Atlantic RBCA (Risk-Based Corrective Action)

for Impacted Sites in Atlantic Canada

Version 3.1

User Guidance

June 2019

Notice to Document Users

Considerable care has been exercised in preparing this publication. However, no party, including without limitation, Atlantic PIRI or its individual members, makes any representation or warranty regarding the accuracy, correctness, or completeness of the information contained herein, and no such party shall be liable for any direct, indirect, consequential, or incidental or other damages resulting from the use of this publication or the information contained herein.

Information in this publication is subject to change without notice. Atlantic PIRI or its individual members, disclaims any responsibility or obligation to update the information contained herein.

Please refer to the Atlantic RBCA website www.atlanticrbca.com for the most current version of this and supporting documents.

Note: The blue text in this document indicates a link to another location within the document or to a website.

Table of Contents

List of Tables

List of Appendices

1.0 INTRODUCTION

1.1 BACKGROUND

Risk-Based Corrective Action (known as RBCA or "Rebecca") has been used as the process for the development of Tier I and Tier II petroleum hydrocarbon (PHC) assessment/remediation standards in Atlantic Canada since 1999. Atlantic RBCA is a process developed to consider typical site conditions in Atlantic Canada for four common land uses (agricultural[1], residential, commercial and industrial[1]). The Atlantic RBCA process is supported by two main components: 1) the regulatory endorsed philosophy of risk assessment, risk management and a tiered approach to remediation; and 2) a technical tool kit (composed of a software model, supporting technical guidance and applicable Provincial legislation, regulations, and policy guidance).

A Memorandum of Understanding (MOU) signed by the four Atlantic Deputy Ministers of Environment (originally in 1996 and most recently renewed in 2008) provides the mandate for a multi-stakeholder group, the **Atlantic Partnership in RBCA Implementation (PIRI)** to develop and promote the Atlantic RBCA process of managing impacted sites in Atlantic Canada. Atlantic PIRI developed and released Version 1 of the Atlantic RBCA process, User Guidance and the RBCA Tool Kit for Atlantic Canada (referred to hereafter as the Atlantic RBCA Tool Kit) in 1999. Version 1 of the Atlantic RBCA Tool Kit was based on the ASTM Standard E 1739-95, Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites. Atlantic RBCA was revised in 2003 to reflect changes recommended for harmonization with Canada Wide Standards for Petroleum Hydrocarbons (CWS PHC) developed by the Canadian Council of Ministers of the Environment (CCME) in 2001. Atlantic RBCA Version 2.0 was subsequently updated to reflect the ASTM Standard E2081-00 and continues to be based on the carbon fractionation data published by the US TPH Criteria Working Group. The model used to develop the updated Atlantic RBCA Tool Kit is marketed in the United States as the RBCA Tool Kit for Chemical Releases.

The 2003 Tier I Risk-Based Screening Levels (RBSLs) were developed using the Atlantic RBCA Tool Kit Version 2.0 to facilitate assessment and planning for sites that meet specified default conditions. The Atlantic RBCA Tool Kit also supports site-specific (Tier II) risk assessment and remediation planning and the software Tool Kit includes effective tools for more detailed Tier III assessments, if required. The entire Atlantic PIRI process is based on a philosophy of continuous improvement and defendable scientific knowledge.

In January 2008, CCME completed their five-year review of the CWS PHC for soil. Where each of the Atlantic Provinces' Environment Ministers had signed the CCME Harmonization Agreements respecting environmental standards, they are each bound to ensure an equivalent level of environmental protection with CCME standards. As a result, Atlantic PIRI conducted an internal review of the 2008 CWS-PHC and supporting documents and recommended several changes to Atlantic RBCA Version 2.0. The changes incorporated into the Atlantic RBCA Version 3 toolkit primarily reflect a number of default modeling parameter values revised in the 2008 CWS PHC report.

[1] Agricultural and Industrial Land Uses have been added in Atlantic RBCA Version 3. Descriptions of all four land uses provided in Section 1.2.

Atlantic PIRI subsequently commissioned Groundwater Services Inc. (GSI) to complete the required changes to the Atlantic RBCA Tool Kit. The result is the revised Atlantic RBCA (Version 3.2.2) software Tool Kit for Atlantic Canada, this updated User Guidance document, and supporting documentation (Appendices 1-8). Provincial regulators may also update their policies and guidelines as required to support these changes.

Revised Tier I RBSL Tables and Tier II Pathway-Specific Screening Level (PSSL) Tables for PHCs including benzene, toluene, ethylbenzene, xylenes (BTEX) and total petroleum hydrocarbons (TPH) have also been developed by Atlantic PIRI using the Atlantic RBCA Tool Kit Version 3.2.2. Consistent with previous versions, upper concentration limits are included in the table for the purposes of practical limits for delineation at Tier I.

The Atlantic RBCA Toolkit Version 3.2.2 was also updated to support risk assessment of selected chlorinated volatile organic compounds (CVOCs or chlorinated solvents) associated with dry cleaning operations, including perchloroethylene (PCE, also known as tetrachloroethylene), trichloroethylene (TCE), *cis*-1,2-dichloroethylene (*cis*-1,2-DCE), *trans*-1,2-dichloroethylene (*trans*-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and vinyl chloride (herein referred to as CVOCs). However, since that time, the toxicological reference values for several of these CVOCs have changed. Atlantic PIRI has developed Tier II PSSL Tables for CVOCs by manually entering the updated toxicological data in the Chem/Tox database of the Atlantic RBCA Tool Kit Version 3.2.2. The toxicological data used in derivation of the Tier II PSSLs for CVOCs is summarized in Table 5, Appendix 5. Note that Tier I RBSL tables have not been developed for CVOCs (refer to Section 3 for additional discussion).

