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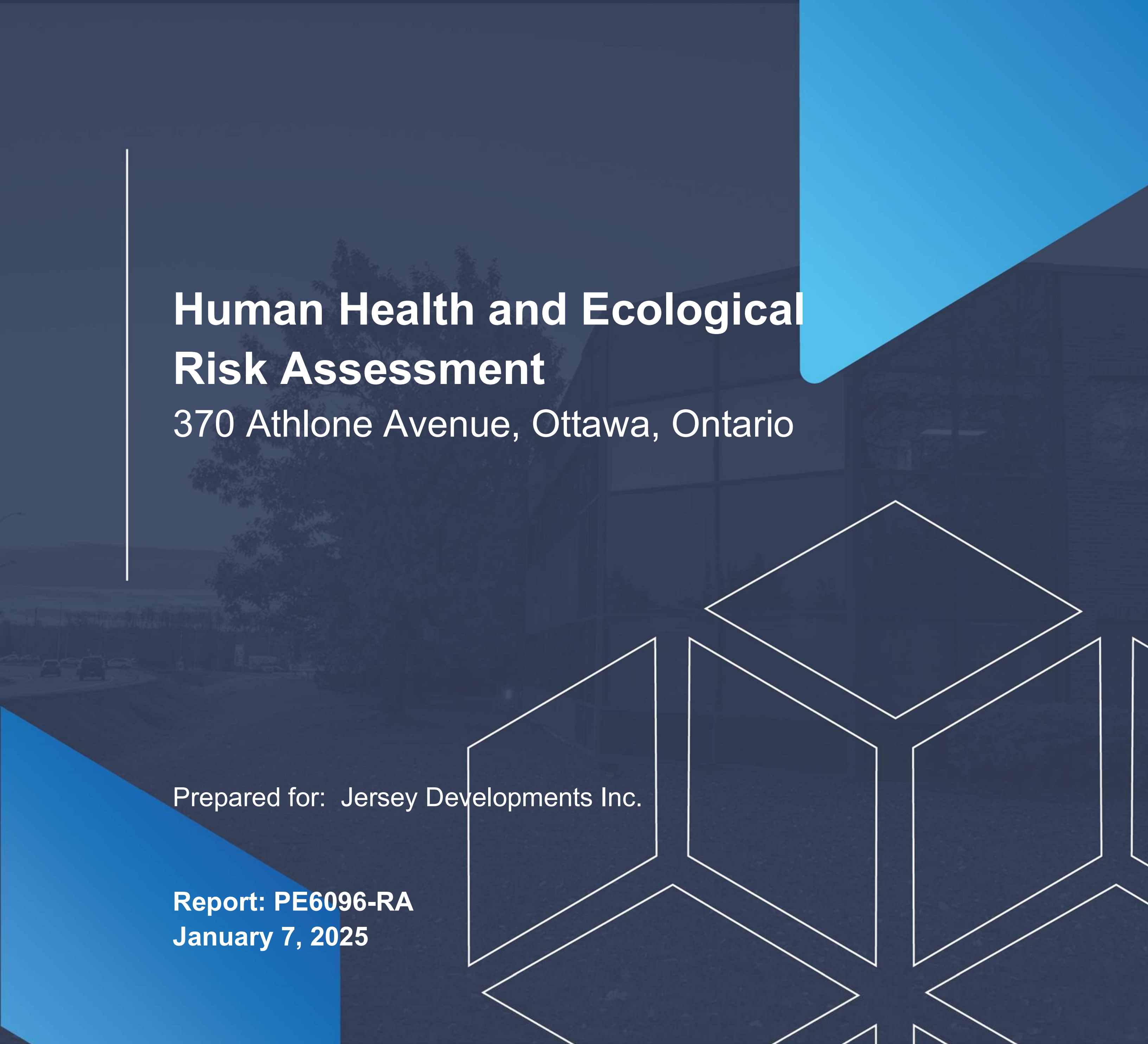

Human Health and Ecological Risk Assessment

370 Athlone Avenue, Ottawa, Ontario

Prepared for: Jersey Developments Inc.

Report: PE6096-RA
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1.0 INTRODUCTION

Paterson Group Inc. (Paterson) was retained by Jersey Developments Inc. to conduct a human health and ecological risk assessment (RA) for the property located at 370 Athlone Avenue in Ottawa, Ontario (the ‘RA Property). Figure 1 shows the general location of the RA Property, while the layout of the property (including property limits) is depicted in Figure 2.

Currently, the RA Property is occupied by a one-storey residential building with a full basement level constructed in 1942, a storage shed, and a detached two-car garage. It is understood that the property may be redeveloped for residential use in the future. As no change in land use is planned, a Record of Site Condition (RSC) under Ontario Regulation 153/04 (as amended) is not required. Accordingly, this RA has been prepared as a “due diligence” risk assessment. The RA will not be used to support an RSC application and will not be submitted for review to the Ministry of the Environment, Conservation and Park (MECP). However, the RA has been prepared pursuant to MECP guidance and has employed the same standards, assumptions, models, and calculations as those used in RAs prepared under O. Reg. 153/04.

1.1 Risk Assessment Objectives and Approach

The objectives of the RA were to:

- ☐ Complete a due diligence risk assessment for the RA Property located at 370 Athlone Avenue, Ottawa, Ontario;
- ☐ Quantitatively or qualitatively assess the risk from exposure to contaminants of concern (COC) in groundwater at the RA Property to the human and ecological receptors that may use the property based on residential land use;
- ☐ Develop risk-based Property Specific Standards (PSS) for COCs in groundwater at the RA Property; and
- ☐ Where unacceptable risks are identified to either human or ecological receptors, propose risk management (RM) measures to mitigate risks associated with COCs present in groundwater at the RA Property.

The RA consisted of identifying the COCs, based on historical evidence and site investigation activities, followed by the identification of appropriate pathways and receptors based on the current and proposed future land use for the RA Property. The last stage of the RA consisted of developing PSS for all the COCs that were screened into the RA in Section 3. Final PSS for all COCs were based on an estimate of the maximum site concentration plus 20% to account for sampling variability. Where risks to human or ecological receptors were identified at the proposed PSS, RM measures to ameliorate or eliminate risks have been provided.

2.0 SITE CHARACTERIZATION

2.1 Property Information

The RA Property is located on the west side of Athlone Avenue, approximately 45 m north of the Richmond Road and Athlone Avenue intersection, in the City of Ottawa, Ontario. Figure 1 shows the general location of the Site. Property details are provided in Table 2-1.

Table 2-1: Site Identification Information

Civic Address	370 Athlone Avenue, Ottawa, Ontario
Current/Proposed Future Land Use	Residential; proposed residential
Zoning	R4UB – Fourth Density Residential Zone
Latitude & Longitude Coordinates	45° 23' 37.932" N, 75° 45' 5.292" W
Property Owner	Jersey Developments Inc.
Site Area	0.05 ha

The property currently is zoned R4UB – Fourth Density Residential Zone. The property is currently occupied with a residential dwelling with associated storage shed and garage.

The neighbouring lands within the study area consist of residential and commercial properties.

Based on the availability of municipal services, no drinking water wells are expected to be present within the study area.

2.2 Physical Setting

A one-storey residential building with a full basement level, a storage shed and a detached two-car garage are present on the RA Property. The majority of the residence is considered to be the original building constructed in 1942 and is currently heated with a natural gas-fired furnace. The residential dwelling is finished on the exterior with vinyl siding and with a sloped shingled roof. The car garage is finished on the exterior with wood siding and has a sloped shingled roof.

The storage shed is finished on the exterior with concrete blocks with a slanted roof.

2.2.1 Topography and Surface Water Drainage

The surface of the RA Property is flat with no significant gradient. No water bodies or areas of natural and scientific interest were identified within the study area. The nearest named water body with respect to the RA Property is the Ottawa River, located approximately 750 m to the northwest.

2.2.2 Geology

The Geological Survey of Canada website on the Urban Geology of the National Capital Area was reviewed as part of this assessment. Based on the available information, the bedrock in the area of the subject site consists of interbedded limestone and dolomite of the Gull River Formation. The surficial geology consists of glacial till plains, with an overburden thickness ranging from approximately 2 m to 3 m.

Paterson conducted a subsurface investigation in May 2023 as part of a Phase II Environmental Site Investigation (ESA). Three boreholes (BH1-23 to BH3-23) were advanced to a depth of 7.60 m below ground surface (mbgs) and terminated within the bedrock. The subsurface soil profile encountered at the borehole locations consisted of fill material (concrete slab or topsoil, crushed stone, gravel, brown silty sand and trace clay) to depths between 1.45 and 1.72 mbgs, underlain by silty sand to sandy silt and glacial till. Bedrock was encountered/confirmed at depths ranging from 4.88 mbgs to 5.28 mbgs.

2.2.3 Hydrogeology

All three boreholes advanced at the RA Property in May 2023 were instrumented with groundwater monitoring wells (BH1-23–BH3-23). Groundwater levels were measured on May 23, 2023. Groundwater was encountered within the overburden at depths ranging from 4.55 m to 4.67 m below the existing ground surface. Using the groundwater elevations recorded during the sampling event, groundwater contour mapping was completed. Groundwater flow was calculated to be in a southern direction with a horizontal hydraulic gradient of approximately 0.006 m/m.

2.3 Contaminants of Concern

2.3.1 Potentially Contaminating Activities

Based on the Phase I and II ESA, four potentially contaminating activities (PCAs) resulting in three areas of potential environmental concern (APECs) were identified on the RA Property. PCAs and APECs are identified in Table 2-2.

Table 2-2: Areas of Potential Environmental Concern

APEC	Location of APEC	PCA	Location of PCA	Contaminants of Potential Concern	Media Potentially Impacted
APEC #1 Former Auto body shop	Western Portion of Site	*Item 10: Commercial Autobody Shops*	0 m West	BTEX PHCs (F_1-F_4) VOCs	Soil and/or Groundwater
APEC #2 Former retail fuel outlet with one (1) UST and Former auto service garage	Eastern Portion of Site	*Item 28: Gasoline and Associated Products Storage in Fixed Tanks* *Item 52: Storage, Maintenance, Fuelling, and Repair of Equipment, Vehicles, and Material Used to Maintain Transportation Systems*	40 m Southeast	BTEX PHCs (F_1-F_4)	Soil and/or Groundwater
APEC #3 Former dry cleaners	Southern Portion of Site	*Item 37 – Operation of Dry Cleaning Equipment (where chemicals are used)*	70 m South	VOCs	Soil and/or Groundwater

Other off-site PCAs were identified within the Phase I Study Area but were deemed not to be of any environmental concern based on their separation distances as well as their inferred down-gradient or cross-gradient orientation with respect to anticipated groundwater flow.

Fill of questionable quality was identified during the drilling program. A layer of fill was encountered above native soils in each of the boreholes at the RA Property to a depth of between 1.45 and 1.72 mbgs. The fill of a questionable quality is considered to be a fourth APEC on the RA Property.

The contaminants of potential concern (COPCs) associated with the APECs are considered to be:

- ☐ Benzene, Toluene, Ethylbenzene, and Xylenes (BTEX);
- ☐ Petroleum Hydrocarbons (PHCs, F1-F4);

- ☐ Volatile organic compounds (VOCs);
- ☐ Polycyclic Aromatic Hydrocarbons (PAHs);
- ☐ Metals.

2.3.2 Previous Investigations

Paterson investigated the subsurface conditions at the RA Property through a soil and groundwater sampling program. The site condition standards (SCS) for the RA Property were obtained from Table 3 of the document entitled, *"Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act"*, prepared by the MECP and dated April 15, 2011. The selected MECP standards were based on the following considerations:

- ☐ Full depth soil conditions – The site is not considered to have a shallow soil condition hereby one-third of the site consists of soil equal to or less than two meters in depth;
- ☐ Coarse-grained soil conditions – Coarse-grained soil standards were chosen as a conservative approach; grain size analysis was not completed;
- ☐ Non-potable groundwater conditions – The City of Ottawa does not rely on groundwater as a source of potable water;
- ☐ Residential land use;
- ☐ The RA Property is not a sensitive site:
    - ○ The site consists of lands more than 30 m from surface water and there are no environmentally sensitive areas within 30 m of the site; and
    - ○ The pH of the surface soil is assumed to be between 5 and 9 and the pH of the subsurface soil is assumed to be between 5 and 11;

A total of 22 soil samples and seven rock core samples were obtained from the three boreholes advanced in May 2023 by means of auger and split spoon sampling. Seven soil samples were submitted for analysis of metals, PAHs, PHC F1–F4, and VOCs. Concentrations of all PHC and VOC parameters were less than the laboratory method detection limits (MDL) in the soil samples analyzed. Concentrations of the following parameters exceeded Table 3 SCS in soil sample BH3-23-AU1:

- ☐ Metals: Arsenic, lead, molybdenum;

☐ PAHs: Acenaphthylene, benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-cd]pyrene.

Concentrations of metals and PAHs in all other soil samples were less than Table 3 SCS.

Three groundwater samples collected May 23, 2023, were submitted for laboratory analysis of PHCs F1-F4 and VOCs. Concentrations of PHCs and VOCs were less than Table 3 SCS with the exception of the following:

☐ VOCs: 1,2-*cis*-dichloroethylene, tetrachloroethylene, trichloroethylene.

The three VOCs above exceeded Table 3 SCS in all three groundwater samples.

2.3.3 Identification of Contaminants of Concern

COCs were identified by comparing maximum measured concentrations to the Table 3 SCS for coarse soil texture and residential land use. Any chemical detected at the RA property that exceeds the applicable SCS is considered to be a COC and was assessed within the RA.

The COCs identified through the chemical screening process were further evaluated in Section 3 (HHRA) and Section 4 (ERA). Chemicals retained for either quantitative and/or qualitative analysis are discussed in the respective human health or ecological secondary screening sections.

2.3.3.1 Contaminants of Concern in Soil

Soil contaminants at the RA Property were present in the shallow fill material. It is understood that the property owner intends to remediate soil impacts by excavating and removing all fill material from the RA Property prior to redevelopment. A confirmatory soil sampling program will be conducted to demonstrate that soil at the RA Property meets Table 3 SCS prior to construction of a new building. As such, risks from soil contaminants were not evaluated in the RA.

2.3.3.2 Contaminants of Concern in Groundwater

Contaminants of concern in groundwater were determined by screening the maximum measured concentrations of chemical parameters against applicable Table 3 SCS. The COC screening of groundwater is summarized in Table 2-3.

