are provided in Appendix C, and well locations are shown on Figure 2-2.

Table 2-1
Summary of City of Merritt groundwater supply wells

Well ID		Voght Park #1	Voght Park #2	Collettville	Fairley Park	Kengard
Well Tag Number (WTN)		unknown	34180	108220	38902	97218
Well Plate ID (WPID)		12729	12728	12727	12730	29680
Maximum Supply Capacity (L/s)[A]		106.4	83.3	56.4	75.8	110+[B]
Location	Easting (m) (10 U)	657254	657254	657090	657656	658859
	Northing (m) (10 U)	5553201	5553201	5553162	5553319	5553563
	Elevation (masl)	595	595	594	597	602
Well Construction Data	Static Water Level (m bgs)	3.48	3.63	4.3	1.86	3.71
	Well Depth (m bgs)	29.9	34.1	45.1	25.3	139
	Screened Interval(s) (m bgs)	20.7 - 29.9	9.8 - 34.1	37.6 - 45.1	19.2 - 25.3	120 - 139
	Casing diameter (mm)	400	400	250	300	400
	Screen diameter (mm)	unknown	unknown	unknown	unknown	300

Notes:
A – As reported in Opus Dayton Knight (2012).
B – Kengard is reported as 50 L/s in Opus Dayton Knight (2012). However, a 5-day pumping test at 110 L/s in 2009 suggests a theoretical maximum supply capacity of 150 L/s.

The City currently satisfies all potable water requirements via groundwater extraction from five supply wells. Four of the five supply wells (Voght Park #1, Voght Park #2, Fairley Park, Collettville) are completed in the surficial unconfined sediments of the Merritt Aquifer, and one additional well (Kengard) is completed in a lower confined aquifer (the Kengard Aquifer).

Four of the five water supply wells are installed relatively close to one another, and their 10-year capture zones overlap.

2.1.8 Water Quality

2.1.8.1 Source Water Quality

Associated reviewed laboratory reports provided by the City and publicly available data on the BC Environmental Monitoring System (EMS) website to assess concentrations of key indicators of anthropogenic inputs to groundwater (chloride, sodium, sulphate, TDS, and nitrate). In some cases, exceedances of the Guidelines for Canadian Drinking Water Quality (GCDWQ) were identified in the data. Guideline levels specified in the GCDWQ are generally designated as either a maximum acceptable concentration (MAC) or an aesthetic objective (AO) (Health Canada 2017). The MAC guidelines are health-risk-based and determined based on the known health effects associated with the substance. The AO guidelines apply to those variables that adversely affect taste or intended, typical water uses (e.g., staining of laundry) but do not pose a health hazard.

Generally, data were available from between 2003 and 2016, although the data availability varied for each well. The findings are summarized below.

- Fairley Park Well: The Fairley Park well is showing indications of anthropogenic effects. There is some evidence of an increase over time in nitrate, chloride, sulphate, and TDS levels. Nitrate-N concentrations are above 1 mg/L, which indicates that anthropogenic inputs are likely. Concentrations remain well below the MAC of 10 mg/L, but should be monitored in the future. Both sodium (12.6 mg/L in 2003 to 19.6 mg/L in 2016) and chloride (15.3 mg/L in March 2003 to 50.9 mg/L in 2016) have increased over time, but results remain below the GCDWQ AO levels which are 200 mg/L and 250 mg/L, respectively. Sulphate has also increased, from 18.5 mg/L in 2003 to 34.9 mg/L in 2016. The GCDWQ AO is 500 mg/L.

- Collettville Well: Nitrate, chloride, and sodium concentrations are relatively low. Sulphate is slightly higher than in some of the other wells, with concentrations typically around 60-70 mg/L. Lead was detected in the raw water at the pumphouse once (0.002 mg/L).

- Voght Park Well #1: Chloride, sodium, sulphate, and TDS are all relatively low. Nitrate-N has been as high as 0.732 mg/L (in 2008), but was lower recently (0.355 mg/L in 2016).

- Voght Park Well #2: Chloride, sodium, sulphate, and TDS are all relatively low. Nitrate-N concentrations have remained below 1 mg/L, but generally are higher than other wells (except Fairley Park), ranging from 0.4 mg/L to 0.8 mg/L.

- Kengard Well: Both manganese and TDS consistently exceed the GCDWQ AO in the water from this well. The water has higher hardness (> 400 mg/L), TDS (657 mg/L), sulphate (>300 mg/L) and conductivity (900 µs/cm) than the other wells. Chloride is generally low (< 10 mg/L). Lead has been periodically detected in the raw water but has been below the MAC of 0.01 mg/L. Ammonia-N, which is not typically tested at the well, was detected at 0.0309 mg/L in November 2016. There is no drinking water guideline for ammonia, which typically converts to nitrate in groundwater.

Water quality data from 1987 – 2015 (total of 13 samples) from Observation Well 296 (Figure 2-2) were also reviewed. Both chloride and sodium have increased over time in this well. Chloride increased from 1.6 mg/L in 1987 to 12.6 mg/L in 2015. Sodium has increased from 3.7 mg/L to 6.65 mg/L over the same period. These increases are minor, and concentrations remain well below the maximum GCDWQ AO (250 mg/L for chloride and 200 mg/L for sodium). However, the increase suggests the need for continued monitoring.

2.1.8.2 Treated Water at City Hall

Post-treatment water quality results from City Hall (which receives its water mainly from the Fairley Park well) indicate that lead has periodically been detected. For the most part, concentrations of total lead have been below the current GCDWQ MAC of 0.01 mg/L (Health Canada 2017). However, in July 2015 the concentration of total lead (0.012 mg/L) exceeded guidelines.

Lead in drinking water supplies is an increasing concern in BC. The primary source of lead in drinking water is usually leaching from older pluming service lines that contain lead, rather than the source water itself (Health Canada 2016a). The amount of lead that is leached from the system typically depends on factors such as the age of the pluming system, the amount of time water sits stagnant in the system (as opposed to flushing), and the corrosiveness of the source water (Health Canada 2016a).

Health Canada recently (October 2016) released a revised proposed guideline document for lead in which the GCDWQ MAC is reduced to 0.005 mg/L (Health Canada 2016b), which will increase the likelihood of drinking water guidelines being exceeded. The guideline technical document also states that previous studies cannot identify a level below which lead is no longer associated with health effects, and therefore lead in water should be kept as low as reasonably achievable (Health Canada 2016b). The document is still in the public consultation phase, and is not yet finalized.

Trihalomethanes have also been periodically detected in water at City Hall. Trihalomethanes are a group of compounds that can form when organic matter reacts with the chlorine used for disinfection (Health Canada 2006). They are considered a possible to probable carcinogen, depending on the specific compound (Health Canada 2006). There are also reported links between trihalomethanes and reproductive effects, although more studies are needed (Health Canada 2006). Although trihalomethanes have not been

detected in most samples; dibromochloromethane (0.001 mg/L) and bromoform (0.001 mg/L) were present in the sample from February 2015 and dibromochloromethane (0.002 mg/L) was detected in the sample from February 2012. There is no GCDWQ MAC for these parameters individually, but there is a MAC guideline value for trihalomethanes (0.100 mg/L), which includes dibromochloromethane, bromoform, chloroform, and bromodichloromethane. The result for total trihalomethanes on February 2015 met this guideline.

2.2 DELINEATION OF THE CAPTURE ZONE

Capture zones represent the area around a wellhead under which groundwater will arrive at a pumping well within a given period. The 200-day and 10-year travel times were used to delineate areas of concern for pathogens and chemical spills, respectively. A 200-day capture zone represents the survival time of pathogens (including viruses) and is consistent with the new version of the BC Ministry of Health's Guideline for Determining Groundwater at Risk of Containing Pathogens (MOH 2015). A 10-year capture zone represents an intermediate time of travel within which chemical and hydrocarbon spills and leaks would be of concern. Some protection plans show 25 year and even 90 year times of travel; however, in our experience, a 10-year time of travel provides a reasonable limit where advanced modelling of capture zones is not being completed. This is a relatively simple method to calculate capture zones, and therefore some uncertainty can be expected.

Table 1-4 in Module 1 of the Source-to-Tap Guideline summarizes the different capture zone delineation methods, from simple to more complex, and recommends which one to follow depending on the size of the water system and the hydrogeologic setting (MHLS 2010). For the City's population of 7,000 people, and for areas of high well density and in sand and gravel aquifers, the Source-to-Tap Guideline recommends using analytical equations and hydrogeologic mapping to determine the capture zones.

When developing the capture zones, Associated initially used an analytical equation method outlined by Ceric and Haitjema (2005), which includes a mathematical approach to justify the method selection between the circular, eccentric, or boat-shaped capture zone analytical equations that are presented in the BC Well Protection Toolkit (MOE 2000), and is dependent on the hydraulic gradient of the water table. A previous study (MOE 2009) calculated the hydraulic gradient in June and August of 2009 to be 0.007 m/m and the groundwater flow direction to be towards the northwest. When used in the model, the resulting boat-shaped capture zones were narrow and extended far to the southeast. However, based on a review of pumping levels and other data, a calculated fixed radius (CFR) capture zone method is more suitable for the purposes of this SWAPP for the following reasons:

- pumping test data from the Kengard well indicates that interference is observed in the Fairley Park and OBS 296 wells, indicating a more circular capture zone than previously calculated;
- pumping test data from Voght Park well indicates that within minutes of pumping the Voght Park, water levels draw down at Collettville and vice versa, indicating a more circular capture zone than previously calculated;
- the Ceric and Haitjema method recommends a circular analytical equation when the hydraulic gradient is very small (i.e. very flat);

- the boundaries of the provincially mapped aquifer are more consistent with the results of a circular method; and
- the analytical equation method is not recommended when there is little information about the slope of a water table (MOE 2000).

The CFR method uses the pumping rate, aquifer porosity, aquifer thickness, and time-of-travel of interest to calculate a radius. Table 2-2 summarizes the results of the CFR.

Table 2-2
Circular fixed radius capture zone analysis

Well ID	Maximum pumping capacity (L/s)	Actual use in 2015 (L/s)[A]	Porosity	Aquifer thickness (m)	Capture zone	Capture zone radius (m)
Voght Park #1	110[B]	49.2	0.3	26[C]	200-Day	280
					10-Year	1180
Voght Park #2	125[B]	12.6	0.3	30[C]	200-Day	270
					10-Year	1170
Fairley Park	58[D]	11.2	0.3	23[C]	200-Day	210
					10-Year	910
Collettville	50[E]	22.8	0.3	41[C]	200-Day	150
					10-Year	640
Kengard	110[F]	2.1	0.3	26[G]	200-Day	280
					10-Year	1200

Notes:
A – Daily Water Consumption Report – 2015 (K.Vilac, 2017, personal communication). Determined based on litres pumped in a year divided by the number of seconds in a year.
B – K. Vilac, 2017, personal communication.
C – Determined based on the difference between the static water level (EBA 2002) and the bottom of the well screen.
D – Western Water Associates Limited (2015). Based on spot checks of flow records from 2013 to 2015.
E – Piteau 2012.
F – Pumping rate used for 5-day pumping test in 2009. Well is reportedly used at 50 L/s (Opus Dayton Knight 2012) but is likely capable of rates greater than 110 L/s (BC Groundwater 2011).
G – Determined based on lithology presented in BC Groundwater (2011).

Once the capture zones were delineated, the edges were refined using hydrogeological mapping (MOE Aquifer 74) and surficial mapping (Fulton 1974). In cases of disagreement between the hydrogeological mapping and the surficial mapping, the larger area (more conservative) was used. Wherever capture zones overlapped they were combined.

In addition to 200-day and 10-year capture zones, well protection zones of 100 m were applied to all wells. The well protection zone represents the area of greatest risk to source water. Herein, the capture zones are referred to as **Aquifer Protection Areas** (APA):

- The 100 m well protection zone is referred to as **APA-A**,
- the 200-day capture zone is referred to as **APA-B**, and

- the 10-year capture zone is referred to as **APA-C**.

The delineated APAs for all wells are shown on Figure 2-2.

Table 2-2 indicates that the actual use of these wells is as about half the maximum pumping capacity, so the calculated capture zones are conservative (i.e. the actual travel times are longer, enabling more opportunity for attenuation).

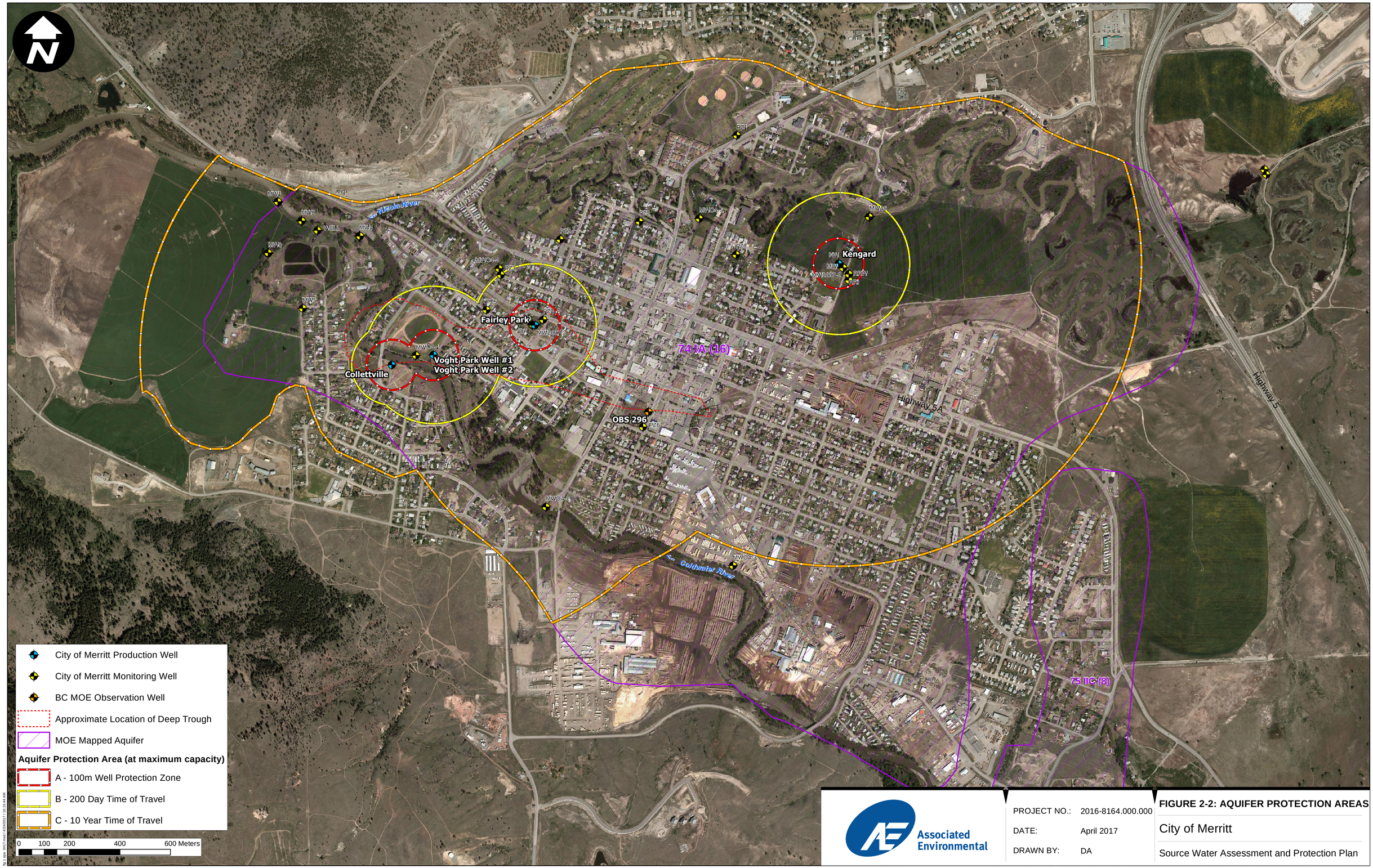

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FIGURE 2-2: AQUIFER PROTECTION AREAS

City of Merritt

Source Water Assessment and Protection Plan

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3 Module 2: Contaminant Source Inventory

Module 2 includes a contaminant source inventory that identifies the inherent risks to water quality as well as describing land uses, human activities, and other potential contaminant sources that could affect source water quality within the APA's. The term "contaminant source" is defined in the Source-to-Tap Guideline to mean both actual/existing and potential source of contamination.

3.1 TYPES OF HAZARDS

3.1.1 Point Source and Non-Point Source Hazards

The term hazards are defined in the Source-to-Tap Guideline to mean both actual/existing and potential hazards. Hazards are typically categorized as point source or non-point source. Point sources of contamination arise from a single, identifiable location (e.g., the discharge from a wastewater treatment plant). Non-point sources arise from multiple diffuse sources over an area (e.g., infiltration from agricultural land, septic fields).

There are seven main types of land uses that can cause a point source or non-point source hazard. Examples of hazards from each type are:

- Naturally occurring: pathogens from wildlife including bacteria (*E. coli*), and protozoa such as *Giardia lamblia.* Bacteria die off in a matter of weeks, but protozoa can remain active for months because of a protective shell.
- Agricultural: nitrates, phosphates, pesticides, pathogens, and accidental releases of hydrocarbons and other machinery fluids
- Forestry-related: phenolics and nitrates from decomposing wood waste, turbidity, accidental release of motor fuel and other machinery fluids
- Municipal: fertilizers and pesticides from fields/parks, stormwater run-off, salt (sodium chloride)
- Commercial and industrial: permitted point discharges and accidental releases of chemicals
- Industrial: permitted point discharges and accidental releases specific contaminants from specific industrial land uses
- Residential: pathogens from leaking septic tanks, accidental releases from heating oil tanks, regular application pesticides, accidental release from solvents.

