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Small Town Redevelopment Dreams

October 2024

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- Legion members of a small hamlet would like to build a small memorial for veterans and utilize the adjacent community hall as new legion building.

02 Methods

- Intrusive investigation to update soil data and collect undisturbed soil cores for hydraulic conductivity analysis.

04 Results

- Updated soil concentrations and new hydraulic conductivity data.

03 Conceptual Site Model

- Site conditions based on information collected at site before 2024.

04 Discussion

- Exclusion of the domestic use aquifer exposure pathway and evidence to support incomplete vapour inhalation exposure pathway.

Introduction

Background

1989

UST removal and excavation including offsite disposal of impacted soil

Removal of seven USTs and excavation of impacted soil. Impacted soil was trucked to a landfill for disposal. Remaining soil and groundwater impacts were left on-and-offsite.

1994

First environmental investigation – eight boreholes + wells

Eight boreholes drilled and all completed as monitoring wells. Two local groundwater supply wells were also sampled from a private property adjacent to the site. The minimal soil and groundwater samples submitted for analysis met applicable guidelines, including those samples submitted from the local supply wells.

2003

Subsequent environmental investigation – 14 borehole + wells

Fourteen boreholes drilled and all completed as monitoring wells. Hydraulic conductivity results were less than 1 x 10^{-7} m/s. Several soil and groundwater samples did not meet applied guidelines. Depth to shallow groundwater was less than three meters in predominantly fine-grained stratigraphy. The deeper DUA utilized by the community was estimated at greater than 10 m in depth.

2004 - Present

Numerous GWMS and updated Supplemental Phase II ESA

Annual or biennial groundwater monitoring and sampling since 2004. Supplemental Phase II ESAs conducted in 2005 and 2011. Soil vapour wells were installed next to residential property west of site. Soil vapour samples met applied guidelines. Subsurface soil and groundwater impacts almost assessed, with further data needed for delineation and hydraulic conductivity.

Supplemental Phase II Environmental Site Assessment

SETTING

All fuel facilities, including seven USTs, were removed in 1989. Some had been in place since 1939. The site is zoned as UR – Urban Residential which accommodates appropriate forms of residential developments within hamlets. The site is covered by grass or gravel. Graveled areas are used as parking for the adjacent community hall.

NEIGHBOURS

- The site is surrounded by roads, utility lanes, and private properties.
- The private properties are zoned UR – Urban Residential or INT – Institutional.
- INT – Institutional zoning accommodates municipal infrastructure, like the community hall that is present adjacent the site.

FEATURES

- **Each developed property within the hamlet has a private groundwater well for domestic use.**
- **Local wells are generally completed 20 m to 40 m in depth.**
- **Shallower groundwater (less than 10 m) has no defined use.**

Supplemental Phase II Environmental Site Assessment

SCOPE

SLR was retained to conduct a Supplemental Phase II Environmental Site Assessment (ESA) at the site. It is located within a hamlet adjacent a major highway. Many lots are empty or underutilized. Further assessment of the site may allow its use for the legion activities.

OBJECTIVE

- Assess natural attenuation of petroleum hydrocarbon (PHCs) in soil and groundwater.
  - Soil PHC concentrations were last assessed in 2011.
  - Groundwater monitoring and sampling has been conducted annually or every two years between 2005 and 2023.
- Assess exclusion of the Domestic Use Aquifer (DUA) exposure pathway.
- Collect data for potential Risk Management Plan (RMP).

SCOPE

- Drill nine boreholes eight to 15 m in depth.
- Install two monitoring wells.
- Submit soil and groundwater samples for benzene, toluene, ethylbenzene, and xylenes (BTEX) and PHC fractions F1-F4 or F1-F2.

Methods

Fieldwork 1-2-3…4

SAFETY

01

USP and private locates

Utility Safety Partners (USP) notification system was used to alert utility owners on and near site. A private utility locator marked utilities not included under the public notification system. Dig Shaw was contacted to check for their utilities of which there were none in the area.

DRILLING

02

Direct-push track rig

Eight boreholes were advanced using a direct push track rig to reduce cross contamination. Auger refusal happened in some boreholes due to stiff clay till. “Shelby” tubes (portions of direct push plastic casing) were collected. One monitoring well was installed.

HYDROVAC

03

Sewer utility near borehole

One borehole was advanced by hydrovac in a utility lane. The location of a sewer line could not be determined. A monitoring well was installed in the hydrovac hole for delineation to the west of site.