Table 2-3: Identification of Contaminants of Concern in Groundwater

Parameter	Max. conc. (µg/L)	Table 3 SCS [a] (µg/L)	COC	Rationale
Petroleum Hydrocarbons				
Benzene	<0.5	44	No	RDL < Table 3 SCS
Ethylbenzene	<0.5	2,300	No	RDL < Table 3 SCS
Toluene	<0.5	18,000	No	RDL < Table 3 SCS
Xylenes	<0.5	4,200	No	RDL < Table 3 SCS
PHC F1	220	750	No	Max. < Table 3 SCS
PHC F2	<100	150	No	RDL < Table 3 SCS
PHC F3	<100	500	No	RDL < Table 3 SCS
PHC F4	<100	500	No	RDL < Table 3 SCS
Volatile Organic Chemicals				
Acetone	<5.0	130,000	No	RDL < Table 3 SCS
Bromodichloromethane	<0.5	85,000	No	RDL < Table 3 SCS
Bromoform	<0.5	380	No	RDL < Table 3 SCS
Bromomethane	<0.5	5.6	No	RDL < Table 3 SCS
Carbon tetrachloride	<0.2	0.79	No	RDL < Table 3 SCS
Chlorobenzene	<0.5	630	No	RDL < Table 3 SCS
Chloroform	<0.5	2.4	No	RDL < Table 3 SCS
Dibromochloromethane	<0.5	82,000	No	RDL < Table 3 SCS
1,2-Dichlorobenzene	<0.5	4,600	No	RDL < Table 3 SCS
1,3-Dichlorobenzene	<0.5	9,600	No	RDL < Table 3 SCS
1,4-Dichlorobenzene	<0.5	8	No	RDL < Table 3 SCS
Dichlorodifluoromethane	<1.0	4,400	No	RDL < Table 3 SCS
1,1-Dichloroethane	<0.5	320	No	RDL < Table 3 SCS
1,2-Dichloroethane	<0.5	1.6	No	RDL < Table 3 SCS
1,1-Dichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
1,2-cis-Dichloroethylene	**49.8**	**1.6**	**Yes**	**Max. > Table 3 SCS**
1,2-trans-Dichloroethylene	<0.5	1.6	No	RDL < Table 3 SCS
1,2-Dichloropropane	<0.5	16	No	RDL < Table 3 SCS
1,3-Dichloropropene	<0.5	5.2	No	RDL < Table 3 SCS
Ethylene dibromide	<0.2	0.25	No	RDL < Table 3 SCS
n-Hexane	<1.0	51	No	RDL < Table 3 SCS
Methylene chloride	<5.0	470,000	No	RDL < Table 3 SCS
Methyl ethyl ketone	<5.0	610	No	RDL < Table 3 SCS
Methyl isobutyl ketone	<5.0	140,000	No	RDL < Table 3 SCS
Methyl tert-butyl ether	<2.0	190	No	RDL < Table 3 SCS
Styrene	<0.5	1,300	No	RDL < Table 3 SCS
1,1,1,2-Tetrachloroethane	<0.5	3.4	No	RDL < Table 3 SCS
1,1,2,2-Tetrachloroethane	<0.5	3.2	No	RDL < Table 3 SCS
Tetrachloroethylene	**1,550**	**1.6**	**Yes**	**Max. > Table 3 SCS**
1,1,1-Trichloroethane	<0.5	640	No	RDL < Table 3 SCS
1,1,2-Trichloroethane	<0.5	4.7	No	RDL < Table 3 SCS
Trichloroethylene	**87.0**	**1.6**	**Yes**	**Max. > Table 3 SCS**
Trichlorofluoromethane	<1.0	2,500	No	RDL < Table 3 SCS
Vinyl chloride	<0.5	0.5	No	RDL < Table 3 SCS

[a] Table 3 Generic Site Condition Standards (SCS) in a Non-Potable Groundwater Condition, of the April 15, 2011 Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act* (MOE 2011c)
RDL – Reported detection limit

The following parameters are considered to be COCs at the Site:

☐ VOCs: 1,2-*cis*-dichloroethylene, tetrachloroethylene, trichloroethylene.

Because chlorinated ethylene compounds were detected in groundwater, Paterson evaluated potential risk from vinyl chloride formed by the degradation of five chlorinated ethylene compounds: tetrachloroethylene, trichloroethylene, and three isomers of dichloroethylene (1,1-, *cis*-1,2-, and *trans*-1,2-dichloroethylene). The theoretical future concentration of vinyl chloride was calculated by assuming that 10% of each of the five parent compounds could break down to yield vinyl chloride, and then summing those contributions to the maximum measured concentration of vinyl chloride (Table 2-4).

Table 2-4: Calculation of Potential Future Vinyl Chloride Concentrations in Groundwater

Parameter	Maximum measured concentration or RDL (µg/L)	Potential future concentration (µg/L)	Theoretical future vinyl chloride concentration (µg/L)
1,1-Dichloroethylene	0.5	0.05	169.28
1,2-*cis*-Dichloroethylene	49.8	4.98	
1,2-*trans*-Dichloroethylene	0.5	0.05	
Tetrachloroethylene	1,550	155	
Trichloroethylene	87	8.7	
Vinyl chloride	0.5	0.05	

To ensure that a conservative assessment of potential health concerns for human and ecological receptors, potential analytical variance in the sampling programs completed above was addressed through the use of reasonable estimated maximum (REM) estimates for each parameter screened into the RA. The REM estimate was calculated as the maximum measured concentration plus 20%. Because of the inherent conservatism of the future vinyl chloride estimate, the REM value for this parameter was not calculated and risks were evaluated at the maximum (future) concentration.

3.0 HUMAN HEALTH RISK ASSESSMENT (HHRA)

Human health risks were assessed using methodology developed by Ontario MECP and other health and environment authorities in Canada (e.g., Health Canada) and internationally (e.g., U.S. EPA) that stepwise identifies, characterizes, and integrates the elements of risk.

3.1 Problem Formulation

The problem formulation identifies the human receptors at the Site and the potential pathways by which they could be exposed to COCs. This information is summarized in a conceptual site model (CSM).

3.1.1 Human Health Conceptual Site Model

The human health CSM provides an integrated representation of how environmental media and human receptors are connected. The human health CSM is illustrated in Figure 3.

Subsurface investigations at the RA Property identified the presence of chlorinated VOCs in groundwater at concentrations greater than Table 3 SCS. Soil as a contaminated medium was not assessed in the RA, as all contaminated fill material will be removed from the RA Property prior to redevelopment.

Environmental transport pathways relevant to the site include: (i) volatilization of soil and groundwater COCs into the residential building proposed for the RA Property.

Receptors that are assessed in the HHRA include (i) residents (all ages), (ii) adult construction workers, (iii) adult outdoor workers, and (iv) visitors (all ages). Receptors are discussed in detail in Section 3.2.1.

Exposure pathways that are considered in the HHRA include (i) groundwater contact pathways (ingestion and dermal contact), and (ii) groundwater vapour inhalation. Exposure pathways are discussed in detail in Section 3.2.2.

3.1.2 Identification of COCs for HHRA

A total of three COCs were identified in groundwater by comparing maximum-detected concentrations to MECP Table 3 SCS (as summarized above in Section 2.3). To determine which groundwater COCs required quantitative human health assessment, REM concentrations were screened against component values protective of indoor air inhalation by residents (GW2). As groundwater is not used as a potable water source, screening against component values for direct contact (GW1) was not required. The component value screening is shown in Table 3-1.

Table 3-1: Screening of Groundwater COCs for HHRA

COC	Maximum conc. (μg/L)	REM conc. (μg/L)	Residential inhalation GW2 (μg/L)	Assessment
Dichloroethylene, 1,2-cis-	49.8	59.76	**1.6**	***Inhalation***
Tetrachloroethylene	1550	1,860	**1.6**	***Inhalation***
Trichloroethylene	87	104.4	**1.6**	***Inhalation***
VC (future)	169.28	169.28	**0.16**	***Inhalation***

Bold – component value exceeded by REM concentration.

All three of the groundwater COCs plus future vinyl chloride required quantitative assessment via inhalation pathways.

Note that if a COC was identified as only requiring assessment via one pathway (e.g., inhalation) it was nonetheless conservatively also assessed via the other pathways where possible (i.e., it was also assessed via direct contact). This was to ensure that COCs were conservatively assessed via pathways for which no component values are available (e.g., construction worker exposure to vapours while in a trench or excavation; exposure to groundwater vapours in outdoor air).

3.2 Exposure Assessment

3.2.1 Receptor Characteristics

3.2.1.1 Residents

Residents were quantitatively assessed with regard to inhalation of groundwater vapours in indoor air. Biological characteristics and exposure frequency/duration parameters to quantitatively assess these pathways are provided in Table 3-2. As shown, default values recommended by MECP and/or Health Canada were used for all applicable parameters for a toddler (used to assess non-cancer risk, because if the toddler is not at risk then there is high confidence no other age category is at risk) and for a full-life composite receptor (used to assess cancer risk, because a person could be exposed for their entire life).

Table 3-2: Resident Exposure Parameters

Characteristic	Units	Toddler	Full-life composite	Reference
Body weight	kg	16.5	70.7	MOE (2011)
Inhalation	m^3/hour	0.346	0.655	Health Canada (2012)
Time indoors	hours/day	24	22.5	MOE (2011)
	days/year	350	350	MOE (2011)
Exposure duration	years	4.5	76	MOE (2011)

Table 3-2: Resident Exposure Parameters

Characteristic		Units	Toddler	Full-life composite	Reference
Averaging period	Non-carcinogens	years	4.5	76	MOE (2011)
	Carcinogens	years	76	76	MOE (2011)

Note: Values for composite receptor calculated based on pro-rating all other life stages.

3.2.1.2 Construction Workers

People performing subsurface work (e.g., construction activities or utility maintenance) were quantitatively assessed with regard to the following exposure pathways: inhalation of groundwater vapours in trench air, and direct contact (ingestion and dermal contact) with groundwater in a trench. The extent to which construction/utility work may occur at the site is unknown, but standard HHRA practice is to typically assess an adult construction worker as a receptor due to their potential for higher intake of COCs. Biological characteristics and exposure frequency/duration parameters to quantitatively assess these pathways are provided in Table 3-3. As shown, default values recommended by MECP for a “construction/subsurface worker” were used for most parameters, with the exception of the following:

- *Days per year working in a trench*: MECP does not provide default exposure frequency values for a construction worker working in a trench or excavation. A frequency of 50 days/year was assumed in exposure calculations. This frequency is >25% of the overall exposure frequency of 195 days per year assumed by MECP for the frequency of exposure at a construction site and is deemed reasonably conservative.
- *Groundwater ingestion rate while working in a trench*: Construction workers have been assumed to incidentally ingest groundwater at a rate of 0.15 L/day (150 mL/day, or ~15.3 mL/hour, every hour during a 9.8 hour workday). This is considered conservative, as it is approximately 1/15th MECP’s daily rate for the ingestion of potable water by an adult (the MOE 2011 *Rationale* document lists a rate of 2.3 L/day), and approximately 1/5th U.S. EPA’s hourly rate for the incidental ingestion of water by swimmers (U.S. EPA 2011 *Exposure Factors Handbook* lists a rate of 71 mL/h).
- *Groundwater dermal contact rate while working in a trench*: Construction workers have been assumed to have 10 groundwater-contact events through the course of their workday (i.e., periodic splashing of groundwater onto their hands or arms), with each event lasting 20 seconds (0.006 hours) before the small amounts of water on the skin evaporate or are wiped away. The assumption of 10 events/day at 0.006 hours/event gives final dose estimates

results approximately equal to the dose estimates that would be calculated with an assumption of one event/day at 0.58 hours/event. This latter set of assumptions is the Reasonable Maximum Exposure (RME) scenario from U.S. EPA 2004 *RAGS Part E* guidance for an adult who is showering/bathing.

Table 3-3: Construction Worker Exposure Parameters

Characteristic		Units	Typical adult	Reference
Body weight		kg	70.7	MOE (2011)
Skin	Surface area	cm^2	3,400	MOE (2011)
Intake rates	Groundwater ingestion	L/day	0.15	US EPA (2011) Exposure Factors Handbook
	Inhalation	m^3/hour	1.5	MOE (2011)
Time outdoors		hours/day	9.8	MOE (2011)
		days/year	195	MOE (2011)
Time in trench		hours/event	0.006	Assumed
		events/day	10	Assumed
		days/year	50	Assumed
Exposure duration		years	1.5	MOE (2011)
Averaging period	Non-carcinogens	years	1.5	MOE (2011)
	Carcinogens	years	56	MOE (2011)

3.2.1.3 Outdoor Workers

People working outside (e.g., maintenance or landscaping duties) were quantitatively assessed with regard to inhalation of groundwater vapours in outdoor air. Biological characteristics and exposure frequency/duration parameters to quantitatively assess these pathways are provided in Table 3-4. As shown, default values recommended by MECP for a “long-term outdoor worker” were used for all applicable parameters.

Table 3-4: Outdoor Worker Exposure Parameters

Characteristic		Units	Typical adult	Reference
Body weight		kg	70.7	MOE (2011)
Inhalation		m^3/hour	1.5	Assumption (same as construction worker)
Time outdoors		hours/day	9.8	MOE (2011)
		days/year	195	MOE (2011)
Exposure duration		years	56	MOE (2011)
Averaging period	Non-carcinogens	years	56	MOE (2011)
	Carcinogens	years	56	MOE (2011)

3.2.1.4 Visitors

Visitors of all age groups may visit residential units at the RA Property. The greatest potential source of exposure to COCs for residential visitors is inhaling groundwater vapours that have migrated to the indoor environment. Default exposure frequency values are not provided by MECP for such receptors. However, the frequency of exposure would reasonably be expected to be much less than that of an actual resident. Therefore, the results for residents (i.e., the calculated human health-based values) will be protective of residential visitors. On this basis, residential visitors were not quantitatively assessed in the remaining sections of the HHRA.

3.2.2 Pathway Analysis

3.2.2.1 Groundwater Ingestion and Dermal Contact

The equations used to quantitatively estimate exposure to groundwater COCs are presented in Appendix A. The applicability of these pathways at this site is summarized in Table 3-5.

Table 3-5: Exposure Pathway Summary – Groundwater

Source	Pathway	Receptor	Assessment	Rationale	Exposure frequency and duration
Ground-water	Drinking water ingestion	All receptors	None	Non-potable site	–
	Incidental ingestion and dermal contact in situ	Construction workers	Quantitative	Incidental exposure while in a trench is a pathway of concern	0.006 hours/event, 10 events/day, 50 days/year, 1.5 years
		All other receptors	None	Not reasonably expected to contact groundwater *in situ*	–

3.2.2.2 Vapour Inhalation Pathways

The equations used to quantitatively estimate exposure to groundwater COCs via vapour inhalation pathways are presented in Appendix A. The applicability of these pathways at this site is summarized in Table 3-6.

Table 3-6: Exposure Pathway Summary – Vapours

Source	Pathway	Receptor	Assessment	Rationale	Exposure frequency and duration
Ground-water	Vapour inhalation	Construction workers	Quantitative (trench air)	Assessed to be conservative	9.8 hours/day, 50 days/year, 1.5 years
		Outdoor workers	Quantitative (outdoor air)	Assessed to be conservative	9.8 hours/day, 195 days/year, 56 years
		Residents	Quantitative (indoor air)	Pathway of concern and component values were exceeded	Toddler: 24 hour/day, 350 days/year, 4.5 years Full-life/composite: 22.5 hour/day, 350 days/year, 76 years
		Visitors	Qualitative (indoor air)	Receptor will have less exposure than residents	–

Indoor vapour modelling was performed for proposed residential building based on plans provided to Paterson Group. All model inputs are provided in Appendix B. The following site-specific input parameters were used:

- Dimensions: 2,132 cm by 1,219 cm – The proposed building occupies an area of 2,797 square feet or 259.85 m^2 with dimensions 21.32 m by 12.19 m.
- Depth below grade to bottom of floor: 200 cm.
- Height: 255 cm – The interior height of the indoor area on the ground floor was 8 foot and 4.25 inches or 2.55 m.
- Slab thickness: 21 cm.