In addition, Health Canada updated the Guidelines for Canadian Drinking Water Quality (GCDWQ) in October 2014, which included revised guidelines for ethylbenzene and xylenes. As a result of these changes, Atlantic PIRI revised the Tier I RBSLs and Tier II PSSLs in 2015. This was conducted by manually updating the "Chem/Tox" database in the Atlantic RBCA Toolkit Version 3.2.2. Atlantic PIRI released a Technical Bulletin with respect to these guideline changes and steps followed in updating the Chem/Tox database in June 2015.

The supporting documentation for this User Guidance Document (Appendices 1-8) may be updated from time to time. Atlantic RBCA users are advised to confirm on a regular basis that they are using the most recent version by checking and subscribing to the Atlantic RBCA website www.atlanticrbca.com**.**

1.2 PURPOSE

The purpose of this document is to provide assistance to the users of Version 3.1 of the Atlantic RBCA Tier I RBSL Tables, the Atlantic RBCA Tier II PSSL Tables and the Atlantic RBCA Tool Kit when assessing environmental risk, preparing and implementing a Remedial Action Plan (RAP) and seeking regulatory site closure for sites impacted with PHCs and CVOCs. Note that guidelines developed using the Atlantic RBCA Tool Kit, including the Tier I RBSLs (PHCs), Tier II PSSLs (PHCs and CVOCs) and SSTLs, are based on the potential risks to human health and do not address potential ecological concerns. It is important to note that ecological assessment is part of the RBCA framework and is discussed further in this document.

Atlantic RBCA includes guidelines for four different land uses. The definition of each land use is consistent with CCME (2006) Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines, and accommodates generic conditions for receptors and exposure pathways. The four defined land uses from CCME (2006) are as follows:

- ***Agricultural*:** where the primary land use is growing crops or tending livestock. This also includes agricultural lands that provide habitat for resident or transitory wildlife and native flora.
- ***Residential*:** where the primary activity is residential or recreational activity. This includes buffers between areas of residency and campground areas but excludes wildlands such as national or Provincial parks.
- ***Commercial*:** where the primary activity is commercial (e.g., shopping mall) and not residential or manufacturing. This does not include zones where food is grown.
- ***Industrial*:** where the primary activity involves the production, manufacture, or construction of goods.

Some discussion of Tier III approaches is also presented. Frequently referenced information is included in a number of Appendices. In addition to these technical tools, each of the four Atlantic Provinces has published regulatory and guidance documents for site remediation in their respective provinces, and these must be used in conjunction with the technical tools discussed here.

Specifically, this User Guidance document provides the following:

- guidance on the use of Tier I RBSL Tables;
- guidance on the use of the Tier II PSSL Tables;
- guidance on use of the Atlantic RBCA Tool Kit to supplement instructions provided by GSI;
- guidance on best management practices for environmental site assessment for impacted sites;
- guidance on ecological screening and assessment; and,
- guidance on use of Atlantic RBCA for other parameters (i.e., other than PHCs and CVOCs associated with dry cleaning activities).

Atlantic PIRI will be publishing Environmental Quality Standards (EQS) for Impacted Sites which can be used for assessment of other contaminants of concern. If other contaminants are being assessed at a Tier II/III level, the Site Professional should also consult with the Provincial regulatory authority having jurisdiction since the Atlantic RBCA Tool Kit has currently only been pre-approved for use with PHCs and CVOCs (PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1- DCE and vinyl chloride).

In 2016, Atlantic PIRI published a Guidance for Vapour Intrusion Assessments to provide guidance on the assessment and quantification of the subsurface vapours to indoor air exposure pathway for human health. The guidance includes vapour intrusion screening levels (VISLs) for PHCs. The Guidance for Vapour Intrusion Assessments was updated in April 2019 and is currently available from the Atlantic RBCA website (www.atlanticrbca.com).

A summary of the modifications to Atlantic RBCA Version 3.1 is provided in Table 1-1.