Specific hazards of interest to the City of Merritt water supply system are described in Section 3.2.

3.1.2 Climate Change

In recent years, we have experienced extreme weather and weather-related events across Canada, including storms, flooding, drought, wind, and wildfires. Water system infrastructure, including water quality from water supply wells, is vulnerable to the changing climate. For example, virus detection and concentrations appear to be associated with groundwater recharge events (Bradbury et al. 2013), and more precipitation systematically increased childhood gastrointestinal illness in municipalities accessing untreated water, including both groundwater and surface water sources (Uejio et al. 2014). This suggests

that with a changing climate and more extreme storm events, groundwater supplies may not be as protected from surface contaminants as once thought.

3.2 HAZARD INVENTORY

To identify potential hazards to the Meritt drinking water wells, Associated reviewed available existing records and completed a single-day field survey. From that work, Associated developed a preliminary list of potential hazards that were reviewed with the TAC members during a workshop (Workshop 1). Hazards were then added or removed from the list based on the TAC members' knowledge of the area and the water supply system. A complete list of each identified hazard and associated notes is in Appendix D.

3.2.1 Records Review

The following records, reports, and databases were reviewed to identify potential hazards:

- **BC Contaminated Sites Registry**: The BC Site Registry is a database administered by the MOE that pertains to the environmental condition of land in the province (MOE 2016a). This registry is not a complete database of contaminated sites in BC, but provides a record of sites that the MOE has documented as contaminated or as having undergone a contaminated sites investigation. Search results typically provide a record of current or past contamination, spills, or environmental works at registered sites.

  Using the BC Site Registry, we completed a large area search (i.e., land within a circle with a radius of 5.6 km from the approximate centre of APA-C, or 100 km^2), which returned 43 records for surrounding properties. Of these 43 records, 19 were for properties outside of the APA-C, which were deemed low risk of contamination in the capture zone. Associated obtained synopsis reports for five of the remaining records from a previous report (BC Groundwater 2011) and conducted a custom search through the MOE for the remaining 19 properties. Associated reviewed the relevant records for each property and determined that four of these properties represented some risk of contamination in the capture zone, which were then added to the list of hazards. A table summarizing the records deemed a low risk is provided in Appendix E. The Site Registry search for all sites are provided in Appendix E.

- **Historical Aerial Photographs**: Associated reviewed historical aerial photographs that encompassed the APA areas. Historical aerial photographs were available back to 1948. A detailed review of what is shown in the photographs and how the City of Merritt has changed since then is in Appendix F.

- **Zoning information**: For the purposes of the contaminant source inventory, areas zoned for commercial and industrial land use are expected to pose a higher risk of contamination in the capture zones, while areas zoned for residential, parkland, agricultural, or institutional land use pose a lower risk of contamination of the capture zones. The zoning in APA-C is a mixture of residential, commercial, industrial, agricultural, parkland and institutional land use. The main industrial area is in the southeast portion of the capture zone, along the Coldwater River. This is a large area that has been used for industrial purposes since the 1960s. The main commercial and service commercial areas are in the

northeast and central portion of APA-C. The area in the northeast has been more heavily developed since the 1970s and 1980s. The areas in the east and west of APA C are mainly residential properties. More details are included in the Hazard Inventory Table (Appendix D).

- **Utilities:**
  - **Stormwater**: The stormwater system was assessed in 2013 as part of the City of Merritt's Integrated Stormwater Master Plan (ISMP) (Associated 2013). The ISMP describes how the current stormwater system in the City of Merritt is a combination of storm sewers, manholes, road ditches, drainage ditches, culverts, outfalls, catch-basins, storm leads and curb/gutter systems. In the older part of town, the stormwater system is routed through the shortest path to either the Nicola or Coldwater rivers. The stormwater system also contains a system of shallow and deep dry wells throughout the City where outfalls are not available. These drywells have been excavated to a coarse gravel layer, and essentially act as sumps, whereby water is collected at the surface in storm drains and gutters, and discharged into these dry wells, before directly infiltrating the ground. Associated concluded in the report that the drywells pose a potential concern for contamination of the water supply.
  - **Sanitary sewer**: Associated reviewed a map of the City's sanitary sewer system to determine any potential sources of contamination or contamination pathways in the capture zones. Sanitary lines can pose a risk of contamination if they were to be punctured, or have leaks because contaminants of concern can infiltrate the ground and underlying groundwater. Sanitary sewer lines are located within the 200-day capture zones of all the wells.
  - **Water mains:** Associated reviewed a map of the water main system of the City of Merritt. Watermains of varying diameters are located throughout the different capture zones, and lead to the wells. There is the possibility that the bedding sands in which water mains are constructed would act as a preferential pathway for contaminants to reach the wells. This risk is elevated for water mains that are located close to commercial and industrial properties (e.g.: gas stations, autobody shops, sawmills).
  - **Other**: It is understood that there are private underground utilities in the area (i.e., natural gas and cable). We have made some assumptions based on their location and this information was added to the list of hazards.

- **BC Ministry of Environment Waste Management Database** A search of the MOE's Waste Management Database (MOE 2016b) included the authorization management system database (AMS) and the Environmental Violations Database (EVD). All relevant information was included during Module 7, Characterization of Risk.

- **BC Water Resource Atlas:** A search of the BC Water Resource Atlas was completed to identify all registered water wells within the project area (MOE 2016c). Registered wells are considered a non-point source hazard because material may enter groundwater through these wells if they lack surface seals. The registered wells are shown in Appendix G.

- **Relevant Reports**: Over 30 reports have been prepared for Merritt and surrounding area since 1965. The type of reports range from geological studies, geotechnical investigations, groundwater quality

monitoring programs, aquifer protection planning, groundwater-surface water interaction studies, and annual drinking water reports.

3.2.2 Field Survey

Marta Green, P.Geo., of Associated performed the field survey on December 13, 2016. Ms. Green was accompanied by Alec Macfarlane, Engineering Technologist, and Kevin Vilac, Senior Operator. Relevant information was included during Module 7, Characterization of Risk.

3.2.3 TAC Workshop 1

On December 13, 2016, Associated led TAC Workshop 1 to identify hazards not found during the records review and to obtain more information on the hazards that were identified by Associated during the records review. The workshop was attended by TAC members (Table 1-1). The TAC reviewed the hazards identified during the records review. The TAC then added and removed hazards based on local knowledge. The hazards are separated into point sources and non-point sources.[2] In total, 39 potential point-source hazards and 12 non-point source hazards were identified.

The hazards identified during the records review, field survey, interviews, and TAC Workshop 1 were used to produce the final list of hazards (Appendix D). The locations of the identified point source contaminants are shown in Figure 4-1.

3.2.4 Interviews

The assessment team also completed follow-up interviews with some members of the TAC team, as well as people familiar with the history and the businesses in Merritt, including:

- Staff member, Merritt Archives
- Health and Safety Manager, Aspen Planers
- Manager, Energy and Environment, Tolko Industries

[2] Point sources of contamination arise from a single, identifiable location (e.g., a wastewater treatment plant). Non-point sources arise from multiple diffuse sources over an area (e.g., agricultural land, septic tanks).

4 Module 7: Characterize Risks from Source to Tap

The purpose of Module 7 is to critically assess the adequacy of water protection barriers and assign risk levels to each hazard identified in Module 2. The TAC completed this step during TAC Workshop 2 (risk assessment). First, the risk matrix provided in Module 7 of the Source-to-Tap Guideline was used to assign each hazard as low risk, medium risk, high risk, or very high risk (Section 4.1). Then a SWOT (Strengths, Weakness, Opportunities, and Threats) analysis was completed (Section 4.2).

4.1 TAC WORKSHOP 2 (RISK ASSESSMENT)

According to the Source-to-Tap Guideline, risk is defined as, “the combination of the likelihood that a hazard will occur and cause harm, and the extent and degree of that harm” and can be quantitatively evaluated by multiplying the likelihood of a hazard occurring by the consequence of that hazard (MHLS 2010). To determine potential risks, two ratings were applied to each hazard:

1. The likelihood of occurrence (i.e., the probability the event occurs, and if it occurs, that the contaminant will migrate to the well intake); and
2. The magnitude of consequence if that event was to occur.

Tables 4-1 and 4-2 summarize how each level of risk is assigned using the likelihood of occurrence and magnitude of consequence matrices, respectively.

Table 4-1
Assignment of risk categories – likelihood of occurrence

Level	Description	Probability of Occurrence in Next 10 Years
A	Almost certain – is expected to occur in most circumstances	>90%
B	Likely – will probably occur in most circumstances	71–90%
C	Possible – will probably occur at some time	31–70%
D	Unlikely – could occur at some time	10–30%
E	Rare – may only occur in exceptional circumstances	<10%

Source: Source-to-Tap Guideline (MHLS 2010)

Table 4-2
Assignment of risk categories – magnitude of consequence

Level	Description
1	Insignificant – no illness, little disruption to normal operation, and/or little or no increase in normal operating costs.
2	Minor – small population, mild illness moderately likely, some manageable operation disruption, and/or small increase in operating costs.
3	Moderate – minor impact for large population, mild to moderate illness probable, significant moderation to normal operations but manageable, operating costs increased, and/or increased monitoring.
4	Major – impact for small population, severe illness probable, systems significantly compromised and abnormal operation if at all, and/or high level monitoring required.
5	Catastrophic – major impact for large population, severe illness probable, and/or complete failure of system.

Source: Source-to-Tap Guideline (MHLS 2010)

The likelihood of occurrence and magnitude of consequence are then used to determine the risk to drinking water (Table 4-3).

Table 4-3
Risk (likelihood-consequence) matrix

Likelihood	Consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely)	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

Source: Source-to-Tap Guideline (MHLS 2010)

During Workshop 2, the TAC assigned a likelihood of occurrence and magnitude of consequence score to each hazard identified in Module 2, and then determined risk using the risk matrix (Table 4-3). Tables 4-4

and 4-5 lists each hazard, the TAC agreed upon likelihood of occurrence and magnitude of consequence score, and the risk rating based on that score. The locations of the hazards are shown on Figures 4-1, 4-2, 4-3, and 4-4.

Table 4-4
Hazard risk characterization – point sources

Hazard No.	Hazard[1]	Nearest Well[2]	Likelihood Level[3]	Consequence Level[3]	Risk Level	Action[4]
36	Fairley Park washroom and related sanitary lines	FP	C	4	Very High	3,10
19	Norgaard Ready Mix Ltd.	FP	E	4	High	7,8,9
7	Collettville Sanitary Lift Station and Forcemain	C	C	3	High	3
9	Landscape Company	C	D	4	High	4
12	Site ID[5] 6048 (former Train Refueling Station)	FP	E	4	High	5
15	Lumber Mill 1 (Aspen Planers Ltd.; Site ID 1614)	C	E	4	High	7,8,9
16	Lumber Mill 2 (Tolko Industries Ltd.)	C	E	4	High	7,8,9
18	Lumber Mill 3b (Aspen Planers Ltd.)	C	E	4	High	7,8,9
20	Merritt Auto Wreckers	C	E	4	High	5,6,7
23	Auto Repair Shop (Site ID 1651) (Murray GM)	FP	E	4	High	5,6,7
31	Petro-Canada Service Station (Site ID 11613)	FP	D	4	High	5,6,7
32	Former Service Station (Site ID 5053)	FP	E	4	High	5,6,7
33	Spring Island Trailer Park and private sanitary lines	VP	C	3	High	3
34	Former Fuel Station (Bulk Fuel) (Site ID 982)	FP	E	4	High	5,6,7
35	Former Train Track	FP	E	4	High	5,6,7
37	River Ranch Field	K	D	4	High	11
39	Home Hardware	FP	D	4	High	5,6,7
40	Poultry Operation	VP	D	4	High	11,20
17	Lumber Mill 3a (Aspen Planers Ltd.)	K	D	4	High	7,8,9
24	Auto Repair Shop (Frank Douthwright's Mechanical Service)	FP	E	4	High	5,6,7
1	Collettville well direct contamination	C	E	3	Moderate	1

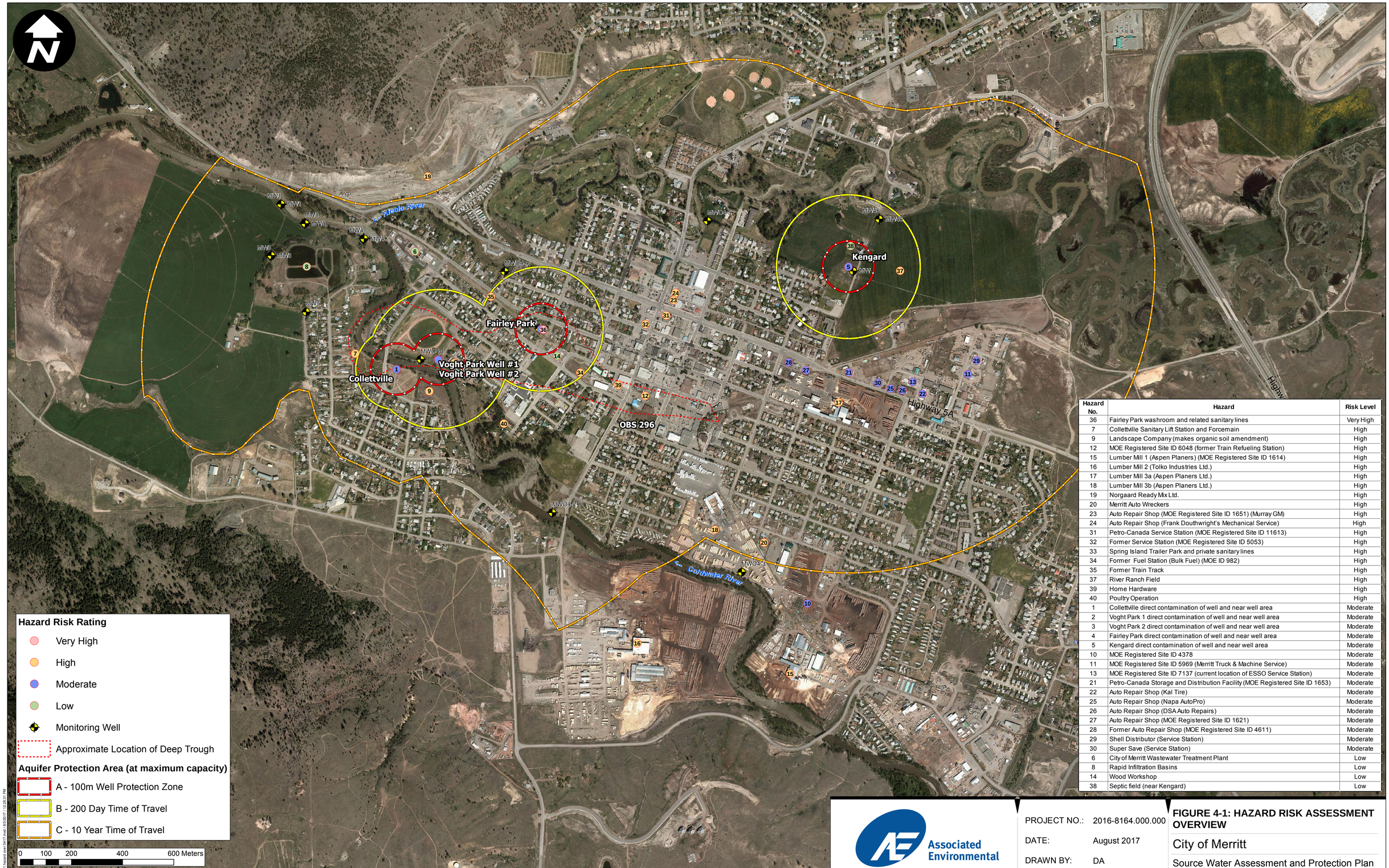
Hazard No.	Hazard[1]	Nearest Well[2]	Likelihood Level[3]	Consequence Level[3]	Risk Level	Action[4]
2	Voght Park 1 well direct contamination	VP	E	3	Moderate	1
3	Voght Park 2 well direct contamination	VP	E	3	Moderate	1
4	Fairley Park well direct contamination	FP	E	3	Moderate	1
5	Kengard well direct contamination	K	E	3	Moderate	1
10	Site ID 4378	K	E	3	Moderate	None
11	Site ID 5969 (Merritt Truck & Machine Service)	K	E	3	Moderate	None
13	Site ID 7137 (current location of ESSO Service Station)	K	E	3	Moderate	5,6,7
21	Petro-Canada Storage and Distribution Facility (Site ID 1653)	K	D	3	Moderate	5,6,7
22	Auto Repair Shop (Kal Tire)	K	E	3	Moderate	5,6,7
25	Auto Repair Shop (Napa Autopro)	K	D	3	Moderate	5,6,7
26	Auto Repair Shop (DSA Auto Repairs)	K	E	3	Moderate	5,6,7
27	Auto Repair Shop (Site ID 1621)	K	D	3	Moderate	5,6,7
28	Former Auto Repair Shop (Site ID 4611)	K	D	3	Moderate	5,6,7
29	Shell Distributor (Service Station)	K	D	3	Moderate	5,6,7
30	Super Save (Service Station)	K	D	3	Moderate	5,6,7
6	Wastewater Treatment Plant	VP	E	2	Low	2
8	Rapid Infiltration Basins	C	E	2	Low	2
14	Wood Workshop	FP	E	1	Low	None
38	Septic field (near Kengard)	K	E	2	Low	None

Notes:
[1] See Appendix D for a more detailed description of each hazard.
[2] FP = Fairly Park well, C = Collettville well, VP = Voght Park wells, K = Kengard well
[3] See Tables 4-1 and 4-2.
[4] See Table 5-2 for action details.
[5] Site ID = MOE Registered Contaminated Site (Section 3.2.1 and Appendix E)

Table 4-5
Hazard risk characterization – non-point sources

Hazard No.	Hazard[1]	Likelihood Level[2]	Consequence Level[2]	Risk Level	Action[3]
A	Sanitary sewer lines	C	4	Very High	3,18
B	Lead in water supply infrastructure	A	3	Very High	21
C	Drainage dry wells (storm system)	D	4	High	13,14,15
D	Storm drainage mains and water mains	D	4	High	6,13,16,17
E	Roads and transportation infrastructure	C	3	High	13,17,18,19
F	Other Industry (from zoning)	C	3	High	13,22
G	Other Commercial (from zoning)	C	3	High	22
H	Natural gas lines and other private utilities (e.g. fibre-optic, natural gas, oil)	E	3	Moderate	23
I	Residential properties	E	3	Moderate	22
J	Other wells in capture zone (domestic, irrigation, monitoring)	E	2	Low	20
K	Animals and pests	E	1	Low	24
L	Residential heating oil underground or aboveground storage tanks	E	2	Low	5,25

Notes:
[1] See Appendix D for a more detailed description of each hazard.
[2] See Tables 4-1 and 4-2.
[3] See Table 5-2 for action details.