All other parameters were set equal to a generic building with a high rate of air exchange. Groundwater contamination was modelled at 455 cm below grade (minimum depth to groundwater measured at the site was 4.55 m).

3.2.2.3 Negligible Exposure Pathways

Vapour skin contact was qualitatively identified, but not assessed quantitatively or discussed further in the RA as its contribution to overall COC exposure is considered negligible. In addition, the development of a reliable exposure estimate for this pathway has not been identified in the scientific literature or through other recognized regulatory agencies.

3.2.3 Exposure Estimates

Exposure estimates were calculated using standard models and equations (refer to Appendix B). For direct contact exposure pathways, exposure estimates were calculated as average daily does (ADD) summing contributions from dermal contact and incidental groundwater ingestion. These summed values were compared to TRVs in the risk characterization phase.

Trichloroethylene is a developmental toxicant. Health risks from developmental toxicants were assessed differently than other COCs. Exposure calculations used adult female characteristics and did not pro-rate exposure frequencies.

Exposure estimates for groundwater COCs are presented in Table 3-7 (oral/dermal pathways) and Table 3-8 (inhalation pathways).

Note that all exposure estimate results are also provided in detail in Appendix B.

Table 3-7: Exposure Estimates – Groundwater COC Oral/Dermal Contact

	Total average daily dose			
COC	Toddler resident (mg/kg-day)	Full life/ composite resident (mg/kg-day)	Construction worker (mg/kg-day)	Outdoor worker (mg/kg-day)
Dichloroethylene, 1,2-cis-	–	–	2.29E-05	–
Tetrachloroethylene	–	–	1.35E-03	–
Trichloroethylene	–	–	4.32E-05	–
Trichloroethylene (developmental)	–	–	1.89E-03	
Vinyl chloride (future)	–	–	5.88E-05	–

Table 3-8: Exposure Estimates – Groundwater COC Inhalation

	Total groundwater vapour concentration			
COC	Toddler resident (mg/m^3)	Full life/ composite resident (mg/m^3)	Construction worker (mg/m^3)	Outdoor worker (mg/m^3)
Dichloroethylene, 1,2-cis-	5.46E-03	5.12E-03	4.10E-06	4.65E-07
Tetrachloroethylene	6.48E-01	6.08E-01	5.41E-04	6.09E-05
Trichloroethylene	2.29E-02	2.14E-02	1.86E-05	2.09E-06
Trichloroethylene (developmental)	2.39E-02	2.39E-02	3.32E-04	9.58E-06
Vinyl chloride (future)	1.54E-01	1.45E-01	1.14E-04	1.28E-05

3.2.3.1 Uncertainties in the Exposure Assessment

Each of the areas of the exposure assessment described above is associated with some level of uncertainty. To ensure that estimates of exposure to COCs were not underestimated, conservative assumptions were used throughout the exposure assessment. In combination, these conservative assumptions have the effect of almost certainly overestimating exposure to the COCs. Uncertainties and the ways in which they were dealt with include the following.

Groundwater concentrations of the COCs at the site exhibit variability. It was assumed in the risk assessment that the maximum detected concentration of each COC was representative of the entire site. This is a highly conservative assumption when one considers the frequency of detection, the frequency of exceeding the SCS, and the measures of central tendency and variability at the site. Notwithstanding, this assumption ensures that health risks are not underestimated, and in fact means that the results of this risk assessment almost certainly overestimate potential health risks associated with the site.

The maximum concentrations plus 20% of COCs detected in the soil and groundwater were used for this assessment rather than estimates developed using the central tendency (CT) or upper bound estimates such as the 95% upper confidence limit (UCL) on the mean. Consequently, exposure estimates (ADDs), while taking into account sampling variability, are likely conservatively overestimated. Consequently, the actual exposure (and ultimately hazard and risk) associated with COCs at the site is likely to be lower.

A number of conservative assumptions have also been made regarding estimates of receptor characteristics (e.g., daily ingestion rates, inhalation rates, skin surface areas, days per year on site, exposure durations). Combining the conservative point estimates of each of these parameters with the REM concentration effectively overestimates the calculated exposures for receptors potentially exposed to COCs at the site.

Exposure estimates were conservatively assessed in the absence of risk management measures. For example, construction worker exposure to groundwater in a trench was assessed, even though it is expected that trenches will be dewatered prior to commencing work (as required under O. Reg. 231/91, Section 230), and that appropriate basic personal protective equipment (PPE) will be worn during construction activities.

The use of any mathematical model to estimate ingestion, dermal or inhalation exposure of COCs in groundwater introduces a moderate degree of uncertainty. For example, a number of assumptions are typically fundamental to Johnson and Ettinger subsurface vapour intrusion modelling (e.g., vapour transport is through a homogeneously porous medium; steady state conditions exist at the site; an infinite source of contamination exists; mixing in the building is uniform; no preferential pathways exist; and transformation processes such as biodegradation do not occur). Although these assumptions are not necessarily realistic, they are nonetheless conservative and ensure that the predicted concentrations of COC vapour reaching indoor air are not underestimated.

COC vapour concentrations were estimated in trench air, despite no component values being available for this pathway, and were estimated in outdoor air, despite component values for this pathway being unavailable (groundwater-to-outdoor air).

3.3 Toxicity Assessment

3.3.1 Hazard Assessment

The hazard assessment categorizes the types of adverse health effects a COC may potentially cause. COCs are typically categorized with respect to the nature of their toxicity in three main ways:

- ☐ Chemicals that cause adverse health effects other than cancer;
- ☐ Chemicals that cause cancer; and
- ☐ Chemicals that act as developmental toxicants.

All the COCs in this HHRA have the potential to cause adverse health effects unrelated to cancer. All except molybdenum are considered carcinogens. Trichloroethylene is classified as a developmental toxicant.

3.3.2 Dose-Response Assessment

Dose-response assessment is the process of characterizing the relationship between the dose of an agent administered or received and the incidence of an adverse health effect in the exposed population. Once the relationship is characterized then a toxicological reference value (TRV) can be established. TRVs were obtained from MECP (mostly Canadian and U.S. EPA sources) or, if not available, other recognized regulatory jurisdictions.

3.3.2.1 Threshold-Acting Chemicals

TRVs for non-carcinogenic chemicals are classified based on whether the exposure is from oral/dermal contact or from inhalation pathways. For oral and dermal pathways, TRVs may be reported as a tolerable daily intake (TDI) or a reference dose (RfD) and are expressed in units of mg/k/day. For inhalation pathways, TRVs may be reported as a tolerable concentration (TC) or a reference concentration (RfC) and are reported in units of mg/m^3.

The TRVs used to assess non-cancer hazard in the HHRA are provided in Table 3-9. MECP-recommended TRVs were used for all COCs.

Table 3-9: Human Health TRVs – Threshold Health Effects

COC	Type	Value	Units	Source
1,2-cis-Dichloroethylene	Oral	2.0E-03	mg/kg/day	MOE 2011
	Inhalation	1.5E-01	mg/m^3	MOE 2011
Tetrachloroethylene	Oral	6.0E-03	mg/kg/day	MOE 2011
	Inhalation	4.0E-02	mg/m^3	MOE 2011
Trichloroethylene	Oral	5.0E-04	mg/kg/day	MOE 2014
	Inhalation	2.0E-03	mg/m^3	MOE 2014
Vinyl chloride	Oral	3.0E-03	mg/kg/day	MOE 2011
	Inhalation	1.0E-01	mg/m^3	MOE 2011

nv – no value available.

3.3.2.2 Non-Threshold-Acting Chemicals

TRVs for non-threshold-acting chemicals (carcinogens) for oral/dermal pathways are referred to as cancer slope factors (CSF) and are expressed in units of (mg/kg/day)$^{-1}$. The CSF can be defined as an upper bound, approximating a 95% confidence limit, on the increased cancer risk from a lifetime exposure to an agent. TRVs for inhalation pathways are referred to as unit risk factors (URF) with units of (mg/m^3)$^{-1}$. URFs represent excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 mg/m^3 in air.

The TRVs used to assess cancer risk in the HHRA are summarized and referenced in Table 3-10. MECP-recommended TRVs were used for all COCs.

Table 3-10: Human Health TRVs – Non-Threshold Health Risks

COC	Type	Value	Units	Basis
Tetrachloroethylene	Oral	2.1E-03	(mg/kg/day)$^{-1}$	MOE 2014
	Inhalation	2.6E-04	(mg/m^3)$^{-1}$	MOE 2014
Trichloroethylene	Oral	4.6E-02	(mg/kg/day)$^{-1}$	MOE 2014
	Inhalation	4.1E-03	(mg/m^3)$^{-1}$	MOE 2014
Vinyl chloride	Oral (full life)	1.4E+00	(mg/kg/day)$^{-1}$	MOE 2011
	Oral (adult only)	7.2E-01	(mg/kg/day)$^{-1}$	MOE 2011
	Inhalation (full life)	8.8E-03	(mg/m^3)$^{-1}$	MOE 2011
	Inhalation (adult only)	4.4E-03	(mg/m^3)$^{-1}$	MOE 2011

nv – no value available.

3.3.2.3 Developmental Toxicants

Developmental toxicity is accounted for in the Exposure Assessment by excluding pro-rating factors. As previously stated, one of the COCs in this RA is classified as a developmental toxicant (TCE).

3.3.2.4 Uncertainties in the Toxicity Assessment

In the dose-response assessment, the major sources of uncertainty concerning the toxicity assessment include the extrapolation from high doses in animals to low doses in humans, and conservative assumptions built into the derivation of TRVs. Each of the toxicologically based exposure limits used to estimate potential health risks have uncertainty factors associated with them. These factors largely account for the strength of the toxicological data and incorporate uncertainty factors to account for intra-species and interspecies extrapolations of toxicological data as well as extrapolations from acute and sub-chronic exposure studies to chronic exposures.

The assumed cancer slope factors and unit risks provided by the regulatory jurisdictions were assumed to be reliable and accurate in characterizing the relationship between chemical concentrations, doses and adverse health effects. Most regulatory agencies typically derive cancer slope factors by evaluating the 95% upper confidence limit of the slope of the dose response curve. The use of this upper limit is highly conservative and is intended to account for uncertainties that are brought upon, for example, by the use of experimental animals. This linear relationship assumption implies that any concentration of a carcinogen other than zero increases the risk of developing cancer by some extent, which could lead to a significant overestimation of the total risk.

3.4 Risk Characterization

3.4.1 Quantitative Interpretation of Human Health Risks

Quantitative risk estimates were generated for each relevant COC/pathway/receptor by calculating one or both of:

- ☐ A hazard quotient (HQ) for potential non-cancer health effects. The method/equation to calculate a HQ value is presented below. All HQ output/results are presented in the tables that follow, as well as in Appendix A. The HQ considered acceptable for most COCs is 0.2 (i.e., 20% of one's allowable exposure to a contaminant is permitted to come from a single contaminated site, thereby providing an allowance for 80% of allowable exposure to come from sources unrelated to the site).

$$\mathrm{HQ} = \frac{\text{Exposure estimate}}{\text{TRV}}$$

- ☐ An incremental lifetime cancer risk (ILCR) for potential risk of developing cancer. The method/equation to calculate an ILCR value is presented below. All ILCR output/results are presented in the tables that follow, as well as in Appendix A. The ILCR considered acceptable by MECP is 0.000001 (i.e., 1×10^{-6}, one-in-one-million, or 0.0001%).

$$\mathrm{ILCR} = \text{Exposure estimate} \times \frac{\text{Years exposed}}{\text{Amortization period}} \times \text{TRV}$$

Quantitative risk estimates are interpreted as follows:

- ☐ Groundwater oral/dermal pathways (Table 3-11): HQ values for tetrachloroethylene and trichloroethylene (developmental) exceeded acceptable limits. The ILCR value for trichloroethylene (developmental) exceeded the acceptable limit of 10^{-6}.
- ☐ Groundwater inhalation pathways:
  - Residents (Table 3-12) – Unacceptable HQ and ILCR values were calculated for tetrachloroethylene, trichloroethylene, and vinyl chloride.
  - Construction workers (Table 3-13) – HQ and ICLR values were less than acceptable limits for all COCs.
  - Outdoor workers (Table 3-14) – HQ and ICLR values were less than acceptable limits for all COCs.

Table 3-11: Risk Results from Groundwater COC Oral/Dermal Contact – Construction Worker

COC	Groundwater REM (µg/L)	Non-cancer hazard Total oral/dermal dose (mg/kg-day)	Oral TRV (mg/kg-day)	HQ	Cancer risk Amortized oral/dermal dose (mg/kg-day)	Oral TRV $(mg/kg\text{-}day)^{-1}$	ILCR
Dichloroethylene, 1,2-cis-	59.76	2.29E-05	2.00E-03	1.15E-02	6.14E-07	-	-
Tetrachloroethylene	1,860	1.35E-03	6.00E-03	**2.25E-01**	3.62E-05	2.10E-03	7.60E-08
Trichloroethylene	104.4	4.32E-05	5.00E-04	8.64E-02	1.16E-06	4.60E-02	5.32E-08
Trichloroethylene (Developmental)	104.4	1.89E-03	5.00E-04	**3.77E+00**	5.06E-05	4.60E-02	**2.33E-06**
Vinyl chloride (future)	169.28	5.88E-05	3.00E-03	1.96E-02	1.58E-06	1.40E+00	2.21E-06

Table 3-12: Risk Results from Groundwater COC Inhalation – Residents

COC	Groundwater REM (µg/L)	Non-cancer hazard Total inhaled conc. (mg/m^3)	Inhalation TRV (mg/m^3)	HQ	Cancer risk Amortized inhaled conc. (mg/m^3)	Inhalation TRV $(mg/m^3)^{-1}$	ILCR
Dichloroethylene, 1,2-cis-	59.76	5.46E-03	1.50E-01	3.64E-02	5.12E-03	-	-
Tetrachloroethylene	1,860	6.48E-01	4.00E-02	**1.62E+01**	6.08E-01	2.60E-04	**1.58E-04**
Trichloroethylene	104.4	2.29E-02	2.00E-03	**1.14E+01**	2.14E-02	4.10E-03	**8.79E-05**
Trichloroethylene (Developmental)	104.4	2.39E-02	2.00E-03	**1.19E+01**	2.39E-02	4.10E-03	**9.78E-05**
Vinyl chloride (future)	169.28	1.54E-01	1.00E-01	**1.54E+00**	1.45E-01	8.80E-03	**1.27E-03**

Table 3-13: Risk Results from Groundwater COC Inhalation – Construction Workers

		Non-cancer hazard			Cancer risk		
COC	**Groundwater REM (µg/L)**	**Total inhaled conc. (mg/m^3)**	**Inhalation TRV (mg/m^3)**	**HQ**	**Amortized inhaled conc. (mg/m^3)**	**Inhalation TRV (mg/m^3)$^{-1}$**	**ILCR**
Dichloroethylene, 1,2-cis-	59.76	4.10E-06	1.50E-01	2.74E-05	1.10E-07	-	-
Tetrachloroethylene	1,860	5.41E-04	4.00E-02	1.35E-02	1.45E-05	2.60E-04	3.77E-09
Trichloroethylene	104.4	1.86E-05	2.00E-03	9.28E-03	4.97E-07	4.10E-03	2.04E-09
Trichloroethylene (Developmental)	104.4	3.32E-04	2.00E-03	1.66E-01	8.88E-06	4.10E-03	3.64E-08
Vinyl chloride (future)	169.28	1.14E-04	1.00E-01	1.14E-03	3.06E-06	8.80E-03	2.69E-08

Table 3-14: Risk Results from Groundwater COC Inhalation – Outdoor Workers

		Non-cancer hazard			Cancer risk		
COC	**Groundwater REM (µg/L)**	**Total inhaled conc. (mg/m^3)**	**Inhalation TRV (mg/m^3)**	**HQ**	**Amortized inhaled conc. (mg/m^3)**	**Inhalation TRV (mg/m^3)$^{-1}$**	**ILCR**
Dichloroethylene, 1,2-cis-	59.76	4.65E-07	1.50E-01	3.10E-06	4.65E-07	-	-
Tetrachloroethylene	1,860	6.09E-05	4.00E-02	1.52E-03	6.09E-05	2.60E-04	1.58E-08
Trichloroethylene	104.4	2.09E-06	2.00E-03	1.04E-03	2.09E-06	4.10E-03	8.57E-09
Trichloroethylene (Developmental)	104.4	9.58E-06	2.00E-03	4.79E-03	9.58E-06	4.10E-03	3.93E-08
Vinyl chloride (future)	169.28	1.28E-05	1.00E-01	1.28E-04	1.28E-05	8.80E-03	1.13E-07

3.4.2 Summary of Required Risk Reduction and Human Health Effects-Based Values

A summary of the HHRA quantitative assessment is presented in Table 3-15.