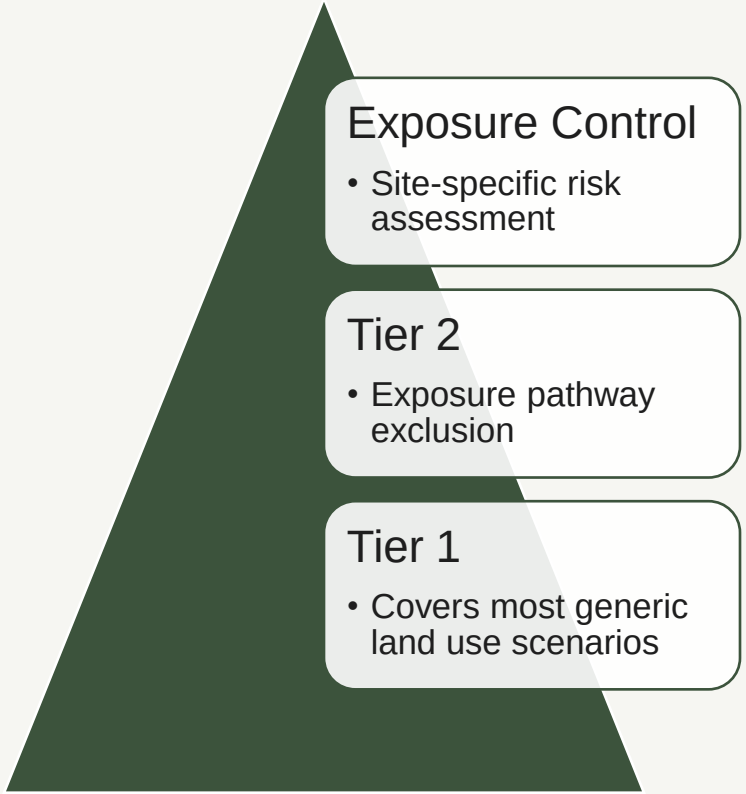
GWMS & SURVEY

04

Tie in new wells to survey

A groundwater monitoring and sampling program was completed approximately two weeks after drilling. All new and existing groundwater monitoring were surveyed to collect top of casing elevation and nearby ground surface elevation.

Regulatory Framework



- Alberta Tier 2 Soil and Groundwater Remediation Guidelines (Tier 2) for Residential Land Use on fine-grained soils, excluding the Freshwater Aquatic Life and Domestic Use Aquifer exposure pathways.
  - Further work is needed to prove the Domestic Use Aquifer can be excluded, which will be explained in Results and Discussion.

Results

Results - Monitoring

Groundwater Elevations & Flow Direction

The average depth to groundwater in monitored wells was 1.27 mbg. Depth to groundwater varied between 0.48 mbg and 3.91 mbg. Groundwater flow direction is northwest. Hydraulic gradient was estimated to be 0.03 m/m.

Monitoring Well Standpipe Vapours

Standpipe headspace vapour levels were below the detection limit of the instrument up to 100 parts per million volume (ppmv).

Light Non-Aqueous Phase Liquids

Light nonaqueous phase liquids were not detected in any monitoring wells.

Results - Analytical

Soil

- Predominantly fine-grained with discontinuous sand lenses.
- Generally met guidelines.
- Laterally and vertically delineated soil impacts.

Groundwater

- Generally met Tier 1 and 2 guidelines.
- Groundwater impacts are laterally assessed.

Hydraulic Conductivity

• The geometric mean of five bulk hydraulic conductivity tests in soil is 3.8 x 10-11, between 7.6 mbg and 11.3 mbg. Shelby tube samples were collected from three unique borehole locations from the site and former service station.

Conceptual Site Model

Conceptual Site Model (1 of 3)

COMPONENT	DETAILS
Areas of Environmental Concern Former service station & bulk plant	Areas of environmental concern include soil and groundwater impacted by the former fueling infrastructure, such as petroleum USTs, supply lines, and pumps.
Contaminants of Concern BTEX, PHC fractions F1-F4	Contaminants of concern associated with former fueling operations are BTEX and PHC fractions F1-F4, which are present in soil and groundwater. Previous assessments have identified that lead is not a contaminant of concern.
Contaminant Migration Scenario Fine-grained stratigraphy	The site is predominantly underlain by fine-grained stratigraphy, which would inhibit vapours moving from depth to surface. There are limited coarse-grained soils on site. Although soil and groundwater impacts are present within these discontinuous coarse-grained soils, it is the majority fine-grained soils which will determine contaminant migration through vapour or groundwater flow.
Exposure Pathways Current and future risks	To evaluate current and future risks from the identified petroleum hydrocarbon impacts in soil and groundwater the following exposure pathways are considered.: (continued on next slide)

Conceptual Site Model (2 of 3)