TABLE 1

SUMMARY OF CHANGES IN ATLANTIC RBCA VERSION 3

Parameter	Variable	Units	Abbr.	CCME	ARBCA Ver 2	ARBCA Ver 3/3.1	Rationale
TEX	To eliminate the historical practice of adding TEX concentrations to TPH fractions for the purposes of Tier II SSTL calculations	n/a	n/a	TEX is excluded from CWS fractions	Toluene is added to arom C7-C8 fraction and Ethylbenzene and xylene are added to arom C8-C10 at Tier II	Exclude TEX from both Tier I and Tier II calculations to be consistent with CCME	Carcinogens such as benzene and benzo(a)pyrene are excluded from CWS PHC. Because of the relatively long history of managing toluene, ethylbenzene and xylenes ("TEX") as target compounds, these are also excluded from PHC (CCME, 2008)
Toxicity Reference Values (TRVs)	Benzene	$(mg/kg_{bw}day)^{-1}$	Sfo	0.31	0.0299	0.226	Harmonization with Health Canada 2009
	Toluene	mg/m^3	RfC	3.8	0.4	3.8	Harmonization with CCME 2004 and Health Canada 2009
	PCE,TCE, DCE, VC	Various	Various	Various	Various	Various	Refer to Table 5, Appendix 5. Adopted from USEPA IRIS (most recent) or HC 2010.
Physical/Chemical Properties	BTEX, PCE,TCE, DCE, VC	Various	Various	Various	Various	Various	Harmonization with CCME 2004 and Health Canada 2009
Soil Properties	Total Soil Porosity - Coarse	Unitless	n	0.36	0.4	0.36	Harmonization with CCME 2006 and CWS 2008
	Total Soil Porosity - Fine	Unitless	n	0.47	0.3	0.47	Harmonization with CCME 2006 and CWS 2008
	Soil Vapour-filled Porosity - Coarse	Unitless	θa	0.241	0.281	0.241	Harmonization with CCME 2006 and CWS 2008
	Soil Vapour-filled Porosity - Fine	Unitless	θa	0.302	0.132	0.302	Harmonization with CCME 2006 and CWS 2008
Relative Dermal Assorption Factors	Benzene	Unitless	AF_{Dermal}	0.08	0.5	0.03	Harmonization with Health Canada 2009
	Toluene	Unitless		0.12	0.5	0.03	Harmonization with Health Canada 2009
	Ethylbenzene	Unitless		0.2	0.5	0.03	Harmonization with Health Canada 2009
	Xylene	Unitless		0.12	0.5	0.03	Harmonization with Health Canada 2009
	TPH Fractions	Unitless		0.2	0.5	0.2	Harmonization with CWS 2008
	PCE,TCE, DCE, VC	Unitless		Various	Various	0.03	Harmonization with Health Canada 2009
Hazard Quotient	PCE,TCE,DCE	Unitless	HQ	0.2	n/a	0.2	Harmonization with CCME
	Toluene, Ethylbenzene, Xylene	Unitless	HQ	0.5	1	0.5	Harmonization with CCME 2004 at Tier I
Land Use Category	Add Agricultural and Industrial Land Use	n/a	n/a	Includes agricultural and industrial	Does not include agricultural and industrial	Includes agricultural and industrial	Harmonization with CCME default human health exposures for Agricultural and Industrial Land Use. Model has full functionality for selecting any combination of receptors.
Soil Leaching to Groundwater; Groundwater Ingestion	Exposure frequency - commercial (potable water ingestion)	days/year	EF_{comm}	365	100	365	CCME do not specify an exposure term for the potable water pathway. Instead, they back-calculate the soil RBSL from an allowable groundwater concentration calculated as [(TDI-EDI)*BW/IR]. As this equation has no exposure term, this inherently assumes 100% of drinking water comes from the commercial site. This is based on the philosophy that drinking water supplies should be the same regardless of end use (e.g., residential vs commercial). Atlantic PIRI have chosen to adopt the same philosophy to drinking water protection.
	Well Dilution Factor	Unitless	WDF	n/a	n/a	varies	Well dilution occurs when the screen (or open borehole) of a water well is open to non-uniform groundwater quality and contaminated groundwater from the source area is blended with clean groundwater as the well is pumped. This attenuation factor is new for Version 3, and is defined as the ratio of the average daily pumping rate from the water supply well (assumed to be 900 L/day) to the average daily volumetric flow rate from the mixing zone.
Soil Leaching to Groundwater; Groundwater Ingestion	Hydraulic gradient	unitless	i	0.028	0.05	0.028	To ground truth a reasonable value for this variable, Atlantic PIRI analyzed hydraulic gradient measurements from 105 sites randomly selected from across Atlantic Canada. Data was determined to be positively skewed and approximated a log-normal distribution. The arithmetic mean of the log-transformed data (geometric mean) = 0.028, which is equivalent to the median (0.03). Based on this analysis, Atlantic PIRI recommend a default value of 0.028, equivalent to the CWS, but independently verified through an analysis of regional Atlantic Canada data.