Hazard No.	Hazard	Risk Level
36	Fairley Park washroom and related sanitary lines	Very High
7	Collettville Sanitary Lift Station and Forcemain	High
9	Landscape Company (makes organic soil amendment)	High
12	MOE Registered Site ID 6048 (former Train Refueling Station)	High
15	Lumber Mill 1 (Aspen Planers) (MOE Registered Site ID 1614)	High
16	Lumber Mill 2 (Tolko Industries Ltd.)	High
17	Lumber Mill 3a (Aspen Planers Ltd.)	High
18	Lumber Mill 3b (Aspen Planers Ltd.)	High
19	Norgaard Ready Mix Ltd.	High
20	Merritt Auto Wreckers	High
23	Auto Repair Shop (MOE Registered Site ID 1651) (Murray GM)	High
24	Auto Repair Shop (Frank Douthwright's Mechanical Service)	High
31	Petro-Canada Service Station (MOE Registered Site ID 11613)	High
32	Former Service Station (MOE Registered Site ID 5053)	High
33	Spring Island Trailer Park and private sanitary lines	High
34	Former Fuel Station (Bulk Fuel) (MOE ID 982)	High
35	Former Train Track	High
37	River Ranch Field	High
39	Home Hardware	High
40	Poultry Operation	High
1	Collettville direct contamination of well and near well area	Moderate
2	Voght Park 1 direct contamination of well and near well area	Moderate
3	Voght Park 2 direct contamination of well and near well area	Moderate
4	Fairley Park direct contamination of well and near well area	Moderate
5	Kengard direct contamination of well and near well area	Moderate
10	MOE Registered Site ID 4378	Moderate
11	MOE Registered Site ID 5969 (Merritt Truck & Machine Service)	Moderate
13	MOE Registered Site ID 7137 (current location of ESSO Service Station)	Moderate
21	Petro-Canada Storage and Distribution Facility (MOE Registered Site ID 1653)	Moderate
22	Auto Repair Shop (Kal Tire)	Moderate
25	Auto Repair Shop (Napa AutoPro)	Moderate
26	Auto Repair Shop (DSA Auto Repairs)	Moderate
27	Auto Repair Shop (MOE Registered Site ID 1621)	Moderate
28	Former Auto Repair Shop (MOE Registered Site ID 4611)	Moderate
29	Shell Distributor (Service Station)	Moderate
30	Super Save (Service Station)	Moderate
6	City of Merritt Wastewater Treatment Plant	Low
8	Rapid Infiltration Basins	Low
14	Wood Workshop	Low
38	Septic field (near Kengard)	Low

Associated Environmental

PROJECT NO.: 2016-8164.000.000

DATE: August 2017

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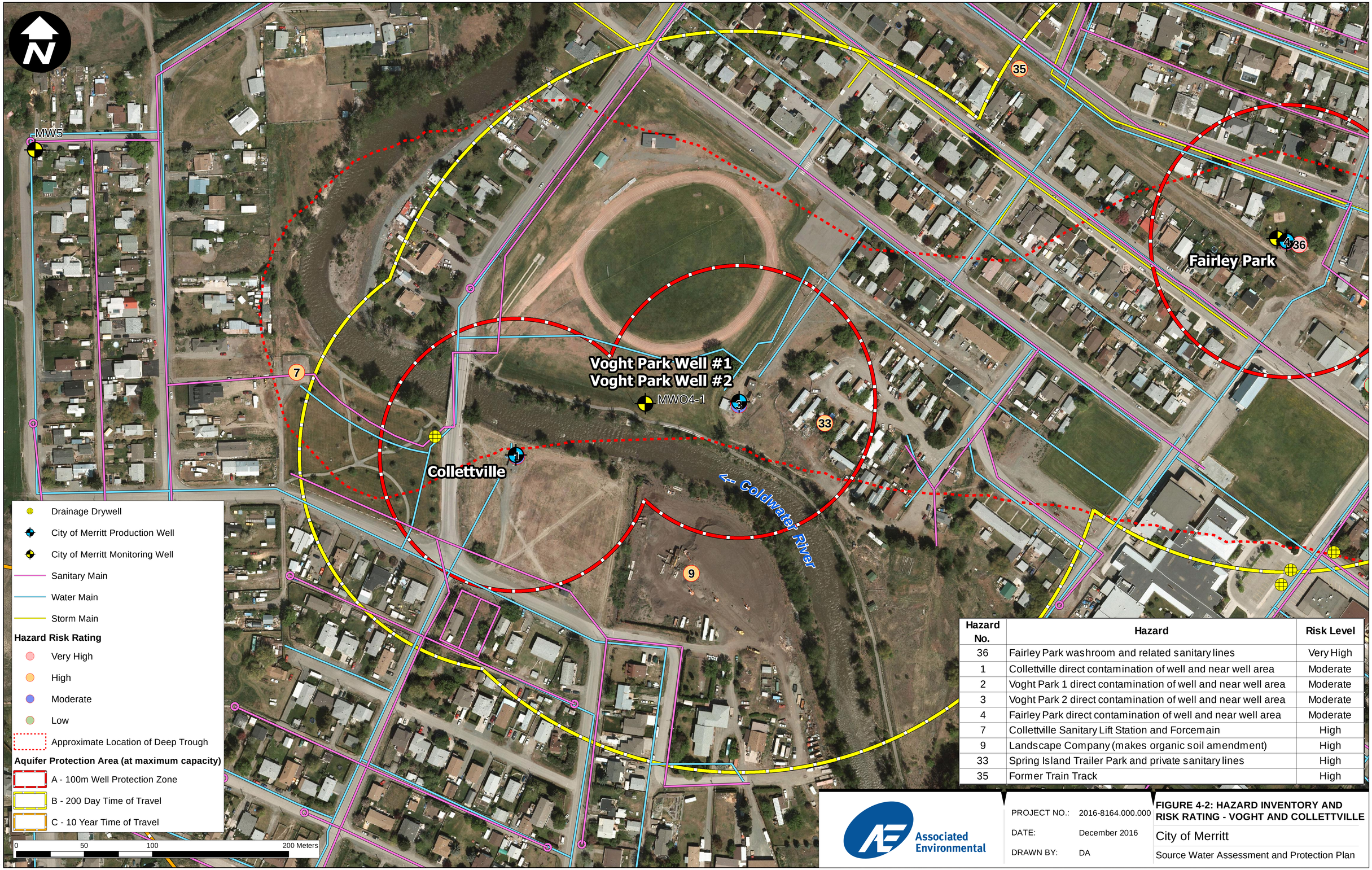
FIGURE 4-1: HAZARD RISK ASSESSMENT OVERVIEW

City of Merritt

Source Water Assessment and Protection Plan

fig 4-1 hazard over 0417.mxd / 8/3/2017 / 2:28:31 PM



Hazard No.	Hazard	Risk Level
36	Fairley Park washroom and related sanitary lines	Very High
1	Collettville direct contamination of well and near well area	Moderate
2	Voght Park 1 direct contamination of well and near well area	Moderate
3	Voght Park 2 direct contamination of well and near well area	Moderate
4	Fairley Park direct contamination of well and near well area	Moderate
7	Collettville Sanitary Lift Station and Forcemain	High
9	Landscape Company (makes organic soil amendment)	High
33	Spring Island Trailer Park and private sanitary lines	High
35	Former Train Track	High

Associated Environmental

PROJECT NO.: 2016-8164.000.000

DATE: December 2016

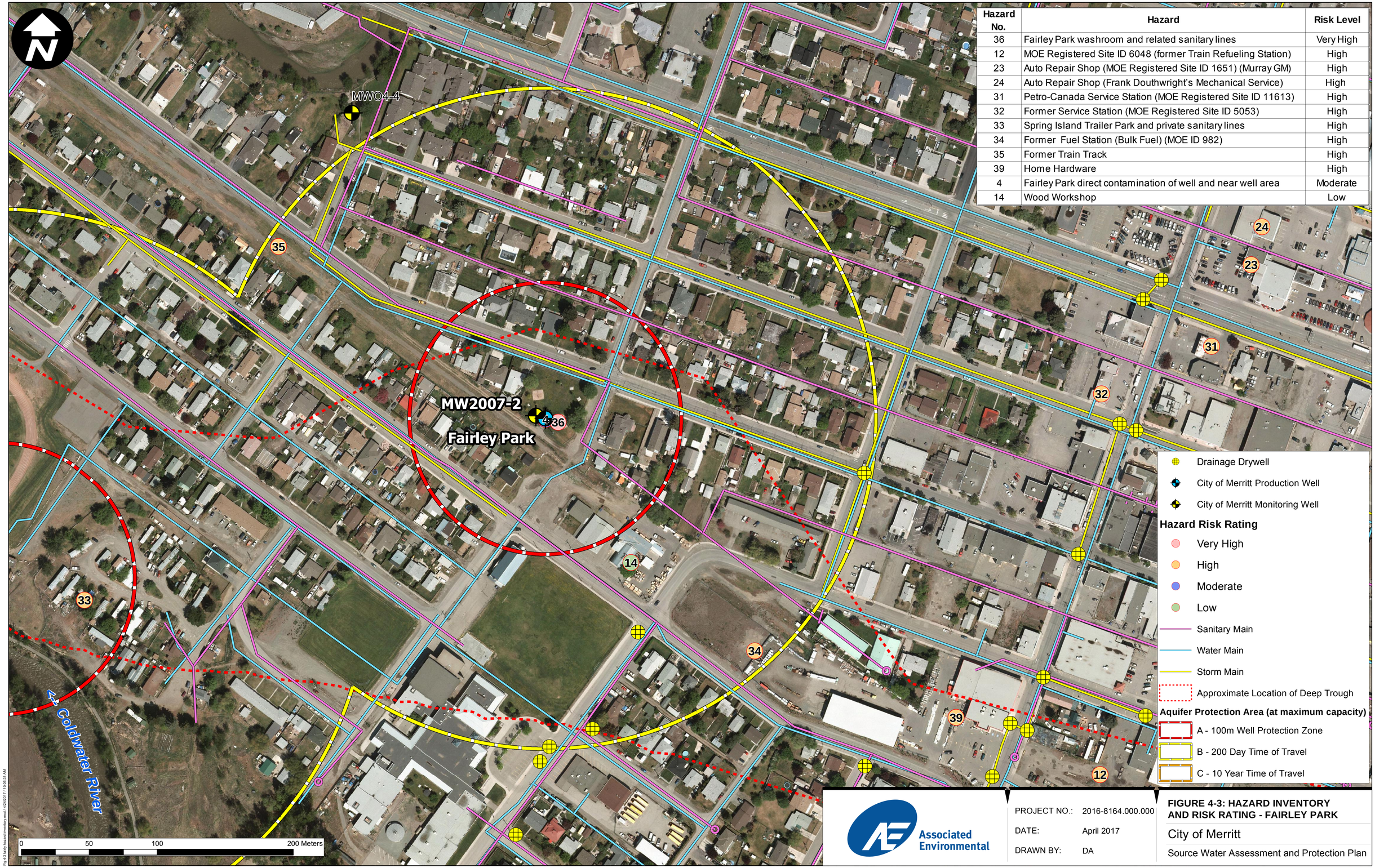
DRAWN BY: DA

FIGURE 4-2: HAZARD INVENTORY AND RISK RATING - VOGHT AND COLLETTVILLE

City of Merritt

Source Water Assessment and Protection Plan

Fig 4-2 voght collette hazard inventory.mxd / 5/12/2017 / 1:13:25 PM



Hazard No.	Hazard	Risk Level
36	Fairley Park washroom and related sanitary lines	Very High
12	MOE Registered Site ID 6048 (former Train Refueling Station)	High
23	Auto Repair Shop (MOE Registered Site ID 1651) (Murray GM)	High
24	Auto Repair Shop (Frank Douthwright's Mechanical Service)	High
31	Petro-Canada Service Station (MOE Registered Site ID 11613)	High
32	Former Service Station (MOE Registered Site ID 5053)	High
33	Spring Island Trailer Park and private sanitary lines	High
34	Former Fuel Station (Bulk Fuel) (MOE ID 982)	High
35	Former Train Track	High
39	Home Hardware	High
4	Fairley Park direct contamination of well and near well area	Moderate
14	Wood Workshop	Low

Associated Environmental

PROJECT NO.: 2016-8164.000.000

DATE: April 2017

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FIGURE 4-3: HAZARD INVENTORY AND RISK RATING - FAIRLEY PARK

City of Merritt

Source Water Assessment and Protection Plan

Fig 4-3 fairley hazard inventory.mxd / 4/24/2017 / 10:05:31 AM

Hazard No.	Hazard	Risk Level
37	River Ranch Field	High
5	Kengard direct contamination of well and near well area	Moderate
38	Septic field (near Kengard)	Low

Associated Environmental

PROJECT NO.: 2016-8164.000.000

DATE: April 2017

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FIGURE 4-4: HAZARD INVENTORY AND RISK RATING - KENGARD PARK

City of Merritt

Source Water Assessment and Protection Plan

4.2 SWOT (STRENGTH, WEAKNESSES, OPPORTUNITIES, THREATS) ANALYSIS

One of the major objectives of the Source-to-Tap Guideline is to incorporate information generated on the water supply system into a comprehensive assessment that identifies the strengths and weaknesses of the overall water system as an integrated whole. The TAC achieved this objective by conducting a SWOT analysis on December 14, 2016. The minutes from that meeting are included in Appendix A.

5 Module 8: Recommended Actions to Improve Drinking Water Protection

The outcome of Module 8 is a set of recommendations for each medium and high risk hazard identified in Module 7. The recommended risk management actions follow the SMART (Specific, Measurable, Achievable, Realistic, Time-bound) principles outlined in Module 8 of the Source-to-Tap Guideline and are based on the **multiple barrier** framework[3] for source protection defined by the Canadian Council of Ministers of the Environment (CCME 2004), which considers practical and cost-effective methods to improve existing barriers or implement new ones, where warranted.

The barriers introduced through source protection augment the natural barriers (or filters) that are already in place in watersheds or aquifers. For aquifers, these include the presence of confining layers and the properties of soils or bedrock that can attenuate contaminant concentrations in groundwater.

The Source-to-Tap Guideline recommends that the TAC, water supplier, and Drinking Water Officer develop risk management actions that are specific, measurable, achievable, realistic, and time-bound, following the principle outlined in Module 8 (MHLS 2010). The suggested timeframes for risk management actions are presented in Table 5-1; however, the Source-To-Tap Guideline suggests that risk level is not the only factor to consider when prioritizing actions; ease of implementation can also be a factor. For example, one could choose to implement a medium risk mitigation action immediately if it is straightforward and inexpensive to do so.

The recommendations to protect drinking water are included in Table 5-2 and are designed to reduce the potential for future source water contamination. It is important to consider all of these recommendations to improve the safety of the water supply systems. To help with this, Associated categorized our recommendations as: engineering/capital works, planning, or operational.

[3] The multi-barrier approach is an integrated system of procedures, processes, and tools that collectively prevent or reduce the contamination of drinking water from source to tap to reduce risks to public health.

Table 5-1
Suggested time categories for risk management actions

Category	Timeframe	Type of Risk Management Action
Immediate	Within 3 months	Actions addressing regulatory violations, imminent public health threats, or water shortages.
Short Term	Within 1 year	Actions that are easy to implement or those addressing significant public health concerns or water quantity issues, enhancement or weak barriers.
Medium Term	1 to 3 years	Actions addressing moderate water quality or quantity concerns, broad systemic issues.
Long Term	3 years +	Actions addressing hazards representing chronic health implications or long-term threats to water availability, broad systemic issues.