For threshold-acting chemicals, a *risk reduction factor* for each applicable receptor/pathway/COC that poses a potentially unacceptable risk was calculated using a ratio approach. For most chemicals, the acceptable HQ limit is 0.2. Risk reduction factors were calculated as:

$$\text{Risk reduction} = {}^{\text{HQ}}/_{0.2}$$

For non-threshold-acting chemicals, the risk reduction factor was calculated as:

$$\text{Risk reduction} = {}^{\text{ILCR}}/_{10^{-6}}$$

A human health *effects-based value* below which no adverse effects are anticipated was calculated for each receptor/ pathway/COC that was calculated to pose a potentially unacceptable risk. Effects-based values were calculated as:

$$\text{Effects based value} = \frac{\text{REM concentration}}{\text{Risk reduction factor}}$$

Risk management (RM) measures are needed to accomplish the necessary risk reductions. RM measures are presented in Section 5.2.

Table 3-15: Summary of Human Health-Based Standards for Groundwater COCs

		Minimum risk-based value				
COC	**REM conc. (µg/g)**	**Oral/dermal exposure (µg/g)**	**Vapour exposure (µg/g)**	**Human health standard (µg/g)**	**RM req'd**	**Risk reduction factor**
Dichloroethylene, 1,2-cis-	49.8	1.04E+03	3.28E+02	3.28E+02	No	–
Tetrachloroethylene	1,550	1.65E+03	**1.18E+01**	**1.18E+01**	**Yes**	132
Trichloroethylene	87	2.42E+02	**1.19E+00**	**1.19E+00**	**Yes**	73.3
Trichloroethylene (Developmental)	87	**5.53E+00**	**1.07E+00**	**1.07E+00**	**Yes**	81.5
Vinyl chloride (future)	169.28	**7.68E+01**	**1.33E-01**	**1.33E-01**	**Yes**	1,270

3.4.3 Pathways Assessed Qualitatively

Vapour Skin Contact

The vapour skin contact pathway was not evaluated quantitatively because its contribution to overall COC exposure is considered negligible. In addition, the development of a reliable exposure estimate for this pathway has not been identified in the scientific literature or through other recognized regulatory agencies.

Odours

Odour exposure pathways were not evaluated quantitatively because there is no means to complete a quantitative assessment, as a dose-response relationship between nuisance odours and direct health impacts cannot be quantified. Odours arising from COCs would not be expected to adversely affect human health.

Free-Phase Product

Groundwater component values for the expected development of free-phase product (half-solubility limit) were not exceeded by any COC.

Exposure to free phase product was not evaluated quantitatively because all COCs were less than free phase thresholds for soil and groundwater. There is also no evidence of free product at the site.

3.4.4 Receptors Assessed Qualitatively

As discussed in Section 3.2.1, some on-Site receptors were assessed qualitatively in this HHRA:

- ☐ Visitors represent people who may visit residential units at the Site. These receptors were not evaluated quantitatively because risks to these receptors are assumed to be conservatively represented by potential risks to residents who live at the Site (i.e., it is unlikely a visitor would be at the site longer than the person living there). Health standards protective of residents are considered to provide adequate protection for visitors.

3.5 Discussion of Uncertainty

Within many of the steps of the risk assessment process, assumptions must be made due to a lack of scientific certainty. The use of assumptions introduces some degree of uncertainty into the risk assessment process. As such, to the extent possible conservative assumptions are made throughout the risk assessment to ensure that estimates of risks to human receptors are exaggerated rather than underestimated. While some uncertainty stems from the variability in sample data due to heterogeneity, this has been addressed through the sampling program conducted for the site, and the use of the maximum plus 20% to account for sampling variability.

The predominant uncertainties in the risk were discussed throughout each section of the RA.

In summary, some typical areas of uncertainty encountered in the risk assessment may include:

- ☐ Adequacy of site characterization;
- ☐ Quality of analytical data;
- ☐ Accuracy of modelling;
- ☐ Accuracy of the assumption concerning frequency, duration and magnitude of exposures; and
- ☐ Availability and accuracy of toxicity data.

Although the magnitude of the uncertainties may not be possible to quantify, the nature of the risk assessment process is to err on the side of public health safety.

3.5.1 Quality of the Analytical Data

Overall, it is the opinion of the risk assessor that there is a sufficient description of the subsurface conditions and the soil and groundwater data are of sufficient quality for assessing exposure pathways and risk to relevant human receptors.

To ensure that a conservative assessment of potential health concerns for human receptors was evaluated, the RA considered potential analytical variance in environmental samples. REM estimates were used for each parameter screened into the RA to evaluate risk. The REM estimate is calculated as the maximum concentration plus 20%.

3.5.2 Accuracy of Modelling

Vapour intrusion modeling was completed using the same formulas as outlined and available in the 2004 J&E models (for soil and groundwater). A fundamental aspect of the J&E model is that vapour transport is through a homogeneously porous medium, which is typically not the case. In addition, there are a number of other assumptions that are often used to develop the attenuation coefficient, including:

- ☐ Steady state conditions exist at the site;
- ☐ An infinite source of contamination exists;
- ☐ Mixing in the building is uniform;

❑ No preferential pathways exist; and

❑ Biodegradation (or any other transformation process) does not occur.

In general, some concern has been expressed with the model as it is sensitive to several input parameters that are difficult to validate with the type of information that is collected in a typical field investigation. Where the model is used as a screening tool, the U.S. EPA cautions that *reasonably conservative assumptions based on* available *data be used as input parameters* (U.S. EPA 2004). Overall, the use of J&E is considered to be acceptable.

3.5.3 Availability and Accuracy of Toxicity Data

In the dose-response assessment, the major sources of uncertainty concerning the toxicity assessment include the extrapolation from high doses in animals to low doses in humans, and conservative assumptions built into the derivation of TRVs. Some of the toxicological based exposure limits used to estimate potential health risks have uncertainty factors associated with them. These factors largely account for the strength of the toxicological data and incorporate uncertainty factors to account for intra-species and interspecies extrapolations of toxicological data as well as extrapolations from acute and sub-chronic exposure studies to chronic exposures.

TDI values incorporate uncertainty factors to address the following sources of uncertainty:

❑ The expected differences in responsiveness between humans and animals;

❑ Variability among individuals within the human population;

❑ Extrapolation from a LOAEL to a NOAEL;

❑ Extrapolation from a sub-chronic to chronic exposure; and

❑ An inadequate toxicity database.

These uncertainty factors reflect the adequacy (or inadequacy) of the toxicological data available for each compound. Where toxicological data is poor or limited to one or two studies, large uncertainty factors are applied to ensure adequate protection of sensitive members of the population.

The assumed cancer slope factors and unit risks provided by the regulatory jurisdictions were considered to be reliable and accurate in characterizing the relationship between chemical concentrations, doses and adverse health effects. Most regulatory agencies typically derive cancer slope factors by evaluating the

95% upper confidence limit of the slope of the dose response curve (U.S. EPA, etc.). The use of this upper limit is highly conservative, and is intended to account for uncertainties that are brought upon, for example, by the use of experimental animals. This linear relationship assumption implies that any concentration of a carcinogen other than zero increases the risk of developing cancer by some extent, which could lead to a significant overestimation of the total risk. To reduce uncertainty, and ensure an overall conservative assessment, the most appropriate TRVs have been used from credible agencies to reduce, as much as possible, uncertainty in the TRVs.

Overall, based on our review and investigation, we have concluded that the uncertainties, while present, do not affect the conclusions obtained in the risk assessment.

4.0 ECOLOGICAL RISK ASSESSMENT (ERA)

4.1 Problem Formulation

4.1.1 Ecological Conceptual Site Model

Subsurface investigations at the RA Property identified the presence of metals and PAHs in soil at concentrations greater than Table 3 SCS; and the presence of chlorinated VOCs in groundwater at concentrations greater than Table 3 SCS.

As noted previously, all contaminated soil will be excavated and removed from the RA Property prior to redevelopment. As such, assessment of risks from soil COCs were not evaluated.

COCs at the RA Property are subject to several environmental transport pathways:

- ☐ Volatilization to atmosphere – VOCs may volatilize from groundwater and migrate to shallow soil strata, where they may discharge to the atmosphere. Vapours are rapidly diluted in outdoor air such that effects on ecological receptors typically are not a concern.
- ☐ Subsurface transport – COCs with sufficient aqueous solubility may undergo subsurface transport, potentially discharging to a down-gradient surface water body. The MECP refers to this exposure pathway as the GW3 pathway.
- ☐ Degradation – VOCs can be degraded over time by both abiotic and biotic pathways.

The nearest water body to the site is the Ottawa River, located approximately 750 m northwest of the site. The river is assumed to provide suitable habitat for a variety of aquatic receptors, including aquatic plants, aquatic invertebrates, amphibians, and fish. As several COCs are capable of subsurface transport via groundwater flow, the potential discharge of contaminated groundwater to the Ottawa River is considered a complete exposure pathway.

Potential ecological receptors on and in the vicinity of the RA Property include plants, soil invertebrates, mammals, and birds. The following terrestrial ecological receptors were identified as on-site Valued Ecosystem Components (VECs):

- ☐ Terrestrial plants, including trees, shrubs, herbs, and grasses typically used in landscaping;
- ☐ Soil invertebrates, represented by earthworms;
- ☐ Mammals: herbivorous meadow vole, insectivorous short-tailed shrew;
- ☐ Birds: herbivorous red-winged blackbird; insectivorous American woodcock.

Off-site receptors consisted of the following aquatic receptors (not identified at the species level):

- ☐ Aquatic plant community;
- ☐ Aquatic invertebrate community;
- ☐ Amphibian community; and
- ☐ Fish community.

Given the distribution of contaminants and the conditions at the site, ecological receptors potentially may be exposed to contaminants via the following exposure pathway:

- ☐ Inhalation of vapours – Mammals and birds may inhale volatile COCs in ambient air. This exposure pathway is considered to be minor.
- ☐ Groundwater migration and discharge to surface water (GW3) – Off-site aquatic receptors may be exposed to COCs in groundwater via discharge of contaminated groundwater to a surface water body. Uptake pathways for aquatic receptors include root uptake (aquatic plants) and direct contact (aquatic invertebrates, amphibians, fish).

Exposure of terrestrial plants via root uptake from groundwater was considered to be an incomplete exposure pathway based on the depth to groundwater at the RA

Property. Most plants extend roots to no more than 1 mbgs. Groundwater at the RA Property was determined to be >3 mbgs.

4.1.2 Identification of Chemicals of Concern for ERA

In Section 2, 1,2-*cis*-dichloroethylene, tetrachloroethylene, trichloroethylene, and vinyl chloride were identified as COCs in groundwater of the site based on comparison to Table 3 SCS. REM concentrations of COCs in groundwater were screened against GW3 component values to identify those requiring further examination. The GW3 component value refers to the pathway involving discharge of groundwater to surface water and is intended to protect aquatic receptors.

The generic Table 3 GW3 value is based on a distance of 36.5 m from the contaminant plume to the down-gradient water body. As the minimum distance from the site to surface water is much greater, REM concentrations were also screened against site-specific GW3 values calculated using the Ministry's Modified Generic Risk Assessment (MGRA) model assuming a distance of 750 m. The secondary screening of COCs using the ecological component value for groundwater is presented in Table 4-1.

Table 4-1: Screening of Groundwater COCs for ERA

COC	REM conc. (µg/L)	Generic GW3 (µg/L)	GW3 @750 m (µg/L)	Pathways evaluated
1,2-cis-Dichloroethylene	59.76	180,000	2.86E+06	(none)
Tetrachloroethylene	1,860	11,000	172,000	(none)
Trichloroethylene	104.4	280,000	4.48E+06	(none)
Vinyl chloride (future)	169.28	450,000	7.29E+06	(none)

REM concentrations of all COCs were much less than both generic and site-specific GW3 values. No groundwater COCs were carried forward in the ERA.

4.2 Receptor Characterization

Not required. No COCs requiring quantitative assessment were identified.

4.3 Exposure Assessment

Not required. No COCs requiring quantitative assessment were identified.

4.4 Hazard Assessment

Not required. No COCs requiring quantitative assessment were identified.

4.5 Risk Characterization

Not required. No COCs requiring quantitative assessment were identified.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main findings of the HHRA were as follows:

- ☐ **COCs in groundwater (oral/dermal pathways):** HQ values for tetrachloroethylene and trichloroethylene (developmental) exceeded acceptable limits. The ILCR value for trichloroethylene (developmental) exceeded the acceptable limit of 10^{-6}.
- ☐ **COCs in groundwater (inhalation pathways):**
  - Residents – Unacceptable HQ and ILCR values were calculated for tetrachloroethylene, trichloroethylene, and vinyl chloride.
  - Construction workers – HQ and ICLR values were less than acceptable limits for all COCs.
  - Outdoor workers – HQ and ICLR values were less than acceptable limits for all COCs.

A summary of the risks to human health are presented in Table 5-1.

Table 5-1: Summary of Risk/Hazard Results for Human Receptors

Source	Pathway	Receptor	Endpoint	Risk
Groundwater	Drinking water ingestion	All receptors	Cancer and non-cancer	No risk (non-potable site)
	Incidental ingestion and dermal contact	Construction Worker	Cancer	Trichloroethylene
			Non-Cancer	Tetrachloroethylene, trichloroethylene
	Vapour inhalation	Resident	Cancer	Tetrachloroethylene, trichloroethylene, vinyl chloride
			Non-Cancer	Tetrachloroethylene, trichloroethylene, vinyl chloride
		Construction Worker	Cancer	No risk
			Non-Cancer	No risk
		Outdoor Worker	Cancer	No risk
			Non-Cancer	No risk

The main findings of the ERA were as follows:

☐ Risks to off-site receptors from groundwater contaminants are negligible. Concentrations of groundwater contaminants at the site were less than GW3 values considered to be protective of aquatic life in the nearest water body (Ottawa River).