TABLE 1

SUMMARY OF CHANGES IN ATLANTIC RBCA VERSION 3

Parameter	Variable	Units	Abbr.	CCME	ARBCA Ver 2	ARBCA Ver 3/3.1	Rationale
Soil Leaching to Groundwater; Groundwater Ingestion	Groundwater mixing zone thickness - coarse	cm	δ_{gw}	74	200	72	CCME CWS use an equation sourced from a BC protocol from 1995. BC have subsequently reviewed their approach and replaced this equation with an alternative approach. Mixing zone thickness is calculated based on infiltration rate versus groundwater flow rate and is based partly on groundwater dispersivity. The commonly accepted approach is based on the US EPA Soil Sceening Guidance (1996) with modifications to reflect differences in groundwater dispersion models. BC adopted Neumann (1990) for groundwater dispersion. Atlantic PIRI adopted Xu & Eckstein (1990) groundwater dispersion model and recommend changing the generic default of 200 cm with calculated values based on the approach of US EPA (1996) modified with dispersivity from XU & Eckstein. This is the only coding change required to the model to change the mixing zone thickness from an entered value to a calculated value.
	Groundwater mixing zone thickness - fine	cm	δ_{gw}	74	200	220	As above.
Soil and Groundwater to Indoor Air	Vapour permeability - coarse	m^2	k_v	5×10^{-12}	1×10^{-12}	5×10^{-12}	Atlantic PIRI accepts the scientific rationale provided in CWS v2 as justification for an increase in soil vapour permeability for coarse grained soils.
	Adjustment Factor	unitless	AF	10	0	10 (BTEX and TPH Only)	It was recognized by CCME CWS that the Johnson & Ettinger model is overly conservative for petroleum hydrocarbons. Proposed changes to soil vapour permeability only make this calculated RBSLs even more conservative. CCME adopted a default adjustment factor of 10. Empirical soil vapour and indoor air data collected at fuel oil spill sites in Atlantic Canada also suggest a significant over-prediction of indoor air petroleum hydrocarbon concentrations from version 3. Therefore Atlantic PIRI recommends adopting a default adjustment factor of 10 for the indoor air pathway only. This adjustment factor applies only to petroleum hydrocarbons (BTEX/TPH)
	Building volume/area ratio - residential	m	L_b	3.6	4.88	3.6	CCME value based on a 2 storey home with an assumption of incomplete mixing to the upper floor, represented by a reduced building volume/area ratio. Atlantic PIRI recommends harmonizing with this update to CCME CWS.
	Building air exchange rate - commercial	exch/s	ER	2.5E-04	3.8E-04	2.5E-04	Atlantic PIRI recommends harmonizing with this update to CCME CWS.
Exposure Assessment	Exposure frequency - commercial (soil ingestion)	days/year	EF_{comm}	240	250	240	Atlantic RBCA v2 is marginally more conservative but at the same time is not consistent with the assumptions for other pathways which are based on 240 days/year. Atlantic PIRI recommends harmonizing with CCME CWS for this variable.
	Amortization - carcinogens	Years	ED_{carc}	N	Y	Y	Although CCME does not amortize exposures, Health Canada recommends amortization for commerical and industrial sites based on a 35 year exposure over a lifetime. Previous versions of Atlantic RBCA amortized 25 year exposures over a 70 year lifetime for both residential and commercial land use. Atlantic PIRI recommends adopting an age-adjusted lifetime exposure (i.e., 80 years) for agricultural and residential land use, and a 35 year exposure amortized over a lifetime for commercial and industrial land use.

1.3 SUPPORTING DOCUMENTATION

Other sources of information are available to assist Atlantic RBCA users and include the following:

- Documentation prepared by GSI and supplied with purchase of the Atlantic RBCA Tool Kit Version 3.2.2 (www.gsi-net.com)
- Provincial Contaminated Site Management Process: regulations, guidelines and related documents for New Brunswick, Prince Edward Island, Newfoundland & Labrador and Nova Scotia, available at www.atlanticrbca.com
- Atlantic RBCA Laboratory Method and Guidelines for Laboratories (www.atlanticrbca.com)
- Atlantic PIRI Guidance for Vapour Intrusion Assessments (www.atlanticrbca.com)
- Atlantic PIRI EcoRBCA Scientific Rationale (www.atlanticrbca.com)
- Canadian Environmental Quality Guidelines (http://cegg-rcqe.ccme.ca/)
- Canada-Wide Standards for Petroleum Hydrocarbons in soil available at the website http://www.ccme.ca/en/resources/contaminated_site_management/phc_cws_in_soil.html

The website www.atlanticrbca.com is maintained and updated on a regular basis by Atlantic PIRI. This website is also a host location for new impacted site information released by Atlantic Provincial regulators. It is recommended that the website be checked regularly to maintain current knowledge of related changes. A free subscription service is available at the website that will notify individuals of new postings and website updates by e-mail.

1.3 USE OF CANADA WIDE STANDARDS – PHCs

The PHC CWS was developed by the CCME under the Harmonization Sub-Agreement on Environmental Standards. The original standard was finalized in 2001. A five-year review was initiated in 2005, which was followed by the release of the next version of the standard in 2008 (CCME, 2008). Like Atlantic RBCA, the PHC CWS is a 3-tiered system that provides remedial objectives for petroleum hydrocarbon impacted soils within various land use categories. This standard only provides criteria and guidance related to soil impacts and does not address potential groundwater/surface water impacts.

In the Atlantic Region, the CWS is most often applied at Federal sites in order that all Federal petroleum contaminated sites across Canada are assessed to the same standard. However, those Federal properties that may be destined for Provincial government or private ownership through divestiture and/or impacts may cross property boundaries into Provincial jurisdictions in the Atlantic Region are often assessed using Atlantic RBCA. Responsible Parties and Site Professionals need to consider the objective of the assessment and be aware of the differences between the CWS and Atlantic RBCA in order to select the most appropriate approach.

Atlantic Canada regulators have been active participants in the development of Atlantic RBCA through Atlantic PIRI. Version 3.1 of Atlantic RBCA has been developed to harmonize, where possible, with the CWS PHC. In addition to changes to the Tool Kit, recent changes to the Atlantic RBCA laboratory method enable direct comparison of site data to either Atlantic RBCA and/or CWS PHC guidelines to promote harmonization and for the benefit of Federal property managers. Considerable industry and regulatory experience has been gained by using the Atlantic RBCA Tool Kit for dealing with petroleum impacted sites. As such, Provincial regulators recommend that private sector companies utilize Atlantic RBCA for managing impacted sites in Atlantic Canada. Where a responsible party wishes to specifically utilize CWS PHC for petroleum hydrocarbon assessment and remediation, Provincial regulators must be consulted in advance.