Source: BC Ministry of Healthy Living and Sport 2010

Table 5-2
Recommended actions to protect drinking water

Action No.[1]	Action	Action Type and rough cost estimate if applicable	Action Timeframe
1	At each pumphouse, continue to inspect regularly for vandalism, preferred pathways, direct openings to the well, and presence of chemical hazards. Seal any preferred pathway or direct opening, and avoid storage of chemicals inside pumphouses. Specific action items related to pumphouses include: • Inspect the gas motor at Voght Park 1 regularly and clean up any drips promptly. Ensure a spill kit is present and operators know how to use it. Consider replacing the gas motor with a non-hydrocarbon energy source. • Preferred pathways are areas underground that have a higher (faster) hydraulic conductivity (more coarse) material than surrounding area (like bedding sands for pipes). If constructing near a wellhead, backfill with material of lower permeability than surrounding area (or use a combination of bentonite and sand backfill, at a ratio of 1:10). • Direct openings include entrances directly to the well column, such as the sounding tube for the datalogger at the top of each wellhead, and air vents. Fill the entrance of the sounding tube with silicone caulking, and replace this each time the datalogger is retrieved. • Review the design of the roof drainage and consider extending the end of the drain spouts to a location farther away from the wellhead, ideally away from the network of underground piping. • Vermin-proof the pumphouses by filling any gaps between doors and the floor, and ensure that all windows or other openings (fan ducts in ceiling for example) have a small mesh screen that is vermin-proof. • Do not store chemicals in the pumphouse. • Continue good housekeeping in pumphouses (regular inspections and cleaning) and treating for pathogens. • Keep the areas around the pumphouses clear and tidy. Do not store vehicles or equipment in the area.	Operational	Ongoing
2	Review WWTP monitoring results annually. Continue collecting water levels monthly, and plot elevation of water table.	Operational	Medium term (1-3 years)
3	Continue to inspect sanitary sewers on rotation, with a priority for those located within APA A, then APA B, and lastly APA C. Consider other leak detection options for a pressurized sanitary line, or additional monitoring to track any changes in water quality (temperature, turbidity, conductivity, pH). Continue to complete regular chlorine residual testing on raw water (pre-chlorine treatment) from all wells, regular total coliforms and *E. coli* testing, and document the results. A long track record of total coliform and chlorine residual results helps to further assess risks from surface and other microbial hazards. If any inconsistent results occur, assess the source of the inconsistency.	Operational	Ongoing / Short term (within 1 year)
4	Ask owner (see Hazard #9 re: Landscape Company near Collettville) if they are producing compost. If so ask for composting plan (leachate management, etc.), which is a requirement under the Organic Matter Recycling Regulations. If only selling compost, then no action needed.	Planning	Short term (within 1 year)
5	Sample for hydrocarbons (LEPH, HEPH, VOC, PAHs) and metals once a year. Continue to use WaterTrax or a similar data management software for all monitoring data. This provides automatic laboratory uploading, comparing to Guidelines, and alerting to email or cell phone if Guidelines are exceeded. It is also a good way of keeping track of data long-term, which helps with continuously reviewing risk to water supply and assessing success of source protection initiatives.	Operational	Short term (within 1 year)
6	Provide the Source Protection Plan to business operators, and communicate with operators once a year as a proactive aquifer protection measure. Ask about reported spills, and environmental protection plans. Prioritize by proximity to well and start with the larger and more industrial-type businesses.	Operational	Short term (within 1 year)
7	Communicate to the public and local community members, and business owners, the importance of best management practices and how it links to aquifer protection and the quality of the City's drinking water. To meet this goal, consider using local media, website, public meetings, chamber of commerce, and BCWWA's water week. Okanagan Basin Water Board has many good tools to promote awareness around water, available at: http://www.obwb.ca/library/groundwater-bylaws-toolkit/.	Planning	Medium term (1-3 years)
8	Provide the Source Protection Plan to saw mill operators, and communicate with operators once a year as a pro-active aquifer protection measure. Ask about reported spills, environmental protection, location of monitoring wells and frequency and analyte list of any surface or groundwater sampling.	Operational	Short term (within 1 year)
9	Sample for hydrocarbons (LEPH, HEPH, VOC, PAHs), nitrate-N, ammonia, total N, and metals once a year (as per Action #5) and chlorophenols and non-chlorinated phenols once every five years from all wells.	Operational	Short term (within 1 year)
10	Review design and construction drawings of the sanitary line to the Fairley Park washroom, and consider re-locating the washroom if any indications of leaks are noted.	Engineering/capital works	Immediate (within 3 months)
11	Meet with agricultural operators within the APA, share the Source Protection Plan report, and encourage best management practices, which includes nutrient management planning. Excellent reference material on nutrient management planning is available on BC Ministry of Agriculture's website: http://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/agricultural-land-and-environment/soil-nutrients/nutrient-management for agricultural operations within the APA C. Consider developing a Development Permit Area (DPA) for groundwater protection. A DPA are areas designated in an OCP to which special guidelines apply. A DPA may be designated for protection of the natural environment or to promote water efficiency that can address watershed health. One of which may be groundwater protection. The guidelines within the DPA may specify areas that remain free of certain types of development, or require additional studies such as environmental impact assessments or nutrient management plans to the satisfaction of the local government. Nutrients applied to agricultural fields can be a significant source of nitrate-N contamination in groundwater supplies if nutrients are over-applied. Nutrient management plans, especially those that include post-harvest soil sampling, so that any excess in nutrient application is considered in the following year's prescription, help reduce the likelihood that over-application of nutrients will occur. More information on DPAs for groundwater protection can be found at OBWB's groundwater bylaws toolkit: http://www.obwb.ca/library/groundwater-bylaws-toolkit/.	Planning	Medium term (1-3 years)
12	Seek out opportunities to promote to the community awareness of the groundwater as a drinking water resource and the importance of source protection. Awareness promotion can be done through articles in the local newspaper, participating in local events and festivals, billboards, website and social media campaigns. Immediate actions could include: posting signage identifying aquifer protection areas in entrances to the City Centre and other key locations, and near wells, provide information including maps of the APAs on the City's web site, and posting the APA maps at City Hall and other community gathering locations.	Operational	Short term (within 1 year)

Table 5-2
Recommended actions to protect drinking water

Action No.[1]	Action	Action Type and rough cost estimate if applicable	Action Timeframe
13	Share the Source Protection Plan with first responders and the Ministry of Transportation and Infrastructure.	Operational	Short term (within 1 year)
14	Review drainage well drawings and assess if any improvements could be made to the design. Best management practices for drainage well design include: pre-treatment such as installation of a filter strip or swale, catch basin inserts (for example, where the top tray is an oil/grit separator, and the lower trays may be activated charcoal, or reconstituted wood fiber which traps oil and grease), and spill control separators. In future, avoid installation of dry wells within the aquifer protection areas. If dry wells are unavoidable, consider best management practices listed above. In particular, Voght Park #2 well appears to be most vulnerable, because the screen starts at 10 m below ground (next shallowest well's screen starts at 19m). Continue to inspect and pump out dry wells within aquifer protection areas regularly. EPA recommends once a month, but given that Merritt is within a dry climate, start quarterly and re-assess frequency after one year. More information is available at: https://www.epa.gov/sites/production/files/2015-08/documents/2007_12_12_uic_class5_study_uic-class5_classvstudy_volume03-stormwaterdrainage.pdf.	Engineering/capital works	Medium term (1-3 years)
15	Continue to use an alternative to salt for winter road maintenance. Regularly (start with monthly) monitor sodium levels, and if an increase in sodium is apparent in any of the wells, complete a detailed assessment into the source.	Operational	Medium term (1-3 years)
16	Complete a detailed review of the water mains to Fairly Park well, and any preferred pathways leading from industrial zoning areas or identified hazards. Include a detailed review of the monitoring well network around Fairley Park. In the event of a large release (particularly in the commercial area east of Fairley Park and industrial area south of Kengard), the location of preferred pathways such as linear utilities will be important. Practice a mock spill release event and follow linear corridors to further assess where spills will migrate to.	Operational	Short term (within 1 year)
17	Review emergency response plans to assess whether sufficient capacity is possible in the event of a loss of temporary supply at each well.	Operational	Ongoing / Medium term (1-3 years)
18	The sewer system is divided into 4 sections. Each year one section is flushed and camera-surveyed, so each line will be flushed and camera-surveyed once every 4 years. Consider prioritizing, and possibly increasing the frequency to annually or once every two years, of the inspection program for the sewer lines that are located within the 200-day capture zones (APA-B).	Operational	Ongoing / Medium term (1-3 years)
19	Post a plaque with the name and address of the well to the outside of each of the 5 wells.	Operational	Short term (within 1 year)
20	Actively engage with each known well owner within the APAs to inform them of the well closure bylaw, work with BC Ministry of Forests, Lands, and Natural Resource Officers to ensure all wells in APAs meet the Groundwater Protection Regulation with respect to well construction and well closure.	Operational, Planning	Medium term (1-3 years)
21	Implement a lead pipe corrosion control program as outlined in Health Canada (2009). The program starts with monitoring lead at consumers taps.	Engineering/capital works	Short term (within 1 year)
22	Consider locations of wells when considering any zoning or OCP changes in the future. Review acceptable practices for each zoning within each APA. For example, best management practices would include no development activity allowed within the well protection zone (APA A), which is a radius of 100 m of each well. This could be completed through a Development Permit Area. See Groundwater Bylaws Toolkit at http://www.obwb.ca/fileadmin/docs/groundwater_bylaws_toolkit.pdf for more ideas on how to complete this as part of planning.	Planning	Medium term (1-3 years)
23	Avoid placing utility lines with the APAs when evaluating the alignment of future underground utility corridors. Provide a copy of the Source Assessment and Protection Plan to each utility company in the area.	Planning	Short term (within 1 year)
24	Continue to encourage use of dog park. Make sure that receptacles are in place for dog waste and regularly check that parks are free of dog waste. Consider locations of wells when considering new dog park locations.	Planning	Medium term (1-3 years)
25	Improve groundwater protection from leaking fuel storage tanks within the APAs through various planning tools. For example: a) In new developments, do not allow USTs, and require a permit to allow covered and contained ASTs in capture zones. This could be facilitated through a Development Permit Area. b) When significant renovations occur on existing homes in capture zones, require removal of UST or AST. See Groundwater Bylaws Toolkit at http://www.obwb.ca/fileadmin/docs/groundwater_bylaws_toolkit.pdf for more ideas on how to complete this as part of planning.	Planning	Medium term (1-3 years)

Notes: APA = Aquifer Protection Area, LEPH = Light extractable petroleum hydrocarbons, HEPH = Heavy extractable petroleum hydrocarbons, PAHs = polycyclic aromatic hydrocarbons, VOCs = volatile organic compounds, DOC = dissolved organic carbon
[1] Tables 4-4 and 4-5 list the action items by hazard.

6 Summary, Conclusions, and Recommendations

6.1 SUMMARY AND CONCLUSIONS

This Source Water Assessment and Protection Plan was completed for the City of Merritt's five water supply wells: Collettville, Voght Park 1, Voght Park 2, Fairley Park, and Kengard. The assessment followed Modules #1, 2, #7, and #8 of the Source-To-Tap Guideline published by the BC government.

The identified potential sources of groundwater contamination (hazards) were based on our review of available information, our discussions with City personnel, and our Senior Hydrogeologist's site visit to each well area. A technical advisory committee assigned a likelihood rating for each contaminant to reach the well and a consequence rating if the contaminant made it to the well. A risk rating for each hazard was based on the combination of likelihood and consequence.

Of the 40 potential point-source hazards and 12 non-point source hazards, three were rated as "very high risk" and 24 as "high risk". The very high risks are as follows:

- The Fairley Park washroom and related sanitary lines, which are located very close to the Fairley Park well and represent a potential point source.
- Sanitary sewer lines throughout the APAs, which can leak and present a non-point source hazard for all the wells. Sanitary sewer lines are present within APA-A (the 100 m well protection zone) for the Collettville and Fairley Park wells, and within APA-B (200-day capture zone) for Voght Park and Kengard wells.
- Lead in water supply infrastructure. The primary source of lead in drinking water is usually leaching from older pluming service lines that contain lead. Given that the national plumbing codes allowed lead in pipes until 1975 and in solder until 1986 (Health Canada 2016a), the likelihood of lead being present in some infrastructure is high. The amount of lead leached depends on several factors including the corrosiveness of the source water. The fact that lead was once detected above drinking water guidelines in the tap water at City Hall (Section 2.1.3) suggests the conditions for leaching are present in at least some cases.

6.2 RECOMMENDATIONS

Based on the results of the risk assessment, Associated recommends the following:

1. The City should complete the action items listed in Table 5-2. To manage public health risk and to adequately maintain the City's valuable infrastructure, the recommended action items should be completed within the timeframe listed in Table 5-2. Some action items do not involve capital funds, such as sharing the maps of the aquifer protection areas with First Responders. Others will require some level of planning and incorporation into annual capital budgets beginning in 2018. In summary, implementation of these recommendations will:
    a. improve emergency preparedness through better communication and training of First Responders;

b. reduce the chance that various contaminants enter the aquifer by educating the key business owners, institution managers (e.g. schools), and City staff about the aquifer protection areas, potential sources of contamination, and an understanding of how contaminants move through aquifers;

c. provide the City with examples of planning tools that can be used to help minimise future land use conflicts;

d. address the management and upgrades of infrastructure in ways that reduce the risk of source water contamination; and

e. improve security and detection systems that improve protection and monitoring of the source water.

2. As part of the multiple barrier approach, continue best management practices, including ongoing operator training, reviewing chlorine residual and coliform results in a timely fashion, and limiting land use activities in the areas within about 100 m of the wells. Implementation and promotion of the multi-barrier approach, and continued improvement of the barriers, is critical for minimizing risks to the community drinking water supply.

Closure

This Source Water Assessment and Protection Plan was prepared for the City of Merritt to improve the safety of the water supply systems.

The services provided by Associated Environmental Consultants Inc. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,
Associated Environmental Consultants Inc.

PROFESSIONAL GEOSCIENTIST OF M. C. GREEN #30867 AUG 22 2017 BRITISH COLUMBIA

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Reviewed by

for

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References

Associated Engineering (Associated). 2013. City of Merritt Integrated Stormwater Master Plan. May 2013.

BC Groundwater Consulting Services Ltd. (BC Groundwater). 2011. Deep Aquifer Development Program – Kengard Production Well. Summary Report 2004-2010. Prepared for the City of Merritt. April 11, 2011.

BC Ministry of Environment (MOE). 1988. Construction and Testing of Observation Well No. 296. Merritt, BC. Contract No. 84.

BC Ministry of Environment (MOE). 2000. Well Protection Toolkit. Water Protection and Sustainability Branch. Available at: http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/well_protection/wellprotect.html

BC Ministry of Environment (MOE). 2009. Review of Ground Water/Surface Water Interactions Within the City of Merritt. Prepared by Bennett, K. and Caverly, A. June 2009.

BC Ministry of Environment (MOE). 2016a. British Columbia Site Registry. Available at: https://www.bconline.gov.bc.ca/site_reg.html.

BC Ministry of Environment (MOE). 2016b. Authorization Database Search. Available at: http://www2.gov.bc.ca/gov/content/environment/waste-management/waste-discharge-authorization/managing-authorizations/authorization-database-search

BC Ministry of Environment (MOE). 2016c. British Columbia Water Resources Atlas. Available at: http://www.env.gov.bc.ca/wsd/data_searches/wrbc/.

BC Ministry of Environment (MOE). 2017. British Columbia iMap BC. Available at: http://maps.gov.bc.ca/ess/sv/imapbc/

BC Ministry of Health (MOH). 2015. Guidance Document for Determining Ground Water at Risk of Containing Pathogens (GARP). Version 2. November 2015. Health Protection Branch, Ministry of Health. Available at: http://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/documents/garp_assessment_v2_dec1_2015_final.pdf

BC Ministry of Healthy Living and Sport (MHLS). 2010. Comprehensive Source-To-Tap Assessment Guideline. Available at: http://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/drinking-water-quality/resources-for-water-system-operators#source-to-tap-assessment

Bradbury, K.R., M.A. Borchardt, M. Gotkowitz, S.K. Spencer, J. Zhu, and R.J. Hunt. 2013. Source and Transport of Human Enteric Viruses in Deep Municipal Water Supply Wells. Environmental Science and Technology 47: 4096-4103

Canadian Council of Ministers of the Environment (CCME). 2004. From Source to Tap: Guidance on the Multi-Barrier Approach to Safe Drinking Water. Available at: http://www.ccme.ca/files/Resources/water/source_tap/mba_guidance_doc_e.pdf

Ceric, A., and H. Haitjema. 2005. On Using Simple Time-of-Travel Capture Zone Delineation Methods. Groundwater. Vol. 43, No. 3, pp. 408-412.

Contaminated Sites Regulation. BC Reg. 375/96.

EBA Engineering Consultants Ltd (EBA). 2002. Aquifer Protection Plan, City of Merritt, Merritt, BC. EBA File No. 0805-5875017.