Exposure Pathways	DETAILS
Vapour Inhalation Human Health – Basement & Sub-slab	Accounts for volatile contaminants vaporizing from soil and/or groundwater into human-occupied spaces. B, X, and PHC fraction F1 exceed guidelines for this pathway. Human-occupied spaces are within 30 m of impacts. It is an applicable and operative pathway.
Direct Soil Contact Human and Ecological	Human direct soil contact is based on incidental ingestion, dermal contact, or inhalation of air-borne soil particles by humans. It is incomplete as impacts are greater than 1.5 m in depth below compacted gravel and clay fill. Ecological direct soil contact is based on plants and invertebrates encountering impacts in soil or shallow groundwater. Impacts are potentially within the plant rooting zone (equal to or less than 1.5 m in depth), but there is limited topsoil onsite. It is incomplete.
Domestic Use Aquifer (DUA) Human Health	DUA is based on human use of groundwater for drinking or bathing. There are no onsite GW users, only adjacent to the site. There is potential to eliminate the DUA due to previous particle size and hydraulic conductivity results.
Freshwater Aquatic Life (FAL) Ecological	FAL pathway is based on aquatic plants, invertebrates, and/or fish being exposed to contaminants where groundwater discharges to a surface water body capable of supporting an aquatic ecosystem. Surface water is not present within 300 m and is inoperative at the site.
Offsite Migration	Offsite migration recognizes commercial and industrial land use may be adjacent more sensitive land uses. Zoning for site is the same, or similar, as surrounding properties. Offsite migration is inoperative at the site.
Management Limits	Management limits are screening criteria to determine if media is heavily impacted and acting as a source. Management limits for some contaminants are exceeded onsite. These concentrations are stable, fully assessed, and appear to not be acting as a source as dissolved hydrocarbons in a nearby monitoring well have consistently been below detection limits.

Conceptual Site Model (3 of 3)

Evaluation of Current Environmental Risk	DETAILS
The potentially operative and complete exposure pathways at site, under its current land use, are vapour inhalation and the domestic use aquifer. Other pathways are inoperative or incomplete due to administrative controls which decrease exposure to soil and groundwater hydrocarbon impacts at the site.	
Vapour Inhalation Human Health – Basement & Sub-slab	Accounts for volatile contaminants vaporizing from soil and/or groundwater into human-occupied spaces. B, X, and PHC fraction F1 exceed guidelines for this pathway. Human-occupied spaces are within 30 m of impacts. It is an applicable and operative pathway.
Domestic Use Aquifer (DUA) Human Health	DUA is based on human use of groundwater for drinking or bathing. There are no onsite GW users, only adjacent site. T**he DUA can be formally excluded due to historical and current particle size and hydraulic conductivity results. Data gaps identified were addressed in the 2024 Supplemental Phase II ESA.**

Discussion

Hydraulic Conductivity

Excluding the Domestic Use Aquifer Exposure Pathway

A domestic use aquifer (DUA) is a geologic unit above the Base of Groundwater Protection (the elevation above mean sea level at which groundwater is naturally non-saline) which has one or more of the following properties:

- A bulk hydraulic conductivity of 1 x 10^{-6} metres per second (m/s) or greater and which is usually at least 0.5 m thick to support a sustained yield of 0.76 litres per minute or more.

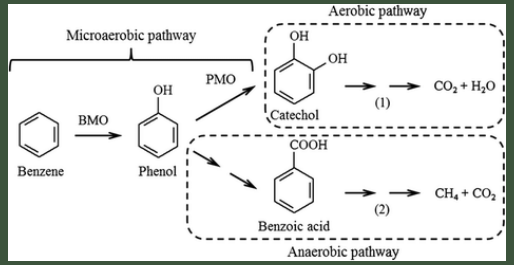
It may be excluded as an operative pathway when:

- At least five metres of massive, undisturbed, unfractured fine-grained material exists with a bulk hydraulic conductivity less than or equal to 1 x 10-7 m/s below the depth of impact.
- Contaminants of concern have a solubility of 10 grams per liter or less.

In-situ and ex-situ hydraulic conductivity results from the site show:

- The geometric mean of seven hydraulic conductivity tests from above 10.5 m is 2.4 x 10^{-8} m/s.
- The geometric mean of five hydraulic conductivity tests from below 10.5 m is 1.6 x 10^{-9} m/s
- Both are less than the 1 x 10^{-6} m/s required for a DUA.

Comparison of Soil PHC Concentrations



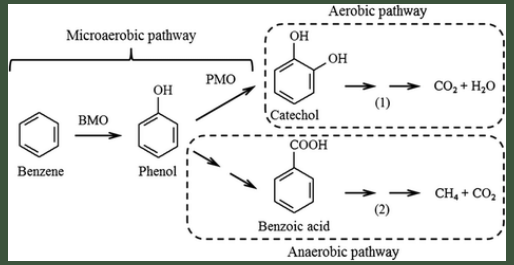
Firmino et al. (2018). Applicability of Microaerobic Technology to Enhance BTEX Removal from Contaminated Waters. Applied Biochemistry and Biotechnology. 184. 1-13. 10.1007/s12010-017-2618-x.