1.4 PUBLIC SAFETY AND ENVIRONMENTAL EMERGENCIES

In certain cases, petroleum hydrocarbon or chlorinated solvent spills or releases can result in situations in which public health and safety may be at risk. Emergency response actions must always be implemented as a priority to protect people and property from any immediate public health and safety threats (e.g., explosive vapours in sewers, fire hazards, etc.) as well as to protect sensitive habitats (e.g., streams, wetlands, etc.).

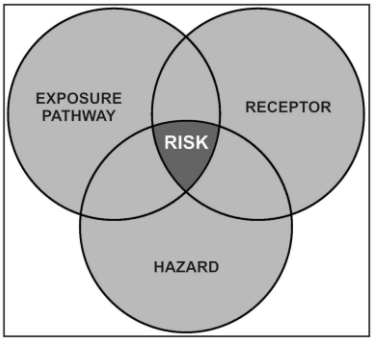
Situations involving protection of public safety will generally be directed by municipal emergency management officials (fire department) and may include evacuation of occupants, ventilation of confined spaces, collection or isolation of mobile free product, installation of barrier pumping systems and/or supply of alternative potable water. Emergency actions related to public safety emergencies are beyond the scope of this document.

2.0 SITE CHARACTERIZATION

The characterization of any contaminated site can be logically divided into two phases: 1) problem formulation and 2) detailed data collection (phased environmental site assessments (ESAs), laboratory analysis, free product assessment and ecological screening). The following provides an overview of some important considerations for application of Atlantic RBCA Version 3.1.

2.1 PROBLEM FORMULATION

Problem formulation involves screening of the three main components of risk as illustrated in the adjoining figure. Key steps in the problem formulation phase include the following:



- Identification of Chemicals of Concern (COCs) based on historical land use and activities, available chemical data, spill or loss incident details, potential contaminant sources (tanks, lines, pump islands, separators, sewers, drains, septic systems, disposal dry wells, etc.), owner and/or operator information.
- Identification of actual or potential human and ecological receptors, including receptors on adjacent properties.

- Identification of potential transport mechanisms and exposure pathways such as direct dermal contact and ingestion, vapour migration to indoor or outdoor spaces, groundwater transport to points of ingestion or physical contact and overland flow. Conduits such as service trenches can provide preferential and high velocity pathways. Pathways must be assessed for immediate and long term human and ecological exposure.

Information collected in the problem formulation phase will provide valuable direction in planning detailed data collection, analysis and interpretation.

2.2 DETAILED DATA COLLECTION

The second phase of site characterization involves detailed data collection. Data collection methods are to be based on gathering information needed to address the problems identified in the problem formulation. This typically involves gathering data through multiple stages of environmental site assessment, laboratory sample analyses, free product assessment, and ecological screening.

2.2.1 Environmental Site Assessment

The Best Management Practices for Environmental Assessment of Impacted Sites provided in Appendix 1 describe generally accepted environmental site assessment practices suitable to PHC and CVOC impacted sites. In addition, minimum site assessment requirements have been formulated to provide the necessary detailed data collection to support site characterization, as typically required by Atlantic Provincial regulators (see Checklist in Appendix 6). Site-specific data collection such as building construction details and soil/groundwater conditions can have a significant influence on the selection of remedial levels.

It is important to note that assessment of CVOCs and PHCs require different approaches, with assessment of CVOCs generally involving much more planning at the work scope stage and throughout the assessment. The design of the investigative program must reflect the fate and transport properties of the contaminant of concern. This is discussed further in the Best Management Practices for Environmental Assessment of Impacted Sites.

For CVOC impacted sites, parent compounds and all theoretical degradation compounds of concern must be assessed in all instances (i.e., PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE and vinyl chloride). On-going monitoring will likely be required for CVOC assessments until the soil, dissolved groundwater and dense non-aqueous phase liquid (DNAPL) plume (if applicable) are demonstrated to be stable or decreasing. Parent and degradation compounds should be monitored even if degradation products are not present or are below screening levels, due to their increasing toxicity and possibility of increase in concentration over time. Consideration should also be given to the use of groundwater chemical transformation models for sites involving long term site management or to calculate the predicted future concentration of accumulated degradation compounds.

Site Professionals should consult Appendix 1 and use the Site Assessment and Tier I/II Checklist in Appendix 7 to confirm that the minimum site characterization data has been collected. The Best Management Practices for Environmental Assessment of Impacted Sites provided in Appendix 1 may be updated independently of the User Guidance document and users are advised to confirm

on a regular basis that they are using the most current version. Check the website at www.atlanticrbca.com.

If Tier I RBSLs or the Tier II PSSLs are to be used to screen site data, the Site Professional must confirm that the conditions present on the site are consistent with or conservative with respect to the default parameter values and assumptions used to calculate the values in the RBSL or PSSL Tables. If not, the site-specific differences may be incorporated by using the Atlantic RBCA Tool Kit to develop Site-Specific Target Levels (SSTLs).