Environment Canada. 2017. 1981 to 2010 Canadian Climate Normals Merritt STP. Available at: http://climate.weather.gc.ca/climate_normals/index_e.html

Environmental Protection Agency (EPA). 2016. Natural Attenuation Strategy for Groundwater Cleanup Focuses on Demonstrating Cause and Effect. Available at: https://toxics.usgs.gov/pubs/eos-v82-n5-2001-natural/

Fulton, R.J. 1974. Surficial Geology Merritt. Scale 1: 126,720. Geological Survey of Canada, Map 1393A.

Health Canada. 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document Trihalomethanes. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. Available at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-trihalomethanes.html

Health Canada. 2009. Guidance on Controlling Corrosion in Drinking Water Distribution Systems. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. Available at: https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidance-controlling-corrosion-drinking-water-distribution-systems.html

Health Canada. 2016a. Water Talk – Reducing your Exposure to Lead from Drinking Water. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/lead-plomb-eng.php

Health Canada. 2016b. Lead in Drinking Water. Document for Public Consultation. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water. Available at:

http://www.healthycanadians.gc.ca/health-system-systeme-sante/consultations/lead-drinking-water-plomb-eau-potable/document-eng.php

Health Canada. 2017. Guidelines for Canadian Drinking Water Quality Summary Table. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index-eng.php.

Kala Groundwater Consultants Ltd. (KALA). 2004. Groundwater Potential Evaluation and Test Well Siting Study – City of Merritt, British Columbia, October 2004. Prepared for the City of Merritt.

Opus Dayton Knight. 2012. Merritt Water Utility Master Plan. December 2012.

Piteau Associates (Piteau). 2012. Rehabilitation of Collettville Well by Okanagan Water Wells, September 2012. Prepared for Mr. Darrell Finnigan, Superintendent of Public Works, City of Merritt.

Uejio, C. K, S. Yale, K. Malecki, M. A. Borchardt, H. A. Anderson, and J. A. Patz. 2014. Drinking Water Systems, Hydrology and Childhood Gastrointestinal Illness in Central and Northern Wisconsin.

Vilac, K. 2017. Personal Communication (telephone conversation and email). Chief Operator of the Water and Wastewater Systems. City of Merritt. January 16, 2017.

Western Water Associates Ltd. 2015. Fairley Park Well – Review of Downhole Video and Pumping Data. Technical Memorandum to Kevin Vilac (City of Merritt). August 2015.

Appendix A – Record of Meeting

Date:	Dec 13-14, 2016	**File:**	2016-8164.000
Time:	1pm	**Page:**	1 of 2
Project:	Well Source Assessment and Protection Plan		
Subject:	Site visit, TAC Workshop 1, and TAC Workshop 2		
Client:	Merritt		
Location:	City of Merritt office		
Present:	Marta Green (Associated Environmental) Sasha Bird, Director, Engineering and Development Alec Macfarlane, Engineering Technologist Kevin Vilac, Senior Operator with history of system Shawn Boven, Manager/Administrator with history of system (Day 1 only) Jessy Bhatti, Large Water Specialist, Interior Health Authority (sent his regrets) Darrell Finnigan, Public Works Superintendent Mark Broderick, Planning and Development Services Manager (part of Day 2)		
Distribution:	Those Present		

RECORD OF MEETING

Day 1: Tuesday, Dec 13, 2016: Site Visit and Technical Advisory Committee (TAC) Workshop 1 - Identify potential contaminant sources, and SWOT Analysis. Alec, Kevin, and Marta completed a visit of the pump-houses and other areas of potential hazards. Darrell Finnigan joined during part of the tour. In the afternoon, we went over project goals, Source to Tap Modules, a background on groundwater flow concepts and the water cycle, completed a SWOT (see last page), and then completed a review of Hazards.

Day 2: Wed, Dec 14, 2016: TAC Workshop 2 (Hazard screening assessment and risk characterization). In this workshop, we reviewed Day 1 and then ranked likelihood of occurrence and magnitude of consequence on some of the Hazards on a table provided by Marta (see next page for ranking values used). The hazards and risk ranking table will comprise part of the draft report, which is the next step.

Subject: Agenda Dec 13-14, 2016
- 2 -

Rank likelihood of occurrence

Level	Description	Probability of Occurrence in Next 10 Years
A	Almost certain - is expected to occur in most circumstances	>90%
B	Likely - will probably occur in most circumstances	71-90%
C	Possible - will probably occur at some time	31-70%
D	Unlikely – could occur at some time	10-30%
E	Rare - may only occur in exceptional circumstances	<10%

Rank magnitude of consequence

Level	Description
1	Insignificant - no illness, little disruption to normal operation, little or no increase in normal operating costs.
2	Minor - small population, mild illness moderately likely, some manageable operation disruption, small increase in operating costs.
3	Moderate - minor impact for large population, mild to moderate illness probable, significant moderation to normal operations but manageable, operating costs increased, increased monitoring.
4	Major - impact to small population, severe illness probably, systems significantly compromised and abnormal operation if at all, high level monitoring required.
5	Catastrophic - Major impact for large population, severe illness probable, complete failure of system.

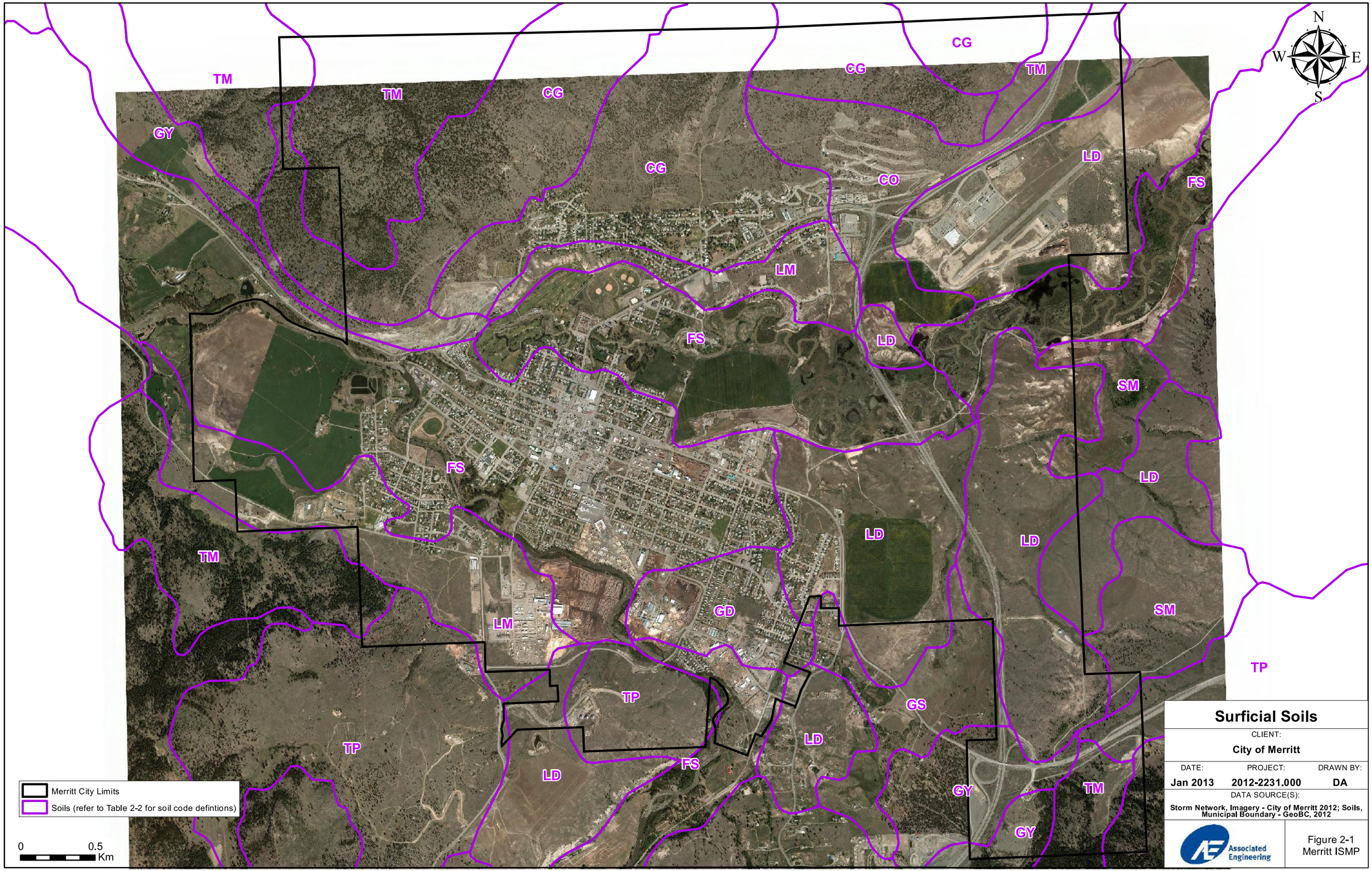
Agree on risk assignments (very high, high, moderate, low).

Likelihood	Consequence				
	1 Insignificant	2 Minor	3 Moderate	4 Major	5 Catastrophic
A (almost certain)	Moderate	High	Very High	Very High	Very High
B (likely)	Moderate	High	High	Very High	Very High
C (possible)	Low	Moderate	High	Very High	Very High
D (unlikely)	Low	Low	Moderate	High	Very High
E (rare)	Low	Low	Moderate	High	High

Strengths, Weakness, Opportunities, Threats

Strengths	Weaknesses	Opportunities	Threats
• Trained and experienced Operators: two level 2 and one Level 1. Two with over ten years of experience. Public Works Superintendent also Level 2 trained and with 15 years of experience at the City • Use WaterTrax and SCADA data to manage water quality and quantity. Watertrax sends automatic alerts if water quality doesn't meet Guidelines. • Do comprehensive water quality once a year on all wells • Great water quality: Coldwater River is a gem • Robust water system: four wells in different areas (but all are still on one or two sources, the Coldwater and Nicola Aquifers) • The land around the majority of the wells are Parkland. • The land around all of the wells is within City Merritt boundaries and so all the land is owned/managed by the City • Winter maintenance program uses a low salt option, which helps keep sodium levels below Guidelines. Program includes a combination of a beet juice/sugar and 1% salt liquid and a sand grit) • There is a well closure bylaw in place since 2008. • There are many monitoring wells and these are monitored monthly	• No corrosion testing • 3 wells close together • Unconfined, shallow aquifer (no confining "cap") to provide protection from surface contaminants • Heavily developed and old town on top of aquifer and around all wells • Fairley Park well has a new washroom very close (check Health Hazards Regulation)	• Nicole Watershed Community Round Table (local group of partners all focused on water) • Local newspaper • Local radio • Wells within City Boundaries (more control over land use) • Conservation Program in progress (working towards universal water metering) • Right now the water system is a low cost to the customer compared to other regions	• Spills • Changes in legislation • Farming • Freeway • Uncommissioned wells • Vandalism • Lack of knowledge on water/value of water • Some low income residents

Appendix B - Surficial Soils Map



Surficial Soils

CLIENT:
City of Merritt

DATE:	PROJECT:	DRAWN BY:
Jan 2013	2012-2231.000	DA

DATA SOURCE(S):
Storm Network, Imagery - City of Merritt 2012; Soils, Municipal Boundary - GeoBC, 2012

Associated Engineering

Figure 2-1
Merritt ISMP

Surficial Sediment Catalogue

Symbol	Name	Soil_parent_material	Drainage	Grouping	Soil_Texture_Classification	SWMM5 (mm/hr)	Green Ampt (mm/hr)	Ksat_Value_low (mm/hr)	Ksat_Value_high (mm/hr)
CG	Cavanaugh	Gravelly, coarse textured colluvial and colluvial fan deposits, moderately to exceedingly stony.	well	1	Gravel			3.60E+03	3.60E+06
CO	Commonage	Coarse textured colluvial fan deposits; moderately to very stony.	well	1	Gravel			3.60E+03	3.60E+06
TM	Timber	Medium and moderately fine textured morainal deposits; slightly to moderately stony.	well	2	Clayey silt gravel sand		2.18E+01	3.60E-06	3.60E+00
TP	Trapp Lake	Medium and moderately fine textured morainal deposits; slightly to moderately stony.	well	2	Clayey silt gravel sand		2.18E+01	3.60E-06	3.60E+00
GD	Godey	Gravelly, coarse textured fluvioglacial deposits with thin, loamy or sandy eolian cappings, slightly to very stony.	rapid	3	Sandy gravel		2.36E+02	3.60E+00	3.60E+04
GS	Glimpse	Coarse and moderately coarse textured textured fluvioglacial deposits; moderately to very stony.	rapid-well	3	Sandy gravel		2.36E+02	3.60E+00	3.60E+04
GY	Glossey	Gravelly, coarse textured fluvioglacial deposits with gravelly, loamy cappings; moderately to very stony.	rapid-well	3	Sandy gravel		2.36E+02	3.60E+00	3.60E+04
SM	Shumway	Moderately coarse and medium textured fluvial and fluvioglacial fan deposits; stone-free or slightly stony.	well	4	Sand	1.20E+02		1.80E+01	3.60E+04
LM	Lundbom	Moderately fine textured lacustrine deposits; stone-free.	well	5	Silty Clay Loam	1.52E+00			
LD	Lac du Bois	Medium and moderately fine textured lacustrine deposits; stone-free.	well	5	Silty Clay Loam	1.52E+00			
FS	Frances	Moderately coarse and medium textured fluvial deposits; stone-free.	imperfect	6	Sandy Loam	1.09E+01			

Appendix C - Well Logs

Table 2. Summary of Details About the City of Merritt Production Wells and Coldwater Improvement District Wells

Well (Date of Construction)	Well Depth m (ft)	Static Water Level m (ft)	Aquifer Material and Screen Interval	Litholog	Remarks
Fairley Park (Jan./66)	25.3 (83)	1.8 (6.0)	Medium sandy gravel; 6.1 m (20 ft) of 3.05 mm (0.120") slot screen set from 19.2 to 25.3 m (63 to 83 ft).	0 - 0.2 m topsoil 0.2 - 0.8 m brown clay 1.8 - 3.0 m loose medium gravel 3.0 - 4.9 m brown silt 4.9 - 20.1 m loose, clean, fine to medium gravel 20.1 - 25.3 m medium sandy gravel 25.3 - 29.6 m grey silt 29.6 - 29.9 m sandy gravel.	300 mm (12") diameter; pumped at rates as high as 67.3 L/sec (1067 USgpm) with total drawdown of 3.9 m. Affected by iron oxide incrustation of aquifer sand and gravel. **Rated capacity of 72.5 L/sec (1150 USgpm; 960 igpm).**
May Street (Oct./70) decomissioned in 2007	30.5 (100)	2.9 (9.5)	loose, coarse, sandy gravel; 3.0 m (10 ft) of 2.54 mm (0.100") slot screen set from 7.6 to 10.7 m (25 to 35 ft).	0 - 0.2 m compact road gravel 0.2 - 0.3 m compact sandy silt 0.3 - 9.4 m loose, coarse, sandy gravel 9.4 - 10.7 m coarse, tight silty gravel 10.7 - 18.3 m brown silt with tan interbeds 18.3 - 18.9 m coarse gravel 18.9 - 22.9 m soft, dark grey clay 22.9 - 30.5 m sandy till, very silty and compact.	400 mm (16") diameter; tested at 29.8 L/sec (473 USgpm) for 18 hours with 3.4 m (11 ft) of drawdown. **Rated capacity of 25.2 L/sec (400 USgpm or 340 igpm).**

From Pacific Hydrology (1990)

Table 2. Summary of Details About the City of Merritt Production Wells and Coldwater Improvement District Wells (Page 2)

Well (Date of Construction)	Well Depth m (ft)	Static Water Level m (ft)	Aquifer Material and Screen Interval	Litholog		Remarks
Voght Park No. 1 (July/71)	29.9 (98)	2.56 (8.4)	Gravel and sand; 2.4 m (8 ft) of 2.03 mm (0.080") slot pipe-size screen over 6.7 m (22 ft) of 3.81 mm (0.150") slot screen set between 20.7 and 29.9 m (68 and 98 ft)	0 - 0.6 m	fill	400 mm (16") diameter; pumped at a maximum rate of 104.1 L/sec (1650 USgpm) in July 1971, with a total drawdown of 11.9 metres (38.95 ft) for a specific capacity of 8.77 L/sec/m (42.4 USgpm/ft). **Rated capacity of 113.5 L/sec (1800 USgpm; 1500 igpm).**
				0.6 - 1.8 m	loose, silty medium gravel	
				1.8 - 4.9 m	very loose gravel	
				4.9 - 7.0 m	compact, gravelly grey silt	
				7.0 - 7.3 m	gravelly compact sand with water	
				7.3 - 11.6 m	sandy gravel	
				11.6 - 12.8 m	very loose gravelly sand	
				12.8 - 14.0 m	tight sandy gravel	
				14.0 - 14.6 m	loose sandy gravel	
				14.6 - 20.4 m	sandy medium gravel	
				20.4 - 21.0 m	sandy gravel with silt varves	
				21.0 - 24.7 m	loose, medium, silty sandy gravel	
				24.7 - 29.9 m	loose gravel	
Voght Park No. 2 (Sept./76)	34.1 (112)	3.6 (11.9)	Gravel; 9.1 m of 300 mm pipe-size screen with 3.05 mm (0.120") slots set between 9.8 and 34.1 m (82 and 112 ft)	0 - 0.3 m	gravel and clay fill	400 mm (16") diameter; pumped at rates as high as 123.8 L/sec (1962 USgpm) with a total drawdown of 6.93 m (22.73 ft), for a specific capacity of 17.86 L/sec/m (86.3 USgpm/ft); USgpm/ft); located 23.8 m (78 ft) from Well No. 1. Rated capacity of 126+ L/sec **(2000+ USgpm; 1670+ igpm).**
				0.3 - 4.9 m	compact silty gravel	
				4.9 - 11.0 m	fine to coarse, loose pebbly gravel some coarse to fine sand and suspended rusty tan silt	
				11.0 - 29.9 m	medium to coarse, loose pebbly gravel with some fine to coarse sand with silty and sandy zones	
				29.9 - 31.1 m	very coarse pebbly gravel with some medium sand	
				31.1 - 34.1 m	medium coarse pebbly gravel with some fine to coarse sand	
				34.1 - 34.8 m	medium coarse sand with some pebbles	