*Concentrations below the detection limit were estimated as one-half the detection limit for calculations. Concentrations were not calculated where: a) detection limits had changed between sampling events, b) both concentrations were below the detection limit, and c) both concentrations were less than 5x the detection limit.

Parameter	Benzene	Toluene	Ethylbenzene	Xylenes	F1	F2	F3	F4
Unit	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
BH207 (2.30 mbg) - drilled in 2002	1.1	0.24	3.5	1.5	120	86	12	22
BH407 (2.00 mbg) - drilled in 2011	0.93	0.06	3.2	0.065	230	81	33	20
Numeric	-0.17	---	-0.30	---	110	-5	---	---
Percent	-15%	---	-9%	---	92%	-6%	---	---
BH303 (2.50 mbg) - drilled in 2004	0.86	< 0.1	1.2	< 0.1	67	18	42	20
BH502 (2.70-3.00 mbg) - drilled in 2024	0.0098	< 0.050	< 0.010	< 0.045	< 10	< 10	< 50	< 50
Numeric	---	---	-1.20	---	-62	-13	---	---
Percent	---	---	- > 99%	---	-93%	-72%	---	---
BH208 (3.40 mbg) - drilled in 2002	5	2	7.2	12	150	43	88	89
BH502 (3.80-4.10 mbg) drilled in 2024	0.27	< 0.050	0.078	0.12	< 10	< 10	< 50	< 50
Numeric	-4.73	-1.98	-7.12	-11.88	-145	-38	---	---
Percent	-95%	-99%	-99%	-99%	-97%	-88%	---	---
BH406 (1.50 mbg) - drilled in 2011	140	480	110	730	8200	1600	31	< 10
BH501 (1.50-1.70 mbg) - drilled in 2024	19	7.1	10	16	870	170	< 50	< 50
Numeric	-121	-473	-100	-714	-7330	-1430	---	---
Percent	-86%	-99%	-91%	-98%	-89%	-89%	---	---
BH406 (6.90 mbg) - drilled in 2011	0.099	0.13	0.043	0.23	< 12	22	350	200
BH501 (6.10-6.40 mbg) - drilled in 2024	< 0.0050	< 0.050	< 0.010	< 0.045	< 10	26	350	190
Numeric	-0.097	-0.11	---	---	---	---	0	---
Percent	-97%	-81%	---	---	---	---	0%	---
BH406 (8.40 mbg) - drilled in 2011	0.16	0.28	0.068	0.35	< 12	< 10	170	75
BH501 (8.20-8.50 mbg) - drilled in 2024	< 0.0050	< 0.050	< 0.010	< 0.045	< 10	< 10	130	67
Numeric	-0.16	-0.26	-0.063	---	---	---	---	---
Percent	-98%	-91%	-93%	---	---	---	---	---

No change
Increase
Decrease

Dissolved Hydrocarbon Concentrations



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Monitoring Well	Benzene	Toluene	Ethylbenzene	Xylenes	F1	F2
BH207	No Trend	No Trend	No Trend	Stable	No Trend	Stable
BH208	Decreasing	Decreasing	Decreasing	Decreasing	No Trend	Stable
BH209	Stable	Decreasing	Decreasing	Stable	Stable	Stable
BH212	Stable	Stable	Stable	Stable	No Trend	No Trend
BH301	Stable	No Trend	Stable	Stable	Stable	Stable
BH304	No Trend	Stable	Stable	Stable	Stable	Stable

Dissolved hydrocarbon concentration trends were determined using a Mann-Kendall statistical trend test, (USEPA 2009) for monitoring wells with four or more analytical results above the method detection limit. The Mann-Kendall statistical trend test compares single analyte concentration for each groundwater sampling event to all previous events. Concentrations which are the same as the previous sampling events score a “0”, decreases score a “-1”, and increases score a “+1”. Changes in concentration data that were less than five times the RDL are given a ‘0’ score to account for inherent analytical error accounted for in all laboratory methods.

A Mann-Kendall Statistic (S) value is obtained from summing scores and indicates either an increasing or decreasing trend at or more than 95 percent confidence. If a trend cannot be determined by the Mann-Kendall trend test, a stable trend can be estimated using a sensitivity analysis of the Mann-Kendall Statistic and the coefficient of variance (CV) (i.e., confidence less than 95 percent, S less than or equal to 0, and a CV less than one).

Generally, the hydrocarbon plume is decreasing or stable which is acceptable for risk management.

Questions + Comments

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SLR