2.2.2 Delineation of Impacts

The extent of PHC impacts in soil and groundwater should be delineated to the applicable Tier I RBSLs. If applicable, the extent of petroleum hydrocarbon impacts in soil vapour should be delineated to the applicable Vapour Intrusion Screening Levels (VISLs) for the site as outlined in the Atlantic PIRI Guidance for Vapour Intrusion Assessments (April 2019). If LNAPL is present on the site, the extent must be fully delineated (Refer to Section 2.2.4).

Atlantic PIRI has not provided Tier I RBSLs for CVOCs. Tier II PSSLs are not available for soil for the indoor air inhalation exposure pathway as the derived values are not attainable by current laboratory methods or due to insufficient toxicological data. There are also no Tier II PSSLs for the indoor air inhalation pathway for *cis,1-2*-DCE and *trans,*1-2-DCE in groundwater as there is insufficient toxicological information. Based on the characteristics of CVOCs, dissolved plumes and vapour plumes would be expected to migrate further than CVOC impacts in soil. Therefore, it is considered acceptable to delineate the extent of CVOC impacts using soil vapour and groundwater data. **The extent of CVOCs shall be delineated to the most stringent Tier II PSSLs for soil and groundwater, and to VISLs for soil vapour**, which can be calculated using reference concentrations (RfCs) provided in Table 5, Appendix 5, and Risk Specific Concentrations (RSCs).

The Best Management Practices for Environmental Assessment of Impacted Sites in Appendix 1 provides additional details regarding delineation of PHC and CVOC impacts at a site.

2.2.3 Laboratory Reporting and Interpretation

Atlantic RBCA versus CWS PHC Laboratory Methodology – PHCs

Atlantic RBCA Version 3.1 provides Tier I RBSLs for PHCs that are considered equivalent or better protection than the CWS PHC. In 2010, a sub-committee of Atlantic PIRI (composed of representatives from laboratories in Atlantic Canada who routinely perform petroleum hydrocarbon analyses) were tasked with identifying and implementing changes to the Atlantic RBCA Method to enable more direct comparison of data generated by the two methods. As such, the Atlantic RBCA results are now directly comparable to either the PIRI guidelines or the CCME CWS Guidelines. Although changes have been made to harmonize the data generated by the two methods, differences between the methods remain. These have been identified in Table 2-1.

TABLE 2-1: COMPARISON OF PHC ANALYTICAL METHODS

	ATLANTIC RBCA	CCME CWS-PHC
Information Location	www.atlanticrbca.com	www.ccme.ca
Methods Available	Tier I and Tier II	Tier I only
Applicable Matrices	Soil and water methods approved	Soil method only. Many labs have developed in-house water methods based on soil method.
Tier I Reporting	BTEX >C_6 - C_{10} (aromatic+aliphatic minus BTEX) >C_{10} – C_{16} (aromatic+aliphatic) >C_{16}-C_{21} (aromatic and aliphatic) >C_{21} – C_{32} (aromatic+aliphatic) Modified TPH (equals all TPH less BTEX)	F1 = C_{06} - C_{10} (aromatic+aliphatic) F2 ≥ C_{10} - C_{16} (aromatic+aliphatic) F3 ≥ C_{16} - C_{34} (aromatic+aliphatic) F4 ≥ C_{34} (aromatic+aliphatic) (Note: BTEX is covered under other CCME methods)
Tier II Reporting	BTEX ***Aromatic Fractions*** C_{06}-C_{07} (not reported since equal to benzene) >C_{07}-C_{08} (not reported since equal to toluene) >C_{08}-C_{10} (less Ethylbenzene and Xylenes) >C_{10}-C_{12} >C_{12}-C_{16} >C_{16}-C_{21} >C_{21}-C_{32} ***Aliphatic Fractions*** C_6-C_8 >C_8-C_{10} >C_{10}-C_{12} >C_{12}-C_{16} >C_{16}-C_{21} >C_{21}-C_{32}	Not applicable

Additional details regarding laboratory procedures are provided in Atlantic RBCA Guidelines for Laboratories Tier I and Tier II Petroleum Hydrocarbon Methods, Version 3.1 and the CCME Reference Method for the Canada-Wide Standard for PHCs in Soil - Tier 1 Method.

Presence of Heavy Petroleum Hydrocarbon Fractions – PHCs

Laboratories reporting results by the Atlantic RBCA method will advise if the chromatogram returned to baseline by the end of the run. If it did not return to baseline, this indicates hydrocarbons >C_{32} may be present at significant concentrations in the sample. In these cases, quantification of the >C_{32} fraction may be required by an alternate method.

Soil and Groundwater Analysis in Potable Water Areas – All Parameters

Site Professionals must ensure that the laboratory provides a low detection analysis for potable water sites by requesting this method at the time of sample submission.

2.2.4 Free Product Assessment

Determination of the presence of non-aqueous phase liquid (NAPL), also known as free phase product (free product), in soil or water is a key assessment step in the Atlantic RBCA process. The primary concern with respect to the presence of free phase hydrocarbon relates to its potential mobility and its ability to act as a contaminant source, which may compromise the long-term reliance on the risk-based approach used to manage the site, as the Atlantic RBCA model does not assess risks related to free product. The free product terminology used in this User Guidance (including free product, mobile and immobile free product, NAPL, DNAPL, LNAPL, RES and SOL) is defined in Appendix 8.