5.2 Recommendations

It is understood that the fill layer where metal and PAH impacts were found will be excavated and removed prior to redevelopment of the RA Property. Excavation and removal of contaminated soil from the property effectively eliminates risk to humans and ecological receptors from direct contact pathways. It is important to note, however, that removal of soil from the property would not diminish risks to residents from groundwater contaminants via vapour intrusion into a building and risks to construction workers from groundwater contact.

It is recommended that risk management (RM) measures be implemented at the RA Property to mitigate or block potential exposure to groundwater COCs. Simple RM measures that could be implemented at the site are provided in the Risk Management Plan in the following section.

6.0 RISK MANAGEMENT PLAN

RM measures are proposed to diminish or eliminate risk for future residents of a building at the RA Property and construction workers that may encounter contaminated groundwater during intrusive activities.

6.1 Risk Management Performance Objectives

The objective of the RM Plan is to ensure that the potential risks to human health are mitigated. The RM measures must be compatible with the proposed current and future land use of the property (residential) and must be capable of providing the required level of risk reduction with minimal maintenance or inspection.

The required risk reductions for the COCs that were quantitatively assessed in the RA and found to pose potential risks to human health or the environment are provided in Table 6-1.

Table 6-1: Required Risk Reductions for Groundwater COCs

COC	REM conc. (µg/g)	Human Health Risk-based value (oral/dermal) (µg/g)	Human Health Risk-based value (inhalation) (µg/g)	Risk reduction factor
Tetrachloroethylene	1,550	–	1.18E+01	132
Trichloroethylene	87	–	1.19E+00	73.3
Trichloroethylene (D)	87	5.53E+00	1.07E+00	81.5
Vinyl chloride (future)	169.28	7.68E+01	1.33E-01	1,270

The performance objectives of the RMMs are listed in Table 6-2. The objectives of the RM measures are to render the risks/hazards to acceptable levels, primarily by eliminating the exposure pathway or reducing the exposure concentrations.

Table 6-2: Risk Management Performance Objectives

RM measure	Applicable pathways of exposure	Discussion/ rationale	Effective % reduction
Soil Vapour Intrusion Mitigation System (SVIMS)	Vapour inhalation (groundwater source) – residential building indoor air	SVIMS prevents accumulation of vapours in interior spaces	Close to 100%
Health and Safety Plan (H&SP)	Construction workers – oral/dermal contact (groundwater)	H&SP specifies personal protective equipment and best practices to minimize contact with groundwater during trenching activities	Diminishes exposure to acceptable limits

6.2 Risk Management Measures

6.2.1 Soil Vapour Intrusion Mitigation System

Any new building that is to be constructed at the RA Property should include a Soil Vapour Intrusion Mitigation System (SVIMS). This RM measure is designed to ameliorate potential health risks to human receptors as a result of build-up of vapours under the building foundation followed by intrusion into indoor air.

The SVIMS consists of (1) a vapour barrier membrane of sufficient thickness that will envelop the entire sub-grade part of the new building; and (2) a sub-slab depressurization system (SSDS).

To depressurize the sub-slab environment and create a negative pressure with respect to the interior of a future building structure, a sub-slab venting layer is applied prior to the construction of a new building. Pressure differentials created by this system will mitigate vapours from entering the building structure. The passive SVIMS consists of a sub-slab venting layer in combination with a vapour intrusion barrier that envelops the entire sub-grade part of the new building, as follows:

- ☐ Underneath the slab throughout the building area, a sub-slab venting layer consisting of:
  - A network of perforated ventilation pipes (or geocomposite vapour collection drains) embedded in granular materials of sufficient permeability (clear stone) and depth;
  - Vent boxes or junctions (or other suitable venting products) that convey all collected soil-vapours into vent risers.
- ☐ Immediately above the vapour venting layer, a geosynthetic vapour barrier meeting appropriate gas permeability and chemical resistance specifications, with a suitable protective geotextile between the venting layer and the geosynthetic vapour barrier. The vapour barrier can be composed of a high-density polyethylene (HDPE) geomembrane and/or a spray-applied membrane. The membrane must surround the structure at its contact with the ground.
- ☐ Sealing of any penetrations through the geosynthetic vapour barrier to ensure integrity of the SVIMS.
- ☐ Immediately above the geosynthetic vapour barrier and below the concrete slab, a protective marker layer to provide a warning to persons disturbing the slab of the existence of the geosynthetic vapour barrier and the vapour venting layer, so as to protect the integrity of the SVIMS.
- ☐ Vent risers to convey the soil-vapours from the sub-slab vapour venting layer to the outside air above the top of the building by means of wind-driven turbines designed and installed to be readily capable of conversion to active venting by means of an electrical fan or other powered device.

The vapour barrier membrane should be 10 mils (0.25 mm) thick and meet the appropriate gas permeability and chemical resistance specifications to be considered substantially impermeable to the soil vapours. The SVIMS system is to be designed by a qualified licensed P.Eng. experienced in these types of designs and installed by competent installers under the supervision of a licensed P.Eng. As per Ontario Building Code (OBC) requirements, all penetrations through the floor slab are to be sealed air-tight so that volatile COCs do not penetrate into the building. All sumps that collect water must be properly sealed and vented as per OBC.

The performance of the SVIMS should be verified to ensure that it was installed properly. Field inspections by a senior technician supervised by a Qualified Person (QP) should be conducted to confirm that all systems, designs, and RM measures related to the vapour mitigation system have been implemented according to the specifications.

6.2.2 Health and Safety Plan

It was determined in the RA that tetrachloroethylene and trichloroethylene are present in groundwater at concentrations that represent a risk to construction workers via dermal contact or incidental ingestion while working in a trench setting. A health and safety plan (H&SP) should be prepared and implemented by a Competent Person as defined under the *Ontario Health and Safety Act* for any excavation which may extend to depths intersecting groundwater to protect construction workers from potential exposure to contaminants. The health and safety plan should be specific to the planned excavation and must consider the COCs at the site and make provision for occupational hygiene, personal protective equipment (PPE), contingency measures, and documentation.

It is recommended that workers follow appropriate occupational health and safety precautions. Under the *Ontario Occupational Health and Safety Act* and Regulations for Construction Projects (OHSA), all construction workers “shall wear such protective clothing and use such personal protective equipment (PPE) or devices as necessary to protect the worker against the hazards to which the worker may be exposed” (O. Reg. 213/91, s. 21(2)).

At a minimum, the health and safety plan should include the following:

- ☐ All Contractors undertaking excavation works at the Site shall ensure that their on-site employees are adequately trained regarding the following to safely perform their assigned duties:
    - Awareness of potential hazards that may be encountered, including potential for contaminant levels to be in trenches where groundwater is pooling into the trench;
    - Safe working practices that must be followed to minimize health and safety risks;
    - Use, maintenance, and limitations of PPE;
    - Emergency action plans.

The health and safety plan should also address the following:

- ☐ All relevant information concerning the presence of, human exposure to, and risk posed by the property specific contaminants through dermal contact and groundwater ingestion including information in the risk assessment;
- ☐ All relevant information, measures and procedures concerning protection of the persons from exposure to the property specific contaminants and the precautions to be taken when undertaking intrusive activities, including the supervision of workers, occupational hygiene requirements, use of personal protective equipment, provision of air flow augmentation in excavations or other areas or situations of minimal air ventilation, and other protective measures and procedures as appropriate;
- ☐ All relevant information concerning the presence and significance of the risk management measures and requirements which are being, or have been, implemented at the RA Property,
- ☐ The procedures and timing for implementing emergency response and contingency measures and procedures, including contact information, in the event of a health and safety incident.

Personal Protective Equipment Requirements

PPE is required to shield or isolate individuals from the chemical and physical hazards posed by contaminants at a site. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. In addition to safety equipment normally required for excavation works, workers should be equipped with:

- ☐ Tyvek coveralls;
- ☐ PVC or latex gloves;
- ☐ Disposable overboots.

Note that there is a requirement under O. Reg. 231/91, Section 230 to de-water trenches prior to entry. Dewatering of trenches will minimize exposure to contaminants in groundwater for construction/utility workers through direct contact pathways.

7.0 REFERENCES

MOE (2005) Procedures for the Use of Risk Assessment under Part XV.1 of the Environmental Protection Act. Ontario Ministry of the Environment, Standards Development Branch. PIBs 5404e.

MOE (2011) Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario. Standards Development Branch, Ontario Ministry of the Environment, Toronto, Ontario. PIBS 7386e01. April 15, 2011.

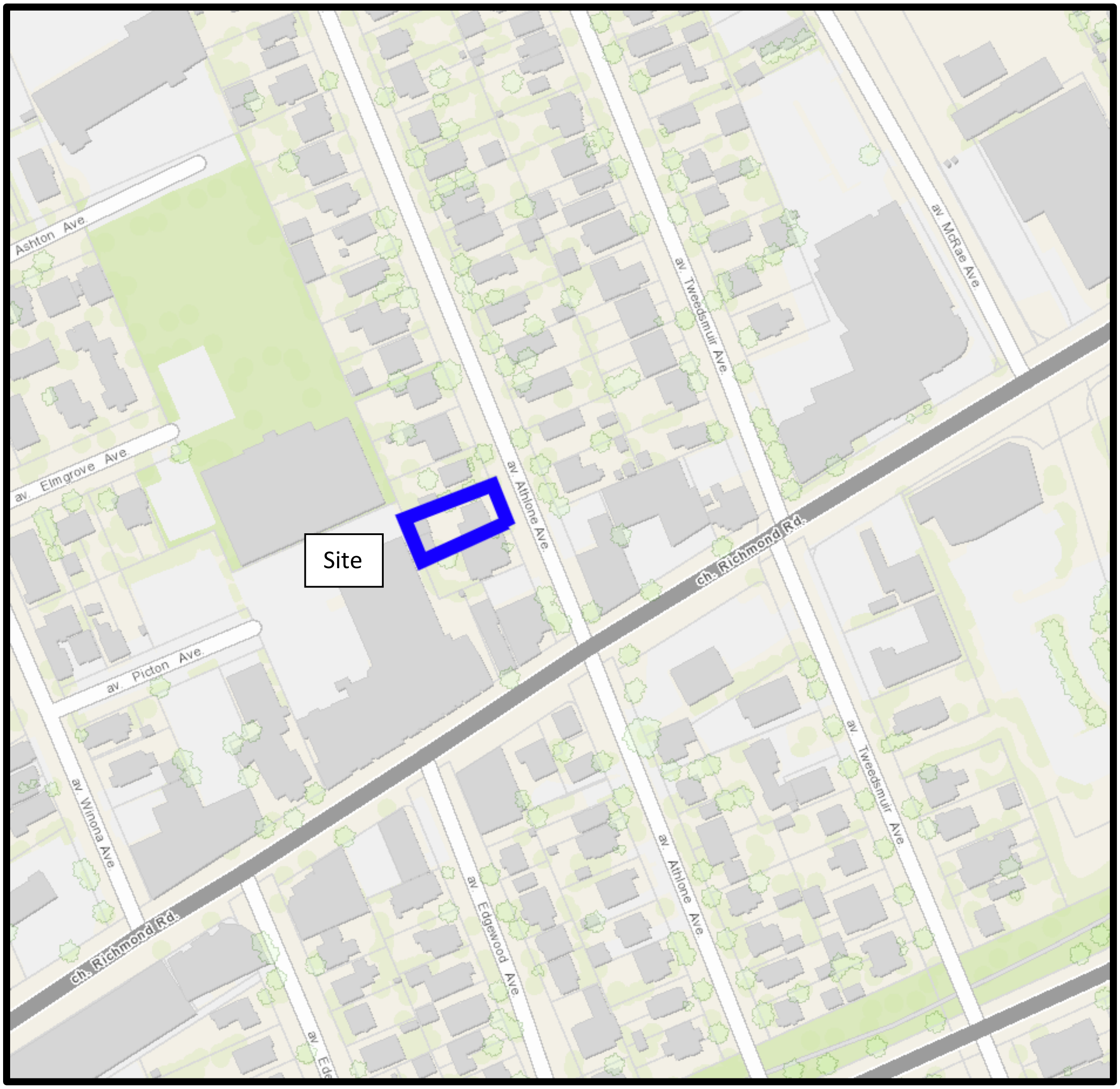
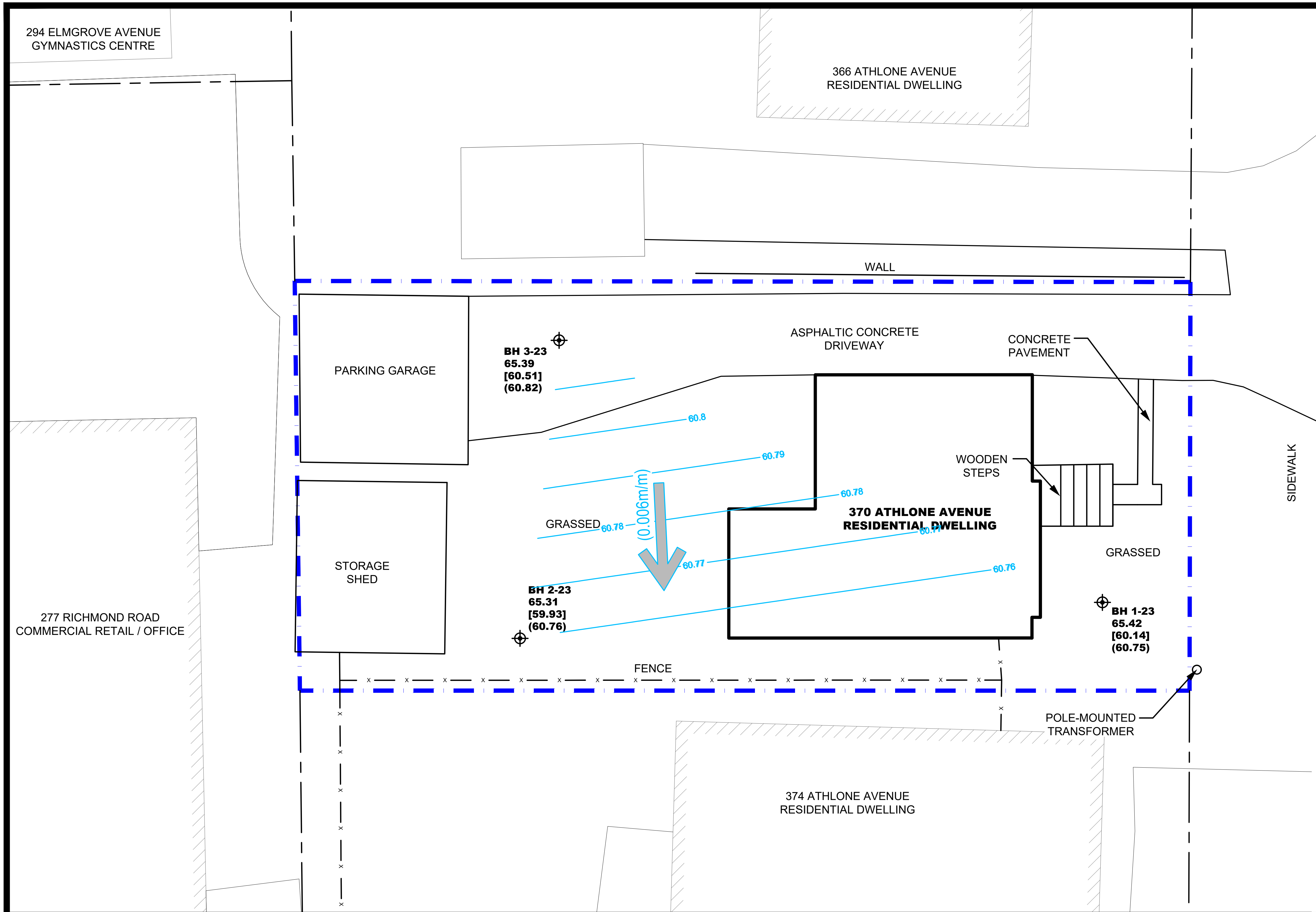