Table 2. Summary of Details About the City of Merritt Production WElls and Coldwater Improvement District Wells (Page 3)

Well (Date of Construction)	Well Depth m (ft)	Static Water Level m (ft)	Aquifer Material and Screen Interval	Litholog		Remarks
Coldwater I.D. No. 1 (Aug./61)	27.4 (90)	2.9 (9.7)	gravel and sand; two sections of screen - 1.5 m (5 ft) from 22.9 to 22.4 m (75 to 80 ft) and 1.5 m from 25.6 to 27.1 m, separated by 1.2 m (4 ft)of blank pipe	0 - 0.3 m	silty sand	200 mm (8") diameter; pumped at 13.7 L/sec (217 USgpm) with 1.7 m (5.5 ft) of of drawdown. **Rated capacity of 22.1? L/sec (350? USgpm; 290? igpm).**
Unknown Well				0.3 - 3.4 m	medium sandy gravel	
				3.4 - 14.6 m	medium to coarse sand with a high silt fraction	
				14.6 - 20.7 m	coarse sand and gravel	
				20.7 - 22.3 m	fine to medium sand	
				22.3 - 23.2 m	sandy gravel, more silt	
				23.2 - 24.7 m	compact sandy gravel	
				24.7 - 27.4 m	gravelly sand	
Coldwater I.D. No. 2 (July/78)	45.1 (148)	3.8 (12.5)	sand and gravel; a 7.5 m (24.70 ft) long assembly of 1.5 m (5 ft)of 3.05 mm (0.120") slot screen over 2.4 m (8 ft) of 178 mm I.D. pipe, over 1.5 m of 5.08 mm (0.200") slot over 1.5 m of 3.05 mm slot, set between 37.6 and 45.1 m (123.3 and 148 ft)	0 - 0.9 m	tan fine sand with clay and silt	250 mm (10") diameter well; pump tested at a maximum rate of 56.85 L/sec (901 USgpm) with a total drawdown of 1.32 m (4.33 ft) for a specific capacity of 43.1 L/sec/m (208 USgpm/ft). **Rated capacity of 75.7+L/sec (1200+ USgpm; 1000+ igpm).**
Colletville Well				0.9 - 9.8 m	small to medium coarse gravel with stringers of clay between 8.2 and 9.8 m (27 and 32 ft)	
				9.8 - 11.9 m	grey clay	
				11.9 - 12.5 m	clay with cobbles; a little water	
				12.5 - 14.6 m	small to medium coarse gravel with thin clay interbeds	
				14.6 - 15.2 m	coarse sand and gravel	
				15.2 - 16.8 m	loose coarse sand	
				16.8 - 18.0 m	tight coarse gravel	
				18.0 - 19.5 m	fine sand with clay interbeds	
				19.5 - 24.4 m	coarse gravel and sand; loose below 22.0 m	
				24.4 - 25.6 m	compact, coarse sand and gravel	
				25.6 - 25.9 m	clay	
				25.9 - 26.2 m	loose, coarse sand and gravel	
				26.2 - 32.3 m	fine sand with pebbles	
				32.3 - 49.1 m	fine to coarse, loose sand and gravel with some cobbles; gravel less below 37.8 m	

Report 1 - Detailed Well Record

Well Tag Number: 97218

Owner: CITY OF MERRITT

Address: 2485 MERRITT

Area: MERRITT

WELL LOCATION:

Land District

District Lot: Plan: Lot:

Township: Section: Range:

Indian Reserve: Meridian: Block:

Quarter:

Island:

BCGS Number (NAD 83): 092I017113 Well:

Class of Well: Water supply

Subclass of Well: Domestic

Orientation of Well: Vertical

Status of Well: New

Licence General Status: UNLICENSED

Well Use: Water Supply System

Observation Well Number:

Observation Well Status:

Construction Method:

Diameter: inches

Casing drive shoe: Y Y

Well Depth: 457.7 feet

Construction Date: 2007-10-26 00:00:00

Driller: J. R. Drilling Central Ltd. Partnership

Well Identification Plate Number: 29680

Plate Attached By:

Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:

Well Yield: (Driller's Estimate)

Development Method: Air lifting

Pump Test Info Flag: N

Artesian Flow:

Artesian Pressure (ft):

Static Level:

WATER QUALITY:

Character:

Colour:

Odour:

Well Disinfected: N

EMS ID:

Water Chemistry Info Flag: N

Field Chemistry Info Flag:

Site Info (SEAM):

Water Utility:

Water Supply System Name:

Water Supply System Well Name:

SURFACE SEAL:

Elevation: feet (ASL)

Final Casing Stick Up: inches

Well Cap Type:

Bedrock Depth: 541 feet

Lithology Info Flag: Y

File Info Flag: N

Sieve Info Flag: N

Screen Info Flag: Y

Site Info Details:

Other Info Flag:

Other Info Details:

Flag: Y

Material: Bentonite clay and cement mixture

Method: Pumped

Depth (ft): 100 feet

Thickness (in): 2 inches

Liner from To: feet

WELL CLOSURE INFORMATION:

Reason For Closure:

Method of Closure:

Closure Sealant Material:

Closure Backfill Material:

Details of Closure:

Screen from	to feet	Type	Slot Size
384.4	396.9		null
396.9	457.7		80

Casing from	to feet	Diameter	Material	Drive Shoe
0	300	20	Steel	Y
null	null	16	Steel	Y

GENERAL REMARKS:

LITHOLOGY INFORMATION:

From 0 to 4 Ft. Soft brown

From 4 to 28 Ft. Medium GRAVEL SAND TILL brown

From 28 to 39 Ft. Medium CLAY SILT grey

From 39 to 44 Ft. Medium GRAVEL SAND SILT POSSIBLY SOME WATER grey

From 44 to 182 Ft. Soft GREY BROWN vari-coloured

From 182 to 184 Ft. Soft GREY BROWN, TRACE GRAVEL vari-coloured

From 184 to 205 Ft. Soft GREY BROWN vari-coloured

From 205 to 225 Ft. Medium SILT SMALL GRAVEL SAND GREY BROWN vari-coloured

From 225 to 267 Ft. Medium COBBLES GRAVEL SAND SILT GREY BROWN WATER BEARING vari-coloured

From 267 to 271 Ft. Loose SILTY CLAY SOME GRAVEL SAND SILT grey

From 271 to 308 Ft. Loose GRAVEL SAND SILT WATER BEARING grey

From 308 to 322 Ft. Medium TRACE GRAVEL SOME SAND MOSTLY SILT grey

From 322 to 357 Ft. Loose COBBLES GRAVEL SAND SILT WATER BEARING grey

From 357 to 363 Ft. Loose SOME GRAVEL MOSTLY SAND SOME SILT grey

From 363 to 366 Ft. Medium MOSTLY SILT SOME SAND GRAVEL grey

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From   366 to   367 Ft.  Loose GRAVEL SAND SILT    grey
From   367 to   441 Ft.  Loose COBBLES GRAVEL SAND SOME SILT   WATER BEARING FAIRLY CLEAN grey
From   446 to   462 Ft.  Loose SMALL COBBLES GRAVEL SAND SOME SILT    grey
From   472 to   541 Ft.  Loose SMALL COBBLES GRAVEL SAND SILT   WATER BEARING FAIRLY CLEAN grey
From   462 to   472 Ft.  Dense GRAVEL SAND SILT   VERY HARD DRILLING grey
From   541 to   545 Ft.  Dense TALC & BEDROCK    white
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- Return to Main
- Return to Search Options
- Return to Search Criteria

Appendix D - Hazard Inventory Results

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
1	Collettville direct contamination of well and near well area	Collettville	City of Merritt	At wellhead	Any contaminant	E (Rare)	No surface seal and coarse unconfined shallow aquifer but the well area is in a park, slope is graded away from the well, and the well is in a sealed box on a concrete pad 3m by 3m. Well is above floodplain in open field. No preferred pathways besides the water line to the pumphouse, electrical, and water level conduit. Water is treated for viruses and protozoa.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well.	Moderate	1
2	Voght Park 1 well (VFD) direct contamination of well and near well area	Voght Park	City of Merritt	At wellhead	Any contaminant	E (Rare)	No surface seal and coarse unconfined shallow aquifer but the well is in an alarmed pumphouse in a park and the well-head is sealed. Roof drains fall onto ground surface and goes into ground. Wash water goes to a dry well about 4 m away from well. Water is treated for viruses and protozoa.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well.	Moderate	1
3	Voght Park 2 well (GE) direct contamination of well and near well area	Voght Park	City of Merritt	At wellhead	Any contaminant	E (Rare)	No surface seal and coarse unconfined shallow aquifer but the well is in an alarmed pumphouse in a park-like setting and the well-head is sealed. Roof drains fall onto ground surface and goes into ground. Wash water goes to a dry well about 4 m away from well. Water is treated for viruses and protozoa.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well.	Moderate	1
4	Fairley Park well - direct contamination of well and near well area	Fairley Park	City of Merritt	At wellhead	Any contaminant	E (Rare)	No surface seal but in a dense urban (well used) park, well is in an alarmed pumphouse and wellhead is sealed. Nitrate concentrations are generally above 1 mg/L, and show some evidence of an increase over time. This likely indicates some anthropogenic inputs, although values are well below the drinking water guideline (10 mg/L).	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well.	Moderate	1
5	Direct well contamination - Kengard well	Kengard	City of Merritt	At wellhead	Any contaminant	E (Rare)	Well has a surface seal and the well is in a sealed box.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well.	Moderate	1
6	Wastewater Treatment Plant	Voght Park	City of Merritt	In northwest area of city. Approx. 400 m N/NW of Voght Park.	Nutrient and Bacteriological Contaminants	E (Rare)	Outside of 200-day time of travel, so only nitrates and chemical hazards would apply. Nitrate-N in upgradient monitoring wells are 0.5 mg/L (1992) and WWTP was commissioned in 1963.	2 (Minor)	Small increase in operating costs.	Low	2
7	Collettville Sanitary Lift Station and Forcemain	Collettville	City of Merritt	Crosses at bridge, 60 m west of Collettville.	Nutrient and Bacteriological Contaminants	C (Possible)	Breaks do occur and within the 200-day capture zone.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well. Treatment may not treat raw sewage (need more like 7 log for viruses)	High	3
8	Rapid Infiltration Basins	Collettville	City of Merritt	Approx. 450 m NW of Collettville	Nutrient and Bacteriological Contaminants	E (Rare)	Final treated effluent from the WWTP is piped under the Coldwater River to a lined containment basin. From this basin, overflow is directed into the rapid infiltration basins. Outside of 200-day time of travel, so only nitrates and chemical hazards would apply. Nitrate-N in upgradient monitoring wells are 0.5 mg/L (1992) and WWTP was commissioned in 1963.	2 (Minor)	Small increase in operating costs.	Low	2

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
9	Landscape Company	Collettville	Private	Approx. 110 m E of Collettville	Nutrients (mainly, nitrate-N) and Pathogens	D (unlikely)	Very little information on this operation. Not sure if this company produces organic soil amendment or just sells it. Composting operations must follow Provincial Regulations; however, they can be a source of nitrates and pathogens. Soils are sandy loam, which is considered “imperfect drainage”. Well is 45 m deep, with multiple clay interbeds and lenses between 18 m below ground surface (m bgs), to 26m bgs. Merritt’s climate is dry, so leachate generation potential is low.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives made it to wells.	High	4
10	MOE Registered Site ID 4378	Kengard	Private. Formerly Weyerhaeuser.	2252 Coldwater Avenue & 1375 Houston Street. Approx. 1.3 m N of Kengard	Wood preservatives, chlorophenols, phenols, LEPH/HEPH, PAHs, PHCs, BTEX, VOCs, metals	E (rare)	This site is registered with the MOE. A Conditional Certificate of Compliance was issued for this site in 2002 related to remediation at the former Weyerhaeuser Sawmill. It was determined that stockpiles of contaminated soil meet the CSR regulation for Industrial Land Use standards. There is no further information about the "conditional" nature of the Certificate of Compliance.	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	None
11	MOE Registered Site ID 5969 (Merritt Truck & Machine Service)	Kengard	Private. Formerly Merritt Truck & Machine Service.	2172 Douglas Street. Approx. 600 m southeast of Kengard	LEPH/HEPH, PAH, BTEX, VOCs, metals	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This site is registered with the MOE. A Notice of Independent Remediation Initiation was submitted to the MOE in 1999. The work plan was to consist of excavating contaminated soils in the former location of an Underground Waste Oil Tank. The MOE acknowledged the initiation and required the property owner to notify them if any off-site contamination was discovered.	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	None
12	MOE Registered Site ID 6048 (former Train Refueling Station)	Fairley Park	Private. Formerly owned by CPR	1691 Garcia Street. Approx. 470 m southeast of Fairley Park	LEPH/HEPH, PAH, BTEX, VOCs, metals	E (rare)	This is less than 500 m away from Fairley Park. 500 m is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This site is registered with the MOE. A Preliminary Site Investigation Report, Level 2 Environmental Site Investigation, and Geotechnical Investigation was submitted to the MOE in 1999 related to the Former Merritt Railyard. The MOE reviewed the investigation and recommended that a more complete investigation be completed as there was not enough information supplied in the reports to comfortably indicate whether environmental concerns were present. However, considered rare because we would have expected to see contamination by now if this was an issue.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives made it to wells. One of the main supply wells.	High	5
13	MOE Registered Site ID 7137 (current location of ESSO Service Station)	Kengard	Private	2543 Nicola Avenue. Approx. 500 m south of Kengard.	LEPH/HEPH, PAH, BTEX, VOCs	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This site is registered with the MOE. Its status is listed as Active- Under Remediation. This is related to some kind of Petroleum Product Wholesale Bulk Storage or Distribution, and existing ASTs and USTs. Given that ESSO is a multi-national corporation and that it is the law to notify neighbours if there is any offsite contamination, we assume this has been remediated.	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5.6,7

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
14	Wood Workshop	Fairley Park	Private Ownership	1775 Coldwater Avenue. Approx. 100 m southeast of Fairley Park	Wood preservatives	E (rare)	Current operation makes pallets. No bulk fuel storage, and no use of preservatives.	1 (Insignificant)	No major contaminants of concern.	Low	None
15	Lumber Mill 1 (now Aspen Planers, formerly Ardew Wood Products Ltd.) (MOE Registered Site ID 1614)	Collettville	Private Ownership	1195 Houston Street. Approximately 900 m SE of Collettville	Wood preservatives, chlorophenols, phenols, PAHs, PHCs, BTEX, metals	E (rare).	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). Aspen Planers bought Ardew Wood Products in early 2010s, and have an environmental protection plan and monitoring wells that are regularly monitored. Although wood preservatives were used in the past (likely in the 1990s or earlier), and pentachlorophenols have been observed in the Ministry of Environment's Observation Well 296 (See Figure 4-1 for location) in 1987 at a concentration of 0.025 mg/L (MOE 1988), lumber mills in Merritt now produce only cut-products, meaning no preservatives are used. Any contamination from the 1990s would have already arrived at the well. This site is registered with the MOE. A Site Profile was received and reviewed by the MOE in 1998 related to the Ardew Wood Products sawmill. The MOE determined that no further investigation was required. However, they included a requirement that if Ardew decided to close the mill, or rezone, the MOE would require them to complete a confirmatory sampling program.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives made it to wells.	High	7,8,9
16	Lumber Mill 2 (Tolko Industries Ltd.)	Collettville	Private Ownership	1750 Lindley Creek Road. Approximately 900 m SE of Collettville	Phenols, nitrates, PAHs, PHCs, BTEX	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This operation never used chlorophenols or other wood treatments. The hydrocarbon contaminants of concern would be from accidental release from on-site commercial vehicles. Tolko Industries also has a permit to discharge refuse from their sawmill operations (authorization #2671). The permit describes the characteristics of the refuse as being comprised of burner ash, log yard debris, and miscellaneous mill cleanup wood waste. The contaminants of concern from a wood waste landfill would be phenols, and possibly nitrates. Lumber mills in this area have been in operation since at least 1960 (as per historical air photos). Since this is located on very edge of 10-year aquifer protection area, and on edge of Coldwater River, it is unlikely contaminants would migrate via groundwater to well field area. Rather, any contaminants would likely discharge to Coldwater River. This mill closed in December 2016.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives made it to wells	High	7,8,9
17	Lumber Mill 3a (Aspen Planers Ltd.)	Kengard	Private Ownership	2399 Quilchena Avenue and Approximately 400 m south of Kengard.	Wood preservatives, chlorophenols, phenols, PAHs, PHCs, BTEX, metals	D (unlikely) for Kengard	See comments for #15. This is about 500m away from Kengard well.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives reached a well	High	7,8,9