Atlantic PIRI considers free product in groundwater as a separate phase product if a thickness greater than 1 mm is measured in a monitoring well. Care should be exercised in determining the presence of free phase product since interface probes may overestimate the thickness and bailers with small openings may underestimate the thickness.

Determination of the presence of free product in soil is more qualitative than the determination in groundwater. At soil residual saturation limits (RES), free product is likely to begin to form within the soil matrix. Mobile free product normally occurs when sufficient NAPL is present in soil pores such that product is visibly freely draining through the soil, or when product will drain in-situ or under mild hand compression. At solubility limits (SOL), free product is likely to be present in groundwater.

PHCs are less dense than water and therefore, free product (LNAPL) would occur at the groundwater table. Since CVOCs are dense, free product (DNAPL) would sink to below the water table until it reaches an aquitard or non-continuous low permeability zone.

Field observations (within test pits, boreholes/monitoring wells or excavations) assist in the identification of free product on sites. Particularly, identification/determination of DNAPL can prove to be difficult and experience in DNAPL field observation is required. Refer to the Best Management Practices for Environmental Assessment of Impacted Sites, Appendix 1, for additional information.

If a responsible party is proposing to manage immobile free product (i.e., leave in place), Atlantic Provincial regulators will require a proposal to do so, which must include the following minimum information:

- a detailed site assessment, including a comprehensive hydrogeological investigation which has determined that free product exists in soil and/or groundwater but is immobile
- confirmation that free product in soil and/or groundwater on the site does not present an unacceptable human or ecological health risk
- a minimum of two (2) years of seasonal groundwater monitoring (including product monitoring) will be required to demonstrate a stable to diminishing plume

- for sites where remediation has been conducted, the minimum two years of seasonal groundwater monitoring (including product monitoring) must be conducted following completion of the remedial activities
- in potable areas or protected wellfields and watersheds, additional monitoring or information may be required by regulators
- for CVOCs, there must be confirmation that the DNAPL and dissolved phase plumes are stable, in concentration and extent, both horizontally and vertically, for parent and daughter products. More than two (2) years of seasonal monitoring will likely be required for sites impacted with CVOCs.

Provincial regulators may accept other lines of evidence which demonstrate immobility; however, these must be discussed with the Provincial regulator in advance.

If assessment indicates that the product is mobile free product, it must be removed unless otherwise approved by the Provincial regulator.

Tier I RBSLs, Tier II PSSLs and calculated Tier II SSTLs are not applicable to a site which contains either mobile or immobile free product as they were developed using a three-phase model approach (i.e., contaminant absorbed to organic carbon, dissolved in water, or present in vapour phase in soil gas). If it is acceptable to the Provincial regulator to leave the product in place, a Tier III approach may be required to confirm no unacceptable risks are associated with the presence of the fourth phase (i.e., NAPL).

2.3 Ecological Screening

While the Atlantic RBCA Tool Kit assesses potential risks to human health, the goal of the Ecological Screening Protocol for Impacted Sites in Atlantic Canada, in Appendix 2, is to assess potential risks to the environment (specifically ecological receptors). To guide the preparation of this protocol in terms of overall protection goals and objectives, the four Atlantic regulators adopted the following principles:

- **Principle 1** – Both human health and ecological health are important considerations in the overall health and sustainability of our environment (including natural ecosystems and built environments).
- **Principle 2** – Society recognizes and accepts differences between natural ecosystems and built/urban environments (areas which result from the development and expectations of society).
- **Principle 3** – Ecological values should be maintained in those areas where they are determined to be of importance to the health and sustainability of the environment, particularly where this is of value to society.
- **Principle 4** – It follows that, for some land uses or situations, ecologically driven remediation may be of varying value or importance. Environmental standards for the protection of ecological receptors should be applied where the maintenance of their abundance and diversity is considered to be a priority, reflecting appropriate choices relative to land-use. The application of ecological standards should also consider long-term integrity and sustainability planning of our environment.

While this protocol is not an ecological risk assessment, the protocol provides a decision making framework that will result in one of following three conclusions:

1. The site does not pose a risk to ecological receptors/habitat and no further action is necessary related to the environment;
2. The site should be remediated to Tier 1 ecological screening levels (ESLs); or
3. The site should undergo further assessment in terms of quantifying ecological risks at the site (e.g., further delineation, quantitative ecological risk assessment, etc.).

The flowchart in the protocol (Figure 1) illustrates these three possible outcomes. The protocol is comprised of three parts.

Part I provides ecological risk-based numerical standards to protect ecological receptors within the four defined land use categories. These ecological screening levels have been adopted from other jurisdictions (e.g., Canadian Council of Ministers of Environment, Alberta) or derived using available models (e.g., PETROTOX). Additional explanation and details of the derivation process are provided, under separate cover, in the document *Scientific Rationale to Support the Tier 1 Ecological Screening Levels for Soil, Surface Water, Groundwater and Sediment in the Ecological Screening Protocol for Impacted Sites in Atlantic Canada.*

Part II prompts practitioners to identify potential ecological habitats and ecological receptors. For PHC impacted sites, assessment of habitats and receptors within a minimum of 200 metres (m) of the suspected contaminated area is required. Since CVOCs can migrate significantly further than PHCs, the scope of the assessment and identification of potential ecological habitats and receptors may be greater. Note that practitioners must exercise reasonable judgment when determining the actual radius of influence of the site, depending on site conditions and/or recommendations of the Provincial regulators. Question 1 within Part II is essentially the Checklist for Ecological Receptor Assessment in Atlantic Canada from the previous version of the User Guidance (Version 2), with additional guidance provided in terms of spatial significance, receptors, etc. Once Part II is completed, Part III must also be completed.

Part III examines the potential exposure pathways present at the site where PHCs and CVOCs have the potential to influence ecological receptors and habitats identified in Part II.

With consideration of the information gathered and assessed in Parts I, II and III, the practitioners will then conclude what, if any, additional steps are necessary in terms of addressing possible ecological risks present at the site or within the surrounding area.

If a more detailed qualitative ecological risk assessment is recommended, guidance for undertaking such a study can be found in the following approaches and documents, subject to Provincial approval.

- CCME Ecological Risk Assessment Framework (CCME, 1996)
- Federal Contaminated Sites Action Plan (FCSAP) Ecological Risk Assessment Guidance (Azimuth, 2012)
- CCME Canada-Wide Standard for PHCs in Soil: User Guidance PHCs in Soil (CCME, 2008)

- British Columbia Ministry of Environment's Protocol 13, Screening Level Risk Assessment (BC, 2008)
- TPH Risk Evaluation at Petroleum-Contaminated Sites (ITRC, 2018)
- Federal Contaminated Sites Action Plan (FCSAP) Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours, Version 6.1 (FSCAP, 2018)

Consultation with Provincial regulators is encouraged to ascertain the desired approach to ecological risk assessment within their respective jurisdictions. If the screening process or an ecological risk assessment concludes that remediation is recommended, the Remedial Action Plan must detail the corrective action proposed to mitigate such risks to the environment.

The results of the screening process are to be included as a section in the Site Assessment and Closure Reports and are to be summarized in Summary Table (Appendix A of the Protocol). The name of the person(s) who completed the screening should be included in the Site Assessment and Closure Reports.

3.0 REMEDIAL OPTIONS – THE TIERED APPROACH

3.1 OVERVIEW

The risk-based approach to management of contaminated sites in Atlantic Canada is based on a three-tier system of assessment of risk that is commonly accepted in North America. Each tier provides an equivalent level of health protection. In Atlantic Canada, the three tiers of risk assessment and risk management accepted by regulators for PHCs and CVOCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE and vinyl chloride) are generally summarized as follows:

Tier I Generic risk-based values selected from the Atlantic Canada Tier I RBSL Tables (see Appendix 3). These RBSLs are used to determine the need for and extent of remedial work required for a site under generic default assumptions. There are no Tier I RBSLs for CVOCs.

Tier II Site-specific values or "Site-Specific Target Levels" (SSTLs) developed by a Site Professional using the Atlantic RBCA Tool Kit and site-specific field data. These SSTLs are used to determine the need for and extent of remedial work required for a site using site-specific conditions. Atlantic RBCA Tool Kit Tier II risk assessment capabilities are designed for human health risk assessment on source and third party properties, in soils and groundwater.

The Atlantic RBCA Version 3.2.2 Tool Kit also provides Site Professionals with the option of using pre-calculated Tier II PSSLs from the Atlantic Canada Tier II Pathway-Specific Screening Level (PSSL) Tables (see Appendix 4) in cases where certain pathways are not complete on a site (e.g., no buildings). Tier II PSSLs have been calculated for PHCs and CVOCs.

Tier III Tier III involves the use of SSTLs developed using technical tools other than or supplementary to the Atlantic RBCA Tool Kit. To develop these SSTLs, a greater amount of site-specific field data is required to determine the need for and extent of remedial work. Ecological risk assessment, if required, would be a Tier III

assessment even if human health risk was managed with Atlantic RBCA Tier I or Tier II methods.

The presence of chemicals at concentrations above the Tier I or Tier II values does not necessarily indicate that an unacceptable risk exists at the site. It does generally indicate that additional investigation and evaluation of potential environmental concerns is warranted, likely at a Tier II or Tier III level, or that remedial action is required.

The tiered approach can be applied to a wide variety of contaminant compounds. ***However, in Atlantic Canada discussions should be held with Provincial regulatory agencies, or their individual Contaminated Site Management Process documents should be consulted, to confirm that the methodologies being used to assess compounds other than PHCs and CVOCs are acceptable.***

Human and ecological risk may be evaluated at a single site using multiple methodologies and levels of evaluation. For example, human health may be evaluated with the Atlantic RBCA Tool Kit at Tier II whereas some ecological risk may be screened out or addressed using other risk models at Tier III.

The objective of the pre-approval of the Atlantic RBCA Tool Kit at Tier II by the Provincial regulators is to simplify and expedite the site management process for the Responsible Parties, Site Professionals and the regulators. The use of other risk assessment methodologies, including ecological risk assessment, and risk assessment for compounds other than the six CVOCs (PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE and vinyl chloride) and PHCs should be discussed with the Provincial regulatory agencies to confirm that the methodologies are acceptable. ***In addition, Provincial policy may require peer review of these reports*.**

Provincial regulators may require peer review of submissions at all three Tiers. However, when Tier III methodologies are used, it is often