FIGURE 1

KEY PLAN



LEGEND:

⌖	BOREHOLE WITH MONITORING WELL LOCATION
65.31	GROUND SURFACE ELEVATION (m)
[59.93]	BEDROCK SURFACE ELEVATION (m)
(60.76)	GROUNDWATER SURFACE ELEVATION (m)
60.8	GROUNDWATER CONTOUR (m)
↓ (0.006m/m)	APPROX. GROUNDWATER FLOW DIRECTION (HORIZONTAL HYDRAULIC GRADIENT)

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:150

0 1 2 3 4 5 10m

PATERSON GROUP

9 AURIGA DRIVE
OTTAWA, ON
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NO.	REVISIONS	DATE	INITIAL

TONY ZACCONI AND DAVID ASTON

PHASE II - ENVIRONMENTAL SITE ASSESSMENT
370 ATHLONE AVENUE

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:150
Date: 06/2023
Drawn by: YA
Report No.: PE6096-1
Checked by: MR
Dwg. No.: PE6096-2
Approved by: MSD
Revision No.:

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11x17

Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site Receptors							Off-Site Receptors			
				Construction Worker	Outdoor Worker	Indoor Worker	Patron	Resident	Visitor	Trespasser	Construction Worker	Outdoor Worker	Indoor Worker	Community Member
Soil	Soil	Soil	Ingestion											
			Dermal Contact											
	Entrainment	Particulates	Inhalation											
	Volatilization	Outdoor Air	Inhalation											
			Vapour Contact											
			Odour											
		Trench Air	Inhalation											
			Vapour Contact											
			Odour											
		Indoor Air	Inhalation											
			Vapour Contact											
			Odour											
	Bioaccumulation	Garden Produce	Ingestion											
	Leaching	Potable Water	Ingestion											
Groundwater	Groundwater	Potable Water	Ingestion											
			Dermal Contact											
	Pooling in Trench	Trench Water	Ingestion	●										
			Dermal Contact	●										
	Volatilization	Outdoor Air	Inhalation	●	●			○	○					
			Vapour Contact	–	–			–	–					
			Odour	–	–			–	–					
		Trench Air	Inhalation	●										
			Vapour Contact	–										
			Odour	–										
		Indoor Air	Inhalation					●	○					
			Vapour Contact					–	–					
			Odour					–	–					

Legend: ● Major exposure pathway ○ Minor exposure pathway – Negligible exposure pathway

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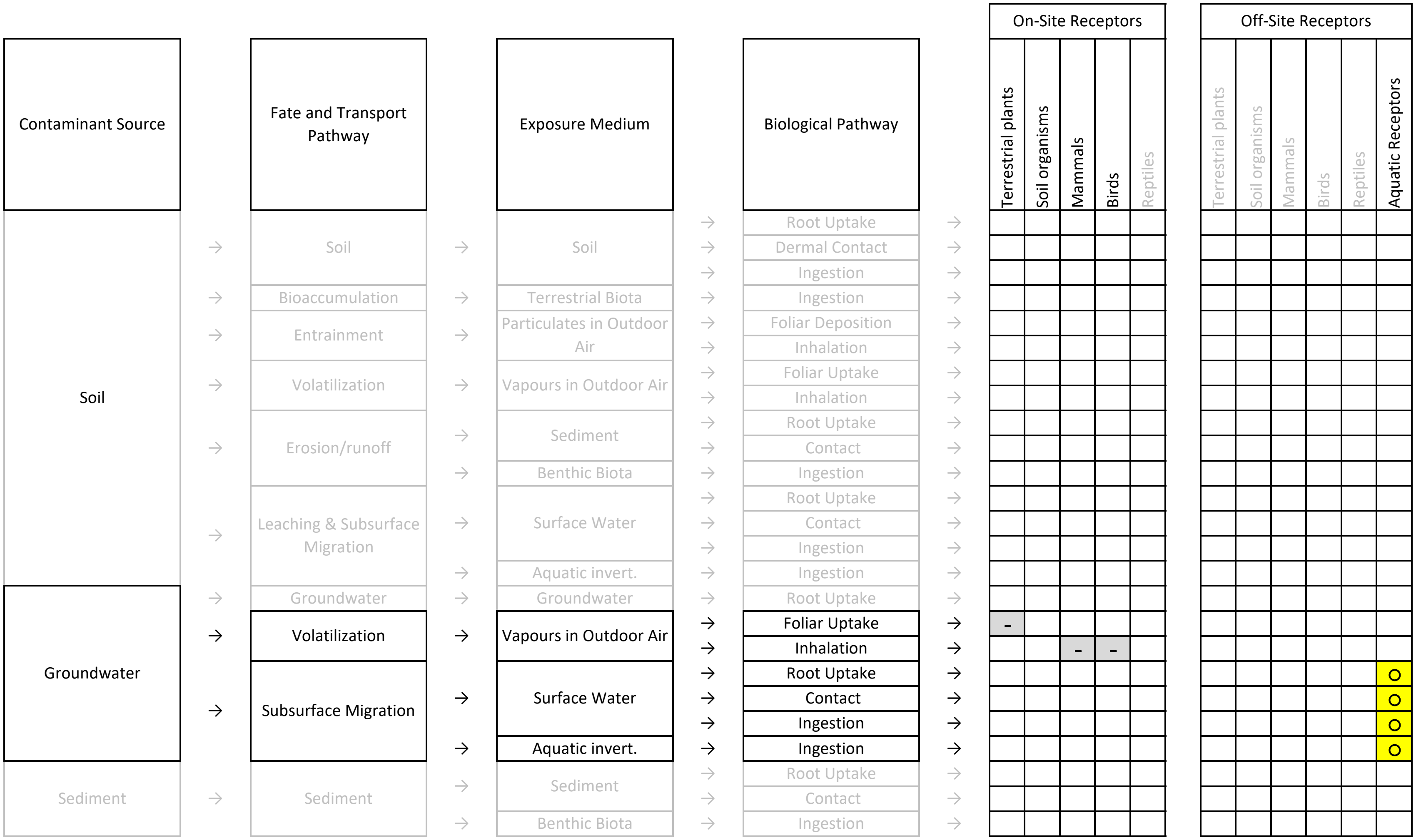
JERSEY DEVELOPMENTS INC.

RISK ASSESSMENT FOR 370 ATHLONE AVENUE

OTTAWA, ONTARIO

HUMAN HEALTH CONCEPTUAL EXPOSURE MODEL

Scale: N/A	Date: 02/2024
Drawn by: CM	Report No.: PE6096-RA
Checked by: MD	Dwg. No.: PE6096-3
Approved by: MD	Revision No.: 0



Contaminant Source	Fate and Transport Pathway	Exposure Medium	Biological Pathway	On-Site Receptors					Off-Site Receptors					
				Terrestrial plants	Soil organisms	Mammals	Birds	Reptiles	Terrestrial plants	Soil organisms	Mammals	Birds	Reptiles	Aquatic Receptors
Soil	Soil	Soil	Root Uptake											
			Dermal Contact											
			Ingestion											
	Bioaccumulation	Terrestrial Biota	Ingestion											
	Entrainment	Particulates in Outdoor Air	Foliar Deposition											
			Inhalation											
	Volatilization	Vapours in Outdoor Air	Foliar Uptake											
			Inhalation											
	Erosion/runoff	Sediment	Root Uptake											
			Contact											
		Benthic Biota	Ingestion											
	Leaching & Subsurface Migration	Surface Water	Root Uptake											
			Contact											
			Ingestion											
		Aquatic invert.	Ingestion											
Groundwater	Groundwater	Groundwater	Root Uptake											
	Volatilization	Vapours in Outdoor Air	Foliar Uptake	-										
			Inhalation			-	-							
	Subsurface Migration	Surface Water	Root Uptake											○
			Contact											○
			Ingestion											○
		Aquatic invert.	Ingestion											○
Sediment	Sediment	Sediment	Root Uptake											
			Contact											
		Benthic Biota	Ingestion											

Legend: ● Major exposure pathway ○ Minor exposure pathway - Negligible exposure pathway

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NO.	REVISIONS	DATE	INIT.
0			

JERSEY DEVELOPMENTS INC.

RISK ASSESSMENT FOR 370 ATHLONE AVENUE

OTTAWA, ONTARIO

ECOLOGICAL CONCEPTUAL EXPOSURE MODEL

Scale: N/A	Date: 02/2024
Drawn by: CM	Report No.: PE6096-RA
Checked by: MD	Dwg. No.: **PE6096-4**
Approved by: MB	Revision No.: 0

APPENDIX A

Analytical Data Summary

Table A1: Soil Analytical Data

Parameter	Units	*Site:*	370 Athlone							No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 R/P/I Coarse	No. exceed
		Sample ID:	BH1-23-AU1 2321086-01	BH1-23-SS5 2321086-03	BH2-23-AU1 2321086-04	BH2-23-SS6 2321086-05	BH3-23-AU1 2321086-06	BH3-23-AU2 2321086-07	BH3-23-SS7 2321086-08							
		Date:	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023							
		Depth:														
pH	–															
Antimony	µg/g		ND (1.0)		ND (1.0)		2.4	ND (1.0)		4	1	1	2.4	2.4	7.5	0
Arsenic	µg/g		4.6		3.2		**80.6**	4.6		4	1	1	**80.6**	**80.6**	18	1
Barium	µg/g		138		100		350	122		4	1	1	350	350	390	0
Beryllium	µg/g		0.5		0.5		1.6	0.5		4	0.5	0.5	1.6	1.6	4	0
Boron (total)	µg/g		9.6		9.4		11.8	13.3		4	5	5	13.3	13.3	120	0
Cadmium	µg/g		ND (0.5)		ND (0.5)		0.6	ND (0.5)		4	0.5	0.5	0.6	0.6	1.2	0
Chromium (Total)	µg/g		25		22.5		24.8	31.6		4	5	5	31.6	31.6	160	0
Cobalt	µg/g		7		6.4		18.8	10.7		4	1	1	18.8	18.8	22	0
Copper	µg/g		18.6		20.8		89.1	27.2		4	5	5	89.1	89.1	140	0
Lead	µg/g		47.4		32.2		**139**	10.3		4	1	1	**139**	**139**	120	1
Molybdenum	µg/g		ND (1.0)		ND (1.0)		**12.2**	1.8		4	1	1	**12.2**	**12.2**	6.9	1
Nickel	µg/g		15.1		12.8		44.6	17.4		4	5	5	44.6	44.6	100	0
Selenium	µg/g		ND (1.0)		ND (1.0)		1.3	ND (1.0)		4	1	1	1.3	1.3	2.4	0
Silver	µg/g		ND (0.3)		ND (0.3)		0.5	ND (0.3)		4	0.3	0.3	0.5	0.5	20	0
Thallium	µg/g		ND (1.0)		ND (1.0)		ND (1.0)	ND (1.0)		4	1	1	0	<1	1	0
Uranium	µg/g		ND (1.0)		ND (1.0)		ND (1.0)	ND (1.0)		4	1	1	0	<1	23	0
Vanadium	µg/g		32.3		31.6		34.4	47.4		4	10	10	47.4	47.4	86	0
Zinc	µg/g		78.8		56.7		138	41.5		4	20	20	138	138	340	0
Acenaphthene	µg/g		ND (0.02)		ND (0.02)		0.06	ND (0.02)		4	0.02	0.02	0.06	0.06	7.9	0
Acenaphthylene	µg/g		ND (0.02)		0.03		**0.31**	ND (0.02)		4	0.02	0.02	**0.31**	**0.31**	0.15	1
Anthracene	µg/g		ND (0.02)		0.05		0.49	ND (0.02)		4	0.02	0.02	0.49	0.49	0.67	0
Benz[a]anthracene	µg/g		0.03		0.13		**2.04**	0.03		4	0.02	0.02	**2.04**	**2.04**	0.5	1
Benzo[a]pyrene	µg/g		0.04		0.13		**2.06**	0.03		4	0.02	0.02	**2.06**	**2.06**	0.3	1
Benzo[b]fluoranthene	µg/g		0.03		0.09		**1.37**	ND (0.02)		4	0.02	0.02	**1.37**	**1.37**	0.78	1
Benzo[ghi]perylene	µg/g		0.03		0.08		0.81	ND (0.02)		4	0.02	0.02	0.81	0.81	6.6	0
Benzo[k]fluoranthene	µg/g		ND (0.02)		0.05		0.76	ND (0.02)		4	0.02	0.02	0.76	0.76	0.78	0
Chrysene	µg/g		0.05		0.15		1.84	0.04		4	0.02	0.02	1.84	1.84	7	0
Dibenz[a,h]anthracene	µg/g		ND (0.02)		ND (0.02)		**0.21**	ND (0.02)		4	0.02	0.02	**0.21**	**0.21**	0.1	1
Fluoranthene	µg/g		0.07		0.27		**4.12**	0.06		4	0.02	0.02	**4.12**	**4.12**	0.69	1
Fluorene	µg/g		ND (0.02)		ND (0.02)		0.09	ND (0.02)		4	0.02	0.02	0.09	0.09	62	0
Indeno[123-cd]pyrene	µg/g		ND (0.02)		0.06		**0.73**	ND (0.02)		4	0.02	0.02	**0.73**	**0.73**	0.38	1
Methylnaphthalene 1-, 2-	µg/g		ND (0.04)		ND (0.04)		0.25	0.08		4	0.04	0.04	0.25	0.25	0.99	0
Naphthalene	µg/g		ND (0.01)		ND (0.01)		0.08	0.02		4	0.01	0.01	0.08	0.08	0.6	0
Phenanthrene	µg/g		0.05		0.23		2.15	0.05		4	0.02	0.02	2.15	2.15	6.2	0
Pyrene	µg/g		0.06		0.22		3.14	0.05		4	0.02	0.02	3.14	3.14	78	0
Benzene	µg/g			ND (0.02)		ND (0.02)			ND (0.02)	3	0.02	0.02	0	<0.02	0.21	0
Ethylbenzene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	2	0
Toluene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	2.3	0
Xylene Mixture	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	3.1	0
Petroleum Hydrocarbons F1	µg/g			ND (7)		ND (7)			ND (7)	3	7	7	0	<7	55	0
Petroleum Hydrocarbons F2	µg/g			ND (4)		ND (4)			ND (4)	3	4	4	0	<4	98	0
Petroleum Hydrocarbons F3	µg/g			ND (8)		ND (8)			ND (8)	3	8	8	0	<8	300	0
Petroleum Hydrocarbons F4	µg/g			ND (6)		ND (6)			ND (6)	3	6	6	0	<6	2800	0
Acetone	µg/g			ND (0.50)		ND (0.50)			ND (0.50)	3	0.5	0.5	0	<0.5	16	0