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
18	Lumber Mill 3b (Aspen Planers Ltd.)	Collettville	Private Ownership	Approximately 900 m SE of Collettville	Wood preservatives, chlorophenols, phenols, PAHs, PHCs, BTEX, metals	E (rare) for main wells Voght, Collettville, and Fairley Park.	See comments for #15. This is more than 500m away from Voght, Collettville, and Fairley Park,	4 (Major)	Could lose well infrastructure if plume of hydrocarbons or wood preservatives reached a well	High	7,8,9
19	Norgaard Ready Mix Ltd.	Fairly Park	Private Ownership	1301 Nicola Ave. Approximately 650 m NW of Fairley Park Well	pH, hydrocarbons from equipment on-site	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). Norgaard Ready Mix Ltd. holds a permit (authorization #106352) under Code of Practice for Concrete and Concrete Products. Previously held a permit (authorization #1980) for discharge of effluent (cancelled in 2013) Historical aerial photographs indicate that this site began operation sometime in the 1960s.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	7,8,9
20	Merritt Auto Wreckers	Collettville	Private Ownership	2402 Priest Ave. Approximately 1 km SE of Collettville	Metals, BTEX, PAHs, PCBs, solvents, asbestos containing materials	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). Merritt Auto Wrecking Ltd. holds a permit under the Vehicle Dismantling and Recycling Industry Environmental Planning Regulation (authorization #100439). Permit was not publicly viewable.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
21	Petro-Canada Storage and Distribution Facility (MOE Registered Site ID 1653)	Kengard	Private Ownership	At corner of Nicola Avenue and CP Rail Crossing. Approximately 400 m south of Kengard	LEPH/HEPH, PAH, BTEX, lead	D (unlikely)	This is less than 500 m away from Kengard well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). Historical aerial photographs indicate that this facility began operation sometime in the mid-1980s. The site is registered with the MOE. Its status is listed as Inactive- No Further Action. No additional details are provided. Given that Petro-Canada is a multi-national corporation and that it is the law to notify neighbours if there is any offsite contamination, we assume this has been remediated. However, new spills can occur undetected until too late. Active permit (authorization #13787) for storm water regulation at a petroleum storage and distribution facility,	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
22	Auto Repair Shop (Kal Tire)	Kengard	Private	2601 Nicola Avenue. About 500 m southeast of Kengard	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
23	Auto Repair Shop (MOE Registered Site ID 1651) (Murray GM)	Fairley Park	Private	2049 Nicola Avenue. About. 500 m northeast of Fairley Park.	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).This site has been registered with the MOE since 1994. A Letter of Comfort was issued by the MOE in 1994 related to the Former Chevron Service Station. This property underwent remediation in 1994 for hydrocarbon contamination after decommissioning of the service station, and the site was remediated to residential/ recreational/ agricultural standards. This historical use of the site is not expected to pose a risk. However, the site currently operates as an auto repair shop.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
24	Auto Repair Shop (Frank Douthwright's Mechanical Service)	Fairley Park	Private	2026 Marmette Avenue. About. 500 m northeast of Fairley Park.	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
25	Auto Repair Shop (Napa Autopro)	Kengard	Private	2114 Nicola Ave. Approximately 450 m southeast of Kengard	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	D (unlikely)	This is less than 500 m away from Kengard well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
26	Auto Repair Shop (DSA Auto Repairs)	Kengard	Private	2575 Nicola Avenue. About. 500 m southeast of Kengard.	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	E (rare)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
27	Auto Repair Shop (MOE Registered Site ID 1621)	Kengard	Private	2380 Nicola Avenue. Approx. 400 m south of Kengard.	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	D (unlikely)	This is less than 500 m away from Kengard well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This site is registered with the MOE as previously undergoing remediation at the site. This historical remediation at the site does not pose environmental concern in the capture zone. However, its current use is as an auto repair shop.	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
28	Former Auto Repair Shop (MOE Registered Site ID 4611)	Kengard	Private	2302 Nicola Avenue. Approx. 400 m south of Kengard	LEPH/HEPH, VOCs, PAH, BTEX, VPH, wear metals, solvents	D (unlikely)	This is less than 500 m away from Kengard well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
29	Shell Distributor (Service Station)	Kengard	Private	Approximate 550 m southeast of Kengard	LEPH/HEPH, VOCs, VPH, PAH, BTEX, metals	D (unlikely)	This is more than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). Given that Shell is a multi-national corporation and that it is the law to notify neighbours if there is any offsite contamination, we assume any spill or leak will be quickly remediated. However, new spills can occur undetected until too late.	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
30	Super Save (Service Station)	Kengard	Private	2525 Nicola Avenue. Approx. 400 m south of Kengard.	LEPH/HEPH, VOCs, VPH, PAH, BTEX, metals	D (unlikely)	This is less than 500 m away from Kengard well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date).	3 (Moderate)	Significant moderation to normal operations but manageable because Kengard well is not a main supply well.	Moderate	5,6,7
31	Petro-Canada Service Station (MOE Registered Site ID 11613)	Fairley Park	Private	2002 Nicola Avenue. Approx. 450 m east of Fairley Park	LEPH/HEPH, VOCs, VPH, PAH, BTEX, metals	D (unlikely)	This is less than 500 m away, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). This site was registered with the MOE in 2009 as completing independent remediation. As such, the historical use of this site poses a low risk of contamination. However, the site is currently still operating as a service station, which potentially poses a risk of contamination in the capture zone. Petro-Canada is a multi-national corporation and it is the law to notify neighbours if there is any offsite contamination.	4 (Major)	Could lose main well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
32	Former Service Station (MOE Registered Site ID 5053)	Fairley Park	Private	1959 Voght Street. Approx. 450 m east of Fairley Park.	LEPH/HEPH, VOCs, VPH, PAH, BTEX, metals	E (rare)	This is less than 500 m away from a drinking water supply well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date). However, this site was registered with the MOE in 1998 related to the removal of a UST from the "Chicken Shack Restaurant". The MOE determined that no further investigation was required. This historical use of the site is not expected to pose a risk of contamination.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
33	Spring Island Trailer Park and private sanitary lines	Voght Park	Private	50 m to east of Voght2.	Pathogens, nitrates	C (Possible)	Breaks do occur and within the 200-day capture zone. Lines connect to the City's sanitary sewer at the park entrance.	3 (Moderate)	May cause mild to moderate illness to small population, and would need to shut pump off and flush well. Treatment may not treat raw sewage (need more like 7 log for viruses from raw sewage)	High	3
34	Former Fuel Station (Bulk Fuel) (MOE ID 982)	Fairley Park	Private	200 m east of Fairley Park	LEPH/HEPH, VOCs, VPH, PAH, BTEX, metals	E (Rare)	This is less than 500 m away from a drinking water supply well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date); however, the site has already been cleaned up. This site was registered with the MOE but was deemed low risk of contamination.	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
35	Former Train Track	Fairley Park	City of Merritt	Adjacent to Fairley Park Well. Running parallel to Quilchena Avenue.	LEPH/HEPH, PAH, BTEX, lead	E (Rare)	This is less than 500 m away from a drinking water supply well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date); however, already cleaned up	4 (Major)	Could lose well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
36	Fairley Park washroom and related sanitary lines	Fairley Park	City of Merritt	15 m away from well	Pathogens, nitrates	C (Possible)	A washroom connected to City sewer is present in Fairley Park, and is located very close to the well. Although the washroom is new (built in 2014-2015), breaks in sanitary lines do occur and the washroom is located within the 200-day capture zone, and within 30 m of the well. If a leak occurs, the washroom would be out of compliance with Health Hazards Regulation: Paragraph 8(1) states "a person who installs a well must ensure that the well is located at least 30 m from any probably source of contamination."	4 (Major)	Although the well now has chlorine treatment and will soon have UV treatment, the treatment is based on 4-log inactivation of viruses, and 3-log inactivation of protozoa. Raw sewage could require up to 7-log inactivation of viruses to make the drinking water safe.	Very High	3, 10

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
37	River Ranch Field	Kengard	Private	50 m east.	Pathogens, nitrates	D (unlikely)	An agricultural field is very close to the well and agricultural operations are known to overapply nutrients to fields, causing nitrate contamination. However, there is a 36 m clay layer above the screen, therefore, some protection from surface contaminants is provided by the geology.	4 (Major)	Could lose well to nitrate contamination	High	11
38	Septic field (near Kengard)	Kengard	Private	100 m north, but still in 200 day APA	Pathogens, nitrates	E (Rare)	One septic field contributes only a small amount of nitrogen species, and there is a thick layer of clay above the screen, therefore, some protection from surface contaminants is provided by the geology.	2 (Minor)	Minor	Low	None
39	Home Hardware	Fairley Park	Private	Approx. 220 m east of Fairley Park well.	Wood preservatives.	D (unlikely)	This is less than 500 m away from a drinking water supply well, which is the radius for applying Drinking Water Use according to Protocol 21 (Ministry of Environment, no date); however, the operation does not store bulk fuel.	4 (Major)	Could lose main well infrastructure if plume of hydrocarbons reached a well	High	5,6,7
40	Poultry Operation	Voght Park	Private	380 m east of Voght Park wells.	Nitrates	D (unlikely)	At 1408 Cleasby St is a poultry operation with about 100 chickens. There is a well located on the neighbour's property to west that could act as a conduit. Nitrate-N concentrations have been low, ranging from 0.4 mg/L to 0.8 mg/L (guideline is 10 mg/L). The top of screen in Voght Park #2 is set at a depth of 10 m. Above this is "compact silty gravel", which may be providing some protection from nitrate-contamination.	4 (Major)	Could lose well to nitrate contamination	High	11, 20
Non-Point Sources											
A	Sanitary sewer lines (in addition to the point sources identified above)	All wells	City of Merritt	Sanitary sewer lines are present in APA A for Collettville and Fairley and in APA B for Voght Park and the Kengard.	Nutrient and Bacteriological Contaminants	C (Possible)	Sanitary lines leak, and the lines are old. The nearest recent leak was 100m south of Fairley Park well. • Collettville: There are sanitary sewer lines in APA A, including one forcemain approximately 50 m from the well. The pump station for the forcemain (Hazard 7) is within APA B. • Voght Park: There are no sanitary sewer lines in APA A, but they are present within APA B (including the forcemain). The nearest line is approximately 120 m from the wells. • Fairley Park: The closest sanitary sewer line to the Fairley Park well is approximately 30 m away, and lines are present throughout APAs A and B. • Kengard: The closets sanitary sewer line is approximately 140 m (just outside APA A but within APA B).	4 (Major)	Although all wells receive chlorine, UV treatment is planned, and regular testing for pathogens occurs, the setback to the nearest sanitary line is if a nearby sanitary line broke, the treatment may be insufficient to protect public health, and the well may need to be turned off for a period of time.	Very high	3, 18
B	Lead in water supply infrastructure		Various (City of Merritt, Private Owners)	Throughout capture zone. Varies	Lead	A (Almost Certain)	The primary source of lead in drinking water is usually leaching from older plumbing service lines that contain lead. Given that the national plumbing codes allowed lead in pipes until 1975 and in solder until 1986 (Health Canada 2016a), the likelihood of lead being present in some infrastructure is high. The amount of lead leached depends on several factors including the corrosivity of the source water. The fact that lead was once detected above drinking water guidelines at City Hall (Section 2.1.3) suggests the necessary conditions for leaching are present in at least some cases.	3 (Moderate)	Health Canada's recent guideline document (still in draft stage for public consultation) indicates that previous studies cannot identify a level below which lead is no longer associated with health effects. Reducing the potential for exposure to lead at the distribution scale can be achieved by removing lead containing service lines and controlling corrosion.	Very High	21

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
C	Drainage Dry Wells connected to storm drainage system capture zone	Fairley	City of Merritt	One drywell located less than 30 m of Collettville Well, approx. 200 m east of Fairley Well**	Any contaminant (main concerns are hydrocarbons, fertilizers, salts)	D (unlikely)	The stormwater system is a combination of storm sewers, manholes, road ditches, drainage ditches, culverts, outfalls, catch-basins, storm leads and curb/gutter systems. In the older part of town, the stormwater system is routed through the shortest path to either the Nicola or Coldwater rivers. The stormwater system also contains a system of shallow and deep dry wells throughout the City where outfalls are not available. These drywells have been excavated to a coarse gravel layer, and essentially act as sumps, whereby water is collected at the surface in storm drains and gutters, and discharged into these dry wells, before directly infiltrating the ground. Wells, excluding Kengard, are screened between 10m and 45m deep (Kengard is screened 120-139m deep). The nearest drywell is 30 m from Collettville well. However, there is some protection from geological units between the bottom of the dry wells (which are likely about 4 m deep), and the screen depths of the wells, and sodium and chloride levels are low. Moreover, the climate is dry in Merritt, and the potential for a high-speed motor vehicle accident in this area is low. The locations of the dry wells are shown in Figures 4-2, 4-3, and 4-4.	4 (Major)	Any type of hydrocarbon spill draining through one of these wells could reach the well, and if this occurred, the well infrastructure could be lost.	High	13,14,15
D	Storm drainage mains and water mains	Fairley	City of Merritt	Storm mains located approximately 30 m north and south of Fairley Well. Water mains connect to each well, and then along nearest road.	Any contaminant from within the storm catchment area and near the water mains (main contaminants of concern are hydrocarbons, fertilizers, salts)	D (unlikely)	Based on a preliminary review of storm and water main drawings: • Voght Park and Collettville: There are no realistic preferred pathways (water or storm mains) between commercial/industrial zoning and the wells. • Fairley Park: There is a direct preferred pathway (via the water main and storm main, approx. 260 m distance) along Quilchena Ave. to the commercial zoning district. The water main connects directly to the well, whereas the storm main comes within approximately 45 m of the well. Kengard: There is a direct preferred pathway (water main only, approx. 400 m distance) from the industrial zoned area and near some identified hazards. No directly preferential pathways from storm.	4 (Major)	Any type of hydrocarbon spill draining through one of these wells could reach the well, and if this occurred, the well infrastructure could be lost.	High	6,13,16,17
E	Roads and transportation infrastructure		City of Merritt/BC Government	Adjacent to wells	Mainly salts, fertilizers, hydrocarbons	C (Possible)	Urban roads are nearby all wells, but no high-speed roads are nearby. Winter road maintenance uses an alternative to salt, and sodium concentrations are low.	3 (Moderate)	An increase in monitoring may be required if winter road maintenance changes.	High	13,18,19
F	Other Industry		Private Ownership	Mainly along Pooley Avenue. Approximately 1.5 m from Kengard	Wood preservatives, Metals, VOCs, BTEX, diesel, paints, other chemicals	C (Possible)	There does not appear to be any industrial zoning within the APA B for any of the wells. The zoning in APA C is a mixture of residential, commercial, industrial, agricultural, parkland and institutional land use. The main industrial area is in the southeast portion of the capture zone, along the Coldwater River. This is a large area that has been used for industrial purposes since the 1960s. The main commercial and service commercial areas are in the northeast and central portion of APA C. The area in the northeast has been more heavily developed since the 1970s and 1980s. The areas in the east and west of APA C are mainly residential properties.	3 (Moderate)	If a contaminant reached the well, major infrastructure may be lost.	High	13, 22

Table D-1
Hazard Inventory and Risk Rating

Hazard No.	Hazard	Nearest Well	Owner	Location & Direction to Nearest Well	Contaminants of Concern	Likelihood Level	Likelihood notes	Consequence Level	Consequence notes	Risk Level	Action # (see Table 5-2)
G	Other Commercial		Various Owners	Throughout capture zone, mainly in city centre, north (Voght Street) and northeast part of town. Approximately 400 m east (city centre)	Any contaminant	C (Possible)	Zoning near the Collettville and Voght Park wells is mainly residential, institutional and parkland land use. However, there is a small area near Hill St. and Walnut Ave. approximately 350 m (but outside APA B) from the Collettville and Voght Park wells that is zoned as service commercial (special regulation). There is also a property zoned as local commercial within APA B for Voght Park and Fairly Park (on the corner of Wilson St. and Coldwater Ave.) There is a large area of commercial zoning just outside APA B for Fairly Park, and one property within APA B is zoned as commercial. APA B for Kengard includes zoning for agricultural, institutional, residential and parkland.	3 (Moderate)	If a contaminant reached a well, major infrastructure may be lost.	High	22
H	Natural gas lines and other private utilities (general - for example, fibre-optic, natural gas, oil)		Fortis and	Throughout capture zone area	Preferred pathway	E (Rare)	The proposed Trans Mountain Pipeline passes by Merritt but is outside of APA C. In general, some private utilities have a combination of above and below ground. Below ground uses low invasive techniques with small diameter directional drilling and little to no imported bedding. The wells are located near publicly owned utilities that would be of higher concern.	3 (Moderate)	If a contaminant reached a well (via a preferred pathway), major infrastructure may be lost. This is a higher concern for preferred pathways within commercial and industrial areas.	Moderate	23
I	Residential properties		Private owners	Throughout capture zone area	Nitrates, pesticides, herbicides, household cleaners, oil and automotive wastes	E (Rare)	Bylaws are in place that allow the City to deal with unsightly premise. Pesticide use is not likely prevalent for residential use because of new restrictions on pesticide sales.	3 (Moderate)	Most contaminants of concern related to residential homes are detectable at trace amounts, and can be observed through regular monitoring. However, since residences are very nearby Fairly Park, if a contaminant was released on a residential property, there may not be time to clean up; therefore, major infrastructure could be lost	Moderate	22
J	Other wells in capture zone (domestic, irrigation, monitoring)		Various Owners	See BC Water Resources Atlas	Any contaminant	E (Rare)	A well closure bylaw is in effect.	2 (Minor)		Low	20
K	Animals and pests		Various owners	In green space throughout study area	Coliform bacteria and other microbes	E (Rare)	There is an off-leash dog park located behind the Recycling Depot on Main Street, by the City Works Yard. The dog park is outside of APA B for Voght Park	1 (Insignificant)	Water is disinfected and chlorine residuals are monitored, reducing the magnitude of consequence.	Low	24
L	Residential heating oil underground or aboveground storage tanks		Various Owners	Potentially throughout capture zone	LEPH/HEPH, BTEX, VPH, PAH, and wear metals	E (Rare)	There are no residential heating oil tanks still being used. They have all been dry when pulled up. Heating oil is made up of heavier hydrocarbons, which are less mobile in groundwater. Any contamination from historical use of heating oil would already have been apparent.	2 (Minor)	Some additional monitoring may be required is trace levels arrive at the well.	Low	5,25

Appendix E - BC Contaminated Sites Registry Search

Table E-1
Contaminated Sites Registry Summary

Site ID	Location	In Capture Zone?	Detail/ Synopsis Report?	Comments/Details	Concern for Contamination in Capture Zone?
0982	1885 Coldwater Ave	**YES**	DETAIL	Certificate of Compliance issued in 2005 using numerical based standards for a former Shell Bulk Plant that underwent remediation.	No
1598	2501 Coldwater Road	**YES**	DETAIL	Final Determination issued in 2000 indicating that the Former Ministry of Forests Complex is not contaminated. This was following remediation of the site to Residential/Recreational/Agricultural Standards	No
1651	2001 Nicola Ave	**YES**	DETAIL	A Letter of Comfort was issued by MOE in 1994 related to the Former Chevron Service Station. This property underwent remediation in 1994 for hydrocarbon contamination after decommissioning of the service station, and the site was remediated to residential/recreational/agricultural standards.	No
1654	2664 Nicola Avenue	**YES**	DETAIL	A Remediation Completion report was submitted to MOE and a Letter of Comfort was issued in 1994 following remediation of soils from underground fuel storage tanks at the former Dearborn Ford property. The property was remediated to Residential/Recreational/Agricultural levels.	No
4025	2840 Voght Street	**YES**	DETAIL	A Site Profile was received and reviewed by MOE in 2001 for a former Petro-Canada Service Station. MOE determined that no further investigation was required. This was following remediation of hydrocarbon contamination in 1994, in which it was determined that the site was clean.	No
4823	1938-1967 Coldwater Ave	**YES**	DETAIL	A Site Profile was received and reviewed by MOE in 1998 for a property related to a discontinued rail bed. MOE determined that no further investigation was required	No
5053	2001 Voght Street	**YES**	DETAIL	A Site Profile and Preliminary Site Investigation report was received and reviewed by MOE in 1998 related to the removal of a underground storage tank (UST) from the "Chicken Shack Restaurant." MOE determined that no further investigation was required	No
6054	2152 Quilchena Avenue	**YES**	DETAIL	A Site Profile was received and reviewed by MOE in 1998 for a former gas station. MOE determined that further investigation was required. A Preliminary Site Investigation report was then submitted for internal review in 1998. That same year it was determined that no further environmental investigation was required.	No
7037	Right of Way W of Chapman St to Main Street	**YES**	DETAIL	A Site Profile was received and reviewed by MOE in 2000 for a property related to bulk commodity storage or shipping (i.e., coal). MOE determined that no further investigation was required	No
7347	1550 Chapman Street	**YES**	DETAIL	A Site Profile was received and reviewed by MOE in 2001. MOE determined that no further investigation was required	No
10296	1999 Nicola Ave	**YES**	DETAIL	A determination of contaminated site was requested in 2007. That same year it was determined that the site was not contaminated. This was on the recommendation of an approved professional.	No
11281	2288 Quilchena Avenue	**YES**	DETAIL	Certificate of Compliance Issued using numerical standards in 2008 on the recommendation of an approved professional.	No
11613	2002 Nicola Avenue	**YES**	DETAIL	A Notice of Independent Remediation Initiation submitted in 2009 and Completion was submitted in 2011. Therefore, the site is not expected to pose environmental concern	No
12062	2490 Priest Avenue	**YES**	DETAIL	A Notice of Independent Remediation Initiation and Completion was submitted in 2010. Therefore, the site is not expected to pose environmental concern	No
0321	2399 Quilchena Ave	**YES**	SYNOPSIS	Status Listed as Inactive - Remediation Complete	No
1621	2380 Nicola Ave	**YES**	SYNOPSIS	Status listed as Inactive - Remediation Complete	No
1653	2419 Nicola Avenue	**YES**	SYNOPSIS	Status listed as Inactive - No Further Action. No additional details provided.	No
4611	2302 Nicola Avenue	**YES**	SYNOPSIS	Status is Inactive - No Further Action. Related to a Tank Pull	No

Table E-1
Contaminated Sites Registry Summary

Site ID	Location	In Capture Zone?	Detail/ Synopsis Report?	Comments/Details	Concern for Contamination in Capture Zone?
1614	1195 Douglas Street	**NO**	DETAIL	A Site Profile was received and reviewed by MOE in 1998 related to the Ardew Wood Products Sawmill. MOE determined that no further investigation was required. However, they included a requirement that if Ardew decided to close the mill, or rezone, they would have to complete a confirmatory sampling program.	No
5968	2021 Birch Avenue	**NO**	DETAIL	A Notice of Independent Remediation Initiation was submitted to MOE in 1999 following the removal of a UST. The remediation plan was to segregate the material and conduct confirmatory sampling before removing contaminated soil to the landfill. The MOE acknowledged the initiation and required the property owner notify them if any off site contamination was discovered. A UST Removal and Soil Remediation Completion Report was submitted in 2001.	No (not in capture zone)
1590	2752 Pooley Ave	**NO**	NO		
1642	3643 Voght Street	**NO**	NA	NA	No
4693	Near Midday Valley Road	**NO**	NA	NA	No
6222	2925 Pooley Avenue	**NO**	NA	NA	No
7152	Midday Valley Road	**NO**	NA	NA	No
7751	3603 Voght Street	**NO**	NA	NA	No
7752	3623 Voght Street	**NO**	NA	NA	No
8713	3999 Airport Road	**NO**	NA	NA	No
10213	Godey Pit- FoxFarm Road	**NO**	NA	NA	No
17936	1-929 Coldwater Road	**NO**	NA	NA	No
17941	1081 Coldwater Road	**NO**	NA	NA	No
17942	2845 Neilson Street	**NO**	NA	NA	No
17943	2865 Neilson Street	**NO**	NA	NA	No
17944	2900 Pooley Avenue	**NO**	NA	NA	No
17945	3000 Pooley Ave	**NO**	NA	NA	No
17948	Neilson Street	**NO**	NA	NA	No
17949	Cook's Ferry First Nations- Antko IR #21	**NO**	NA	NA	No
17950	Lower Nicola Indian Band- Joeyaska IR #2	**NO**	NA	NA	No
18645	Kettle Valley Road at Godey Pit	**NO**	NA	NA	No

As Of: OCT 16, 2016 BC Online: Site Registry 16/11/17
For: PK57542 ASSOCIATED ENVIRONMENTAL CONSULTANT 16:55:16
Folio: 2016-8164 Page 1

43 records selected for 5.0 km from latitude 50 deg, 06 min, 46.6 sec
and Longitude 120 deg, 47 min, 15.4 sec

Site Id	Lastupd	Address / City
0000321	00OCT25	2399 QUILCHENA AVENUE MERRITT
0000982	05MAR07	1885 COLDWATER AVENUE MERRITT
0001590	03MAY13	2752 POOLEY AVENUE MERRITT
0001598	00DEC01	2501 COLDWATER ROAD MERRITT
0001614	04APR05	1195 DOUGLAS STREET MERRITT
0001621	00NOV15	2380 NICOLA AVENUE MERRITT
0001642	02DEC16	3643 VOGHT STREET MERRITT
0001651	03FEB07	2001 NICOLA AVENUE MERRITT
0001653	03FEB07	2419 NICOLA AVENUE MERRITT
0001654	06NOV08	2664 NICOLA AVENUE MERRITT
0004025	01JUL27	2840 VOGHT STREET MERRITT
0004378	10SEP16	2252 COLDWATER AVENUE & 1375 HOUSTON STREET MERRITT
0004611		2302 NICOLA AVENUE MERRITT
0004693	01MAR27	NEAR MIDDAY VALLEY ROAD MERRITT
0004823	04APR07	1938-1967 COLDWATER AVENUE MERRITT
0005053		2001 VOGHT STREET MERRITT
0005968	03FEB25	2021 BIRCH AVENUE MERRITT
0005969	03FEB25	2172 DOUGLAS STREET MERRITT
0006048	03APR04	1691 GARCIA STREET MERRITT
0006054	01FEB22	2152 QUILCHENA AVENUE MERRITT
0006222	03FEB25	2925 POOLEY AVENUE MERRITT
0007037	04APR07	UNKNOWN MERRITT
0007137	09DEC18	2543 NICOLA AVENUE MERRITT
0007152		MIDDAY VALLEY ROAD MERRITT
0007347	04APR07	1550 CHAPMAN STREET MERRITT

As Of: OCT 16, 2016 BC Online: Site Registry 16/11/17
For: PK57542 ASSOCIATED ENVIRONMENTAL CONSULTANT 16:55:16
Folio: 2016-8164 Page 2

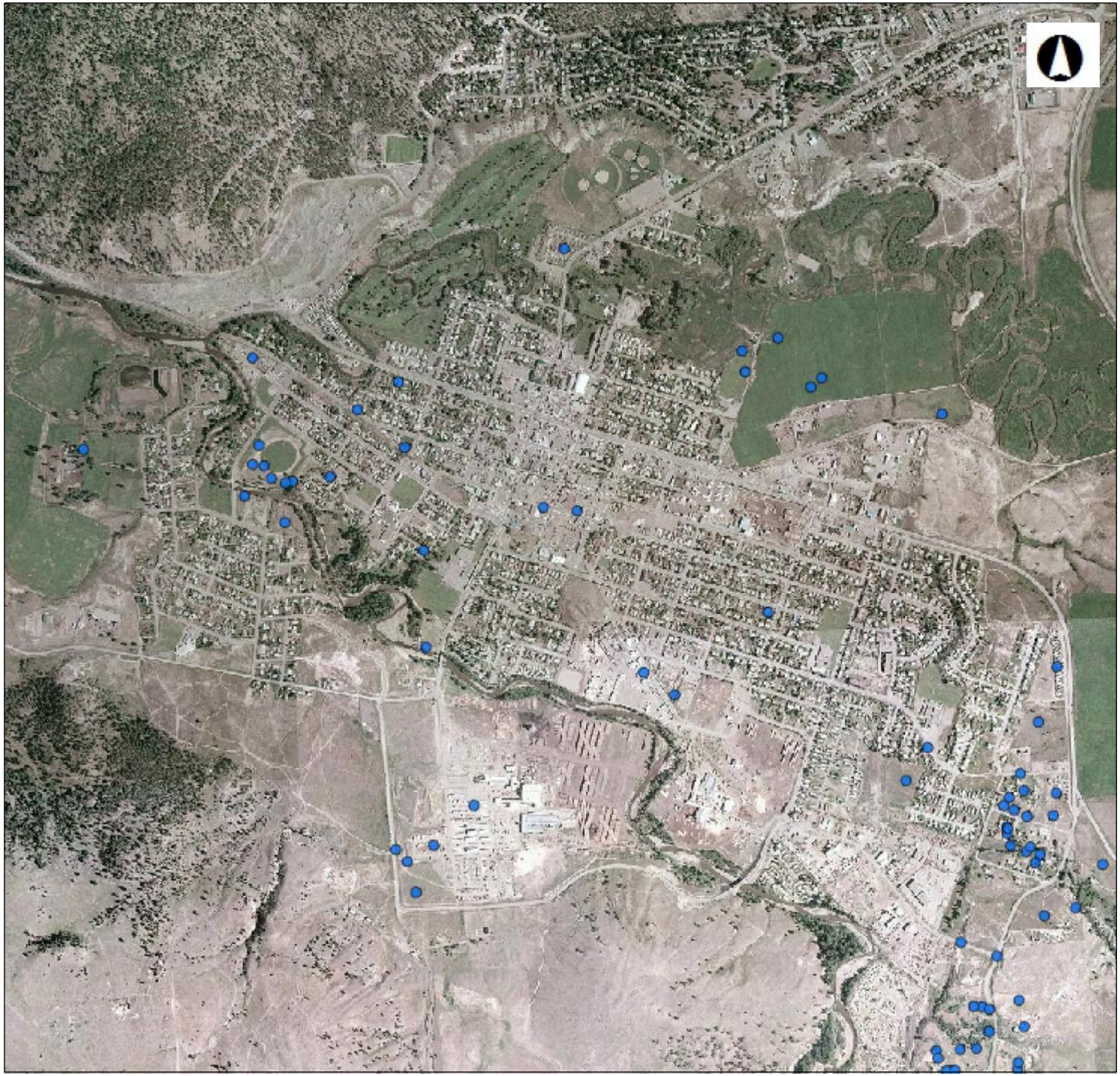
43 records selected for 5.0 km from latitude 50 deg, 06 min, 46.6 sec
and Longitude 120 deg, 47 min, 15.4 sec

Site Id	Lastupd	Address / City
0007751	04APR07	3603 VOGHT STREET MERRITT
0007752	06JUL18	3623 VOGHT STREET MERRITT
0008713	09JAN22	3999 AIRPORT ROAD MERRITT
0010213	16APR13	GODEY PIT - FOXFARM ROAD MERRITT
0010296	09JAN07	1999 NICOLA AVENUE MERRITT
0011281	09JAN21	2288 QUILCHENA AVENUE MERRITT
0011613	11NOV25	2002 NICOLA AVENUE MERRITT
0012062		2490 PRIEST AVENUE MERRITT
0017936	16APR14	1 - 929 COLDWATER ROAD MERRITT
0017941	16APR15	1081 COLDWATER ROAD MERRITT
0017942	16APR15	2845 NEILSON STREET MERRITT
0017943	16APR15	2865 NEILSON STREET MERRITT
0017944	16APR15	2900 POOLEY AVENUE MERRITT
0017945	16APR15	3000 POOLEY AVENUE MERRITT
0017948	16APR15	NEILSON STREET MERRITT
0017949	16APR15	COOK'S FERRY FIRST NATIONS - ANTKO IR #21 MERRITT
0017950	15MAY25	LOWER NICOLA INDIAN BAND - JOEYASKA IR #2 KAMLOOPS
0018645	16APR15	KETTLE VALLEY ROAD AT GODEY PIT MERRITT

Appendix F - Historical Air Photograph Review

Date	Description
2012, 2007, 2005, 2000, 1996, 1991	APA C is a mixture of all zoning types. There is an industrial area in the southeast portion (the majority is just outside of APA C). This area is mostly characterized by several large sawmills as well as other industrial operations. The centre of APA C is dense with commercial properties (Merritt city centre), while to the east of this area there is a mixture of industrial and commercial properties containing several automotive repairs shops, a sawmill, as well as service stations. The east and west portions of APA C are mainly comprised of residential properties and agricultural land. The predominant land uses in APA A and B for the Collettville, Voght Park and Fairley Park wells are residential and parkland, while it is agricultural and residential land use for the Kengard well. The Coldwater River runs through APA A for the Voght Park and Collettville wells.
1986, 1981, 1975	APA C is generally the same as in 1991, except that the commercial and industrial area to the east of the city centre is less developed, and parts of the industrial area in the southeast are less developed. APA A and B for all wells is generally the same as 1991.
1968, 1960	The industrial area in the southeast is still present, however, the easternmost portions of it are less developed than in 1975. The commercial and industrial area to the east of the city centre is not present. Commercial properties in the city centre are less densely developed, and the residential areas in the west and east are also less developed. APA A and B for the Voght Park and Collettville well are generally the same, except there are more forested areas on both sides of the Coldwater River. APA A and B for the Fairley Park well are less densely developed with residential properties. Lastly, APA A and B for the Kengard well is entirely undeveloped or agricultural land.
1948	The industrial area in the southeast portion is no longer visible, though the land appears to be cleared. The city centre is still present, but is much less densely developed with commercial properties. There are small residential developments in the west and east portion of APA C.

Appendix G - Map of Registered Water Wells (BC Water Resource Atlas)



Registered Water Wells

BC Water Resources Atlas 2017

0 0.41 0.81 km

1: 20,000

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CAUTION: Maps obtained using this site are not designed to assist in navigation. These maps may be generalized and may not reflect current conditions. Uncharted hazards may exist. DO NOT USE THESE MAPS FOR NAVIGATIONAL PURPOSES.

Datum: NAD83

Projection: BC Albers

Key Map of British Columbia