Table A1: Soil Analytical Data

		Site:	370 Athlone												Table 3 R/P/I	
		Sample ID:	BH1-23-AU1 2321086-01	BH1-23-SS5 2321086-03	BH2-23-AU1 2321086-04	BH2-23-SS6 2321086-05	BH3-23-AU1 2321086-06	BH3-23-AU2 2321086-07	BH3-23-SS7 2321086-08							
		Date:	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023	23-May-2023							
Parameter	*Units*	*Depth:*								No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Coarse	No. exceed
Bromodichloromethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	13	0
Bromoform	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.27	0
Bromomethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Carbon Tetrachloride	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Chlorobenzene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	2.4	0
Chloroform	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Dibromochloromethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	9.4	0
1,2-Dichlorobenzene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	3.4	0
1,3-Dichlorobenzene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	4.8	0
1,4-Dichlorobenzene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.083	0
Dichlorodifluoromethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	16	0
1,1-Dichloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	3.5	0
1,2-Dichloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
1,1-Dichloroethylene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
1,2-cis-Dichloroethylene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	3.4	0
1,2-trans-Dichloroethylene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.084	0
1,2-Dichloropropane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
1,3-Dichloropropene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Ethylene dibromide	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
(n)-Hexane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	2.8	0
Methyl Ethyl Ketone	µg/g			ND (0.50)		ND (0.50)			ND (0.50)	3	0.5	0.5	0	<0.5	16	0
Methyl Isobutyl Ketone	µg/g			ND (0.50)		ND (0.50)			ND (0.50)	3	0.5	0.5	0	<0.5	1.7	0
Methyl tert-Butyl Ether (MTBE)	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.75	0
Methylene Chloride	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.1	0
Styrene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.7	0
1,1,1,2-Tetrachloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.058	0
1,1,2,2-Tetrachloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Tetrachloroethylene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.28	0
1,1,1-Trichloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.38	0
1,1,2-Trichloroethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.05	0
Trichloroethylene	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	0.061	0
Trichlorofluoromethane	µg/g			ND (0.05)		ND (0.05)			ND (0.05)	3	0.05	0.05	0	<0.05	4	0
Vinyl Chloride	µg/g			ND (0.02)		ND (0.02)			ND (0.02)	3	0.02	0.02	0	<0.02	0.02	0

Table A2: Groundwater Analytical Data

Parameter	Units	*Site:*	370 Athlone			No. samples analyzed	Min. RDL	Max. RDL	Max. detected	Max. for screening	Table 3 SCS Coarse	No. exceed
		Sample ID:	BH1-23-GW1 2321242-01	BH2-23-GW1 2321242-02	BH3-23-GW1 2321242-03							
		Date:	23-May-2023	23-May-2023	23-May-2023							
Benzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	44	0
Ethylbenzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	2300	0
Toluene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	18,000	0
Xylene Mixture	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	4200	0
Petroleum Hydrocarbons F1	µg/L		ND (25)	220	188	3	25	25	220	220	750	0
Petroleum Hydrocarbons F2	µg/L		ND (100)	ND (100)	ND (100)	3	100	100	0	<100	150	0
Petroleum Hydrocarbons F3	µg/L		ND (100)	ND (100)	ND (100)	3	100	100	0	<100	500	0
Petroleum Hydrocarbons F4	µg/L		ND (100)	ND (100)	ND (100)	3	100	100	0	<100	500	0
Acetone	µg/L		ND (5.0)	ND (5.0)	ND (5.0)	3	5	5	0	<5	130,000	0
Bromodichloromethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	85000	0
Bromoform	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	380	0
Bromomethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	5.6	0
Carbon Tetrachloride	µg/L		ND (0.2)	ND (0.2)	ND (0.2)	3	0.2	0.2	0	<0.2	0.79	0
Chlorobenzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	630	0
Chloroform	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	2.4	0
Dibromochloromethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	82000	0
Dichlorodifluoromethane	µg/L		ND (1.0)	ND (1.0)	ND (1.0)	3	1	1	0	<1	4400	0
1,2-Dichlorobenzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	4600	0
1,3-Dichlorobenzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	9600	0
1,4-Dichlorobenzene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	8	0
1,1-Dichloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	320	0
1,2-Dichloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	1.6	0
1,1-Dichloroethylene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	1.6	0
1,2-cis-Dichloroethylene	µg/L		**5.5**	**49.8**	**21.3**	3	0.5	0.5	**49.8**	**49.8**	1.6	3
1,2-trans-Dichloroethylene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	1.6	0
1,2-Dichloropropane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	16	0
1,3-Dichloropropene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	5.2	0
Ethylene dibromide	µg/L		ND (0.2)	ND (0.2)	ND (0.2)	3	0.2	0.2	0	<0.2	0.25	0
(n)-Hexane	µg/L		ND (1.0)	ND (1.0)	ND (1.0)	3	1	1	0	<1	51	0
Methyl Ethyl Ketone	µg/L		ND (5.0)	ND (5.0)	ND (5.0)	3	5	5	0	<5	470000	0
Methyl Isobutyl Ketone	µg/L		ND (5.0)	ND (5.0)	ND (5.0)	3	5	5	0	<5	140000	0
Methyl tert-Butyl Ether (MTBE)	µg/L		ND (2.0)	ND (2.0)	ND (2.0)	3	2	2	0	<2	190	0
Methylene Chloride	µg/L		ND (5.0)	ND (5.0)	ND (5.0)	3	5	5	0	<5	610	0
Styrene	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	1300	0
1,1,1,2-Tetrachloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	3.3	0
1,1,2,2-Tetrachloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	3.2	0
Tetrachloroethylene	µg/L		**154**	**1550**	**591**	3	0.5	0.5	**1550**	**1550**	1.6	3
1,1,1-Trichloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	640	0
1,1,2-Trichloroethane	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	4.7	0
Trichloroethylene	µg/L		**11.8**	**87**	**50.1**	3	0.5	0.5	**87**	**87**	1.6	3
Trichlorofluoromethane	µg/L		ND (1.0)	ND (1.0)	ND (1.0)	3	1	1	0	<1	2500	0
Vinyl Chloride	µg/L		ND (0.5)	ND (0.5)	ND (0.5)	3	0.5	0.5	0	<0.5	0.5	0

APPENDIX B

Human Health Risk Calculations

Table B1: Groundwater COC Screening

Groundwater COC	Maximum groundwater conc. (µg/L)	REM conc. (µg/L)	Coarse textured soil		Coarse/Med/Fine
			Res.	Res.	
			Indoor Air Inhalation	Indoor Air Odour	1/2-Solubility Limit
			GW2	GW2-Odour	
Dichloroethylene, 1,2-cis-	49.8	59.76	**1.6**	–	1.80E+06
Tetrachloroethylene	1550	1860	**1.6**	1.10E+06	1.00E+05
Trichloroethylene	87	104.4	**1.6**	2.40E+06	6.40E+05
VC (future)	169.28	169.28	**0.16**	7.60E+06	4.40E+06

Table B2: Receptor Exposure Parameters

Receptor Characteristic	Units	Residents		Workers			
		Toddler	Full-Life Composite	Outdoor worker	Pregnant outdoor worker	Construction worker	Pregnant construction worker
Body weight	**kg**	16.5	62.44	70.7	63.1	70.7	63.1
Skin surface area	**cm^2**	1,745	3,977	3,400	3090	3,400	3090
Soil adherence rate	**$mg/cm^2/d$**	0.2	0.09	0.2	0.2	0.2	0.2
Soil ingestion rate	**mg/d**	200	58.75	100	100	100	100
	kg/d	2.0E-04	5.9E-05	1.0E-04	1.0E-04	1.0E-04	1.0E-04
Drinking water intake rate	**L/d**	0	0.00	–	–	–	–
Incidental GW ingestion rate	**L/d**	–	–	–	–	0.15	0.15
Inhalation rate	**m^3/h**	0.346	0.655	1.5	1.5	1.5	1.5
PM_{10} concentration	**$\mu g/m^3$**	30	30	100	100	100	100
Time Indoors	**h/d**	24	22.5	–	–	–	–
	d/wk	7	7	–	–	–	–
	wks/y	50	50	–	–	–	–
	d/y	350	350	–	–	–	–
Time Outdoors	**h/d**	24	22.5	9.8	24	9.8	24
	d/wk	7	7	5	7	5	7
	wks/y	39	39	39	52	39	52
	d/y	273	273	195	365	195	365
Time in Trench	**hr/event**	–	–	–	–	0.006	0.006
	events/day	–	–	–	–	10	10
	d/y	–	–	–	–	50	365
Exposure Duration	**y**	4.5	76	56	56	1.5	1.5
Averaging period (non-canc)	**y**	4.5	76	56	56	1.5	1.5
Averaging period (canc)	**y**	76	76	56	56	56	56

Table B3: Soil Parameters

Category	Parameter	Symbol	Unit	Value
J&E Soil Stratum A Parameters	Stratum A SCS soil type			Sand
	Stratum A soil total porosity	n^A	–	0.375
	Stratum A water filled porosity	θ_W^A	cm^3/cm^3	0.054
	Stratum A soil air-filled porosity	θ_a^A	cm^3/cm^3	0.321
	Stratum A soil dry bulk density	ρ_b^A	g/cm^3	1.66
	Stratum A soil organic carbon fraction	f_{OC}^A	–	0.005
	User defined stratum A soil vapour permeability	k_V	cm^2	
	Stratum A effective total fluid saturation	S_{te}	cm^3/cm^3	0.003
	Stratum A soil intrinsic permeability	k_i	cm^2	1.00E-07
	Stratum A soil relative air permeability	k_{rg}	cm^2	0.998
	Stratum A soil effective vapour permeability	k_v	cm^2	9.99E-08
J&E Soil Stratum B Parameters	Stratum B SCS soil type			Gravel Crush
	Stratum B soil total porosity	n^B	–	0.400
	Stratum B water filled porosity	θ_W^B	cm^3/cm^3	0.010
	Stratum B soil air-filled porosity	θ_a^B	cm^3/cm^3	0.390
	Stratum B soil dry bulk density	ρ_b^B	g/cm^3	1.60
	Stratum B soil organic carbon fraction	f_{OC}^B	–	0.000
J&E Soil Stratum C Parameters	Stratum C SCS soil type			Sand
	Stratum C soil total porosity	n^C	–	0.375
	Stratum C water filled porosity	θ_W^C	cm^3/cm^3	0.054
	Stratum C soil air-filled porosity	θ_a^C	cm^3/cm^3	0.321
	Stratum C soil dry bulk density	ρ_b^C	g/cm^3	1.66
	Stratum C soil organic carbon fraction	f_{OC}^C		0.005
J&E Miscellaneous Parameters	Soil/Groundwater temperature		°C	15
	Exposure duration		y	56
	Exposure duration	τ	s	1.77E+09
	Conversion factor	C	$cm^3\text{-}kg/m^3\text{-}g$	1,000

Table B4: Vapour Intrusion Model Input

Category	Site Characteristic	Symbol	Units	Value
Water Potability	Potability of groundwater		–	Non-Potable
Land Use				Residential
Building	Type of Building		–	Site Building-with-Basement
	Length		cm	2,132
	Width		cm	1,219
	Height (of mixing zone)		cm	255
	Slab Thickness	Lcrack	cm	21
	Depth below grade to bottom of floor	L_F	cm	200
	Crack depth below grade	$X_{crack\ or\ Zcrack}$	cm	200
	Crack Width	w	cm	0.1
	Pressure Differential, Building - Soil	Δp	g/cm-sec2	40
	Air Exchange Rate	ER	1/hour	0.3
	Flow rate of soil vapour into building (or leave blank)	Q_{SOIL}	L/min	8.45
	Floor-wall seam perimeter	X_{crack}	cm	6,702
	Building ventilation rate	$Q_{building}$	cm^3/s	5.52E+04
	Area of enclosed space below grade	A_B	cm^2	3.94E+06
	Crack-to-total area ratio	η	–	1.70E-04
J&E Soil Inputs	Depth below grade to top of contaminated soil	zsoil or L_t	cm	0
	Depth to contaminated soil used in indoor model	zsoil or L_t	cm	230
	Soil Source-bldg. separation	L_T	cm	30
	Soil Stratum A - Thickness	h_A	cm	200
	Soil Stratum B - Thickness (Soil model)	h_B	cm	29.90
	Soil Stratum C - Thickness (Soil model)	h_C	cm	0.10
	MECP Source Depletion Multiplier (SDM) Applied	SDM	unitless	Yes
	Depth below grade to bottom of contaminated soil	L_b	cm	0
J&E GW Inputs	Depth below grade to contaminated GW	zgw or L_{WT}	cm	455.00
	Depth to contaminated GW used in indoor model	zgw or L_{WT}	cm	455.00
	GW Source-bldg. separation	L_T	cm	255.00
	Soil Stratum A - Thickness	h_A	cm	200
	Soil Stratum B - Thickness (GW model)	h_B	cm	29.90
	Soil Stratum C - Thickness (GW model)	h_C	cm	225.10
	Soil stratum directly above water table	–	–	C
	SCS soil type directly above water table	–	–	Sand
	Capillary zone thickness	L_{CZ}	cm	17.045
	Capillary zone total porosity	n_{CZ}	cm^3/cm^3	0.375
	Capillary zone water-filled porosity	$\theta_{w,cz}$	cm^3/cm^3	0.253
	Capillary zone air-filled porosity	$\theta_{a,cz}$	cm^3/cm^3	0.122

Table B5: Source Depletion Multiplier

COC	Csoil (mg/kg)	Soil Bulk Density (g/cm^3)	Volume of source zone (Default = 13m x 13m x 2m) (cm^3)	Site Building-with-Basement														
				Length of building (to calculate volume of building below grade) (cm)	Width of building (to calculate volume of building below grade) (cm)	Depth of building below grade (to calculate volume of building below grade) (cm)	Volume of excavated soil (cm^3)	Volume of source zone (Adjusted) (cm^3)	unit conversion	Mass 1: Initial Mass (g)	Initial $C_{indoor\ air}$ (ug/m^3)	Volume of building (m^3)	Air Exchange Rate (1/hour)	unit conversion	Mass 2: Mass Remaining after 1 Week of Soil Gas Entering Building (g)	Half Life (years)	SDM (Source Depletion Multiplier)	Final $C_{indoor\ air}$ (ug/m^3)
Acenaphthylene	0.372	1.66	3.38E+08	1,299	1,219	199.00	3.15E+08	2.29E+07	1E+06	14.1	2.92E-02	663	3.00E-01	1.00E-06	14.1	192.67	1.0	2.87E-02
Anthracene	0.588	1.66	3.38E+08	1,299	1,219	199.00	3.15E+08	2.29E+07	1E+06	22.3	5.28E-03	663	3.00E-01	1.00E-06	22.3	1,683.54	1.0	5.27E-03
Benz[a]anthracene	2.448	1.66	3.38E+08	1,299	1,219	199.00	3.15E+08	2.29E+07	1E+06	93.0	3.31E-04	663	3.00E-01	1.00E-06	93.0	111,887.69	1.0	3.31E-04
Benzo[a]pyrene																		
Benzo[b]fluoranthene																		
Dibenz[a h]anthracene																		
Fluoranthene																		

Table B6: Vapour Intrusion - Groundwater Source - Site Building with Basement

COC	Max. ground-water conc. (µg/L)	REM (µg/L)	Enthalpy of vaporization at ave. GW temperature $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. GW temp. H_{TS} (atm-m^3/mol)	Henry's law constant at ave. GW temp. H'_{TS} (unitless)	Vapour viscosity at average soil temp. μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient D^{eff}_{A} (cm^2/s)	Stratum B effective diffusion coefficient D^{eff}_{B} (cm^2/s)	Stratum C effective diffusion coefficient D^{eff}_{C} (cm^2/s)	Capillary zone effective diffusion coefficient D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient D^{eff}_{T} (cm^2/s)	Diffusion path length L_d (cm)	Convection path length L_p (cm)
Dichloroethylene, 1,2-cis-	49.8	59.76	7.68E+03	2.61E-03	1.10E-01	1.77E-04	1.19E-02	2.00E-02	1.19E-02	4.79E-04	4.67E-03	2.55E+02	2.00E+02
Tetrachloroethylene	1550	1860	9.50E+03	1.01E-02	4.29E-01	1.77E-04	1.16E-02	1.96E-02	1.16E-02	4.62E-04	4.53E-03	2.55E+02	2.00E+02
Trichloroethylene	87	104.4	8.49E+03	5.99E-03	2.54E-01	1.77E-04	1.28E-02	2.15E-02	1.28E-02	5.09E-04	4.98E-03	2.55E+02	2.00E+02
VC (future)	169.28	169.28	4.94E+03	2.09E-02	8.83E-01	1.77E-04	1.71E-02	2.88E-02	1.71E-02	6.79E-04	6.66E-03	2.55E+02	2.00E+02

Table B6: Vapour Intrusion - Groundwater Source - Site Building with Basement

COC	Crack radius r_{crack} (cm)	Average vapour flow rate into building Q_{soil} (cm^3/s)	Crack effective diffusion coefficient D^{crack} (cm^2/s)	Area of crack A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number $exp(Pe^f)$ (unitless)	GW Source vapour conc. C_{source} ($\mu g/m^3$)	Infinite source indoor attenuation coefficient α (unitless)	MOE Default Attenuation Factor α (unitless)	MOE Bio-Attenuation Factor BAF (unitless)	Indoor Building Concentration Carried Forward in Exposure & Risk Calcs: REM $C_{building}$ ($\mu g/m^3$)
Dichloroethylene, 1,2-cis-	1.00E-01	1.41E+02	1.19E-02	6.70E+02	1.19E+161	6.59E+03	8.64E-04		1.00E+00	5.69E+00
Tetrachloroethylene	1.00E-01	1.41E+02	1.16E-02	6.70E+02	4.51E+164	7.98E+05	8.47E-04		1.00E+00	6.76E+02
Trichloroethylene	1.00E-01	1.41E+02	1.28E-02	6.70E+02	1.16E+150	2.65E+04	9.01E-04		1.00E+00	2.38E+01
VC (future)	1.00E-01	1.41E+02	1.71E-02	6.70E+02	6.93E+111	1.50E+05	1.08E-03		1.00E+00	1.61E+02

Table B7: Exposure and Risk Calculations - Groundwater Oral and Dermal Pathways

	Construction worker										
COC	GW Ingestion Dose (mg/kg-day)	GW Dermal Contact Dose (mg/kg-day)	Total GW Oral/Dermal Dose (mg/kg-day)	Threshold Oral TRV (mg/kg-day)	GW Oral/Dermal HQ	Risk reduction required	Total Amortized GW Oral/Dermal Dose (mg/kg-day)	Non-threshold Oral TRV $(mg/kg/d)^{-1}$	GW Oral/Dermal ILCR	Risk reduction required	Risk-based GW conc. (ug/L)
Dichloroethylene, 1,2-cis-	1.74E-05	5.55E-06	2.29E-05	2.00E-03	1.15E-02	5.73E-02	6.14E-07	-	-	-	1.04E+03
Tetrachloroethylene	5.41E-04	8.10E-04	1.35E-03	6.00E-03	**2.25E-01**	1.13E+00	3.62E-05	2.10E-03	7.60E-08	7.60E-02	1.65E+03
Trichloroethylene	3.03E-05	1.29E-05	4.32E-05	5.00E-04	8.64E-02	4.32E-01	1.16E-06	4.60E-02	5.32E-08	5.32E-02	2.42E+02
Trichloroethylene (D)	2.48E-04	1.64E-03	1.89E-03	5.00E-04	**3.77E+00**	1.89E+01	5.06E-05	4.60E-02	**2.33E-06**	2.33E+00	5.53E+00
VC (future)	4.92E-05	9.61E-06	5.88E-05	3.00E-03	1.96E-02	9.80E-02	1.58E-06	1.40E+00	2.21E-06	2.21E+00	7.68E+01

Table B8: Exposure and Risk Calculations - Groundwater Inhalation Pathways

COC	**Toddler**											
	On-Site Building-with-Basement											
	Trench Vapour - GW (mg/m^3)	**Outdoor air (GW source) (mg/m^3)**	**Indoor air (GW source) (mg/m^3)**	**Total Vapour Conc. (GW source) (mg/m^3)**	**Threshold inh. TRV (mg/m^3)**	**GW inhal. HQ**	**Risk reduction required**	**Total Amortized Inhal. Conc. (GW source) (mg/m^3)**	**Non-threshold inhal. TRV ($(mg/m^3)^{-1}$)**	**GW Inhal. ILCR**	**Risk reduction required**	**Risk-based GW conc. (ug/L)**
Dichloroethylene, 1,2-cis-	NA	1.59E-06	5.46E-03	5.46E-03	1.50E-01	3.64E-02	1.82E-01	3.23E-04	-	-	-	3.28E+02
Tetrachloroethylene	NA	2.09E-04	6.48E-01	6.48E-01	4.00E-02	**1.62E+01**	8.10E+01	3.84E-02	2.60E-04	**9.98E-06**	9.98E+00	2.29E+01
Trichloroethylene	NA	7.17E-06	2.29E-02	2.29E-02	2.00E-03	**1.14E+01**	5.72E+01	1.35E-03	4.10E-03	**5.55E-06**	5.55E+00	1.83E+00
TCE (D)	NA	9.58E-06	2.38E-02	2.39E-02	2.00E-03	**1.19E+01**	5.96E+01	1.41E-03	4.10E-03	**5.79E-06**	5.79E+00	1.75E+00
VC (future)	NA	4.40E-05	1.54E-01	1.54E-01	1.00E-01	**1.54E+00**	7.72E+00	9.14E-03	8.80E-03	**8.05E-05**	8.05E+01	2.10E+00

Table B8: Exposure and Risk Calculations - Groundwater Inhalation Pathways

	Full-life composite											
	On-Site Building-with-Basement											
COC	Trench Vapour - GW (mg/m^3)	Outdoor air (GW source) (mg/m^3)	Indoor air (GW source) (mg/m^3)	Total Vapour Conc. (GW source) (mg/m^3)	Threshold inh. TRV (mg/m^3)	GW inhal. HQ	Risk reduction required	Total Amortized Inhal. Conc. (GW source) (mg/m^3)	Non-threshold inhal. TRV $(mg/m^3)^{-1}$	GW Inhal. ILCR	Risk reduction required	Risk-based GW conc. (ug/L)
Dichloroethylene, 1,2-cis-	NA	1.49E-06	5.12E-03	5.12E-03	1.50E-01	3.41E-02	1.71E-01	5.12E-03	-	-	-	3.50E+02
Tetrachloroethylene	NA	1.96E-04	6.08E-01	6.08E-01	4.00E-02	**1.52E+01**	7.60E+01	6.08E-01	2.60E-04	**1.58E-04**	1.58E+02	1.18E+01
Trichloroethylene	NA	6.72E-06	2.14E-02	2.14E-02	2.00E-03	**1.07E+01**	5.36E+01	2.14E-02	4.10E-03	**8.79E-05**	8.79E+01	1.19E+00
TCE (D)	NA	9.58E-06	2.38E-02	2.39E-02	2.00E-03	**1.19E+01**	5.96E+01	2.39E-02	4.10E-03	**9.78E-05**	9.78E+01	1.07E+00
VC (future)	NA	4.12E-05	1.45E-01	1.45E-01	1.00E-01	**1.45E+00**	7.24E+00	1.45E-01	8.80E-03	**1.27E-03**	1.27E+03	1.33E-01

Table B8: Exposure and Risk Calculations - Groundwater Inhalation Pathways

	Outdoor worker											
COC	Trench Vapour - GW (mg/m^3)	Outdoor air (GW source) (mg/m^3)	Indoor air (GW source) (mg/m^3)	Total Vapour Conc. (GW source) (mg/m^3)	Threshold inh. TRV (mg/m^3)	GW inhal. HQ	Risk reduction required	Total Amortized Inhal. Conc. (GW source) (mg/m^3)	Non-threshold inhal. TRV $(mg/m^3)^{-1}$	GW Inhal. ILCR	Risk reduction required	Risk-based GW conc. (ug/L)
Dichloroethylene, 1,2-cis-	NA	4.65E-07	NA	4.65E-07	1.50E-01	3.10E-06	1.55E-05	4.65E-07	-	-	-	3.86E+06
Tetrachloroethylene	NA	6.09E-05	NA	6.09E-05	4.00E-02	1.52E-03	7.61E-03	6.09E-05	2.60E-04	1.58E-08	1.58E-02	1.18E+05
Trichloroethylene	NA	2.09E-06	NA	2.09E-06	2.00E-03	1.04E-03	5.22E-03	2.09E-06	4.10E-03	8.57E-09	8.57E-03	1.22E+04
TCE (D)	NA	9.58E-06	NA	9.58E-06	2.00E-03	4.79E-03	2.39E-02	9.58E-06	4.10E-03	3.93E-08	3.93E-02	2.66E+03
VC (future)	NA	1.28E-05	NA	1.28E-05	1.00E-01	1.28E-04	6.41E-04	1.28E-05	8.80E-03	1.13E-07	1.13E-01	1.50E+03

Table B8: Exposure and Risk Calculations - Groundwater Inhalation Pathways

COC	Construction worker											
	Trench Vapour - GW (mg/m^3)	Outdoor air (GW source) (mg/m^3)	Indoor air (GW source) (mg/m^3)	Total Vapour Conc. (GW source) (mg/m^3)	Threshold inh. TRV (mg/m^3)	GW inhal. HQ	Risk reduction required	Total Amortized Inhal. Conc. (GW source) (mg/m^3)	Non-threshold inhal. TRV (mg/m^3)$^{-1}$	GW Inhal. ILCR	Risk reduction required	Risk-based GW conc. (ug/L)
Dichloroethylene, 1,2-cis-	4.10E-06	NA	NA	4.10E-06	1.50E-01	2.74E-05	1.37E-04	1.10E-07	-	-	-	4.37E+05
Tetrachloroethylene	5.41E-04	NA	NA	5.41E-04	4.00E-02	1.35E-02	6.76E-02	1.45E-05	2.60E-04	3.77E-09	3.77E-03	2.75E+04
Trichloroethylene	1.86E-05	NA	NA	1.86E-05	2.00E-03	9.28E-03	4.64E-02	4.97E-07	4.10E-03	2.04E-09	2.04E-03	2.25E+03
TCE (D)	3.32E-04	NA	NA	3.32E-04	2.00E-03	1.66E-01	8.29E-01	8.88E-06	4.10E-03	3.64E-08	3.64E-02	1.26E+02
VC (future)	1.14E-04	NA	NA	1.14E-04	1.00E-01	1.14E-03	5.71E-03	3.06E-06	8.80E-03	2.69E-08	2.69E-02	6.29E+03

Table B9: RIsk-based Groundwater Concentrations and Property Specific Standards

		Groundwater Risk-based Values										
		Oral/dermal	Inhalation									
Groundwater COC	**Groundwater REM conc. (mg/kg)**	**Construction worker (µg/L)**	**Toddler On-Site Building-with-Basement (µg/L)**	**Full-life composite On-Site Building-with-Basement (µg/L)**	**Outdoor worker (µg/L)**	**Construction worker (µg/L)**	**Minimum (µg/L)**	**Min. risk-based value (µg/g)**	**RM required**	**Risk reduction factor**	**PSS (µg/L)**	**Basis**
Dichloroethylene, 1,2-cis-	49.8	1.04E+03	3.28E+02	3.50E+02	3.86E+06	4.37E+05	3.28E+02	3.28E+02	No		49.8	Max.+20%
Tetrachloroethylene	1550	1.65E+03	**2.29E+01**	**1.18E+01**	1.18E+05	2.75E+04	**1.18E+01**	1.18E+01	**Yes**	1.32E+02	1550	Max.+20%
Trichloroethylene	87	2.42E+02	**1.83E+00**	**1.19E+00**	1.22E+04	2.25E+03	**1.19E+00**	1.19E+00	**Yes**	7.33E+01	87	Max.+20%
TCE (D)	87	**5.53E+00**	**1.75E+00**	**1.07E+00**	2.66E+03	1.26E+02	**1.07E+00**	1.07E+00	**Yes**	8.15E+01	87	Max.+20%
VC (future)	169.28	**7.68E+01**	**2.10E+00**	**1.33E-01**	1.50E+03	6.29E+03	**1.33E-01**	1.33E-01	**Yes**	1.27E+03	169.28	Max.+20%

APPENDIX C

Limitations

Disclaimer and Limitations

1. **Paterson Group Inc.** provided this report for **Jersey Developemnts Inc.** solely for the purpose stated in this report. Paterson does not accept any responsibility for the use of this report for any other purpose other than as specified and intended for the purpose of obtaining an approved Risk Assessment for the RA/PSC Property, to support an RSC filing through the Ontario Ministry of the Environment, Conservation and Parks.
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3. The work performed in the preparation of this RA report and the conclusions presented are subject to the following:
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   (b) Time and Budgetary limitations as described in Contracts with our respective client(s); and
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5. The conclusions and discussion presented in this report were based, in part, on borehole logs that were obtained through visual observations of the site and attendant structures by our Client. Our conclusions cannot and are not extended to include those portions of the site or structures, which were not reasonably available, in our opinion, for direct observation, or by our Client.
6. The site history research provided by our Client included obtaining information from third parties and employees or agents of the owner. No attempt has been made to verify the accuracy of any information provided, unless specifically noted in our report.
7. Because of the limitations referred to above, different environmental conditions from those stated in our report may exist. Should such different conditions be encountered, **Paterson Group Inc.** must be notified in order that it may determine if modifications to the conclusions in the report are necessary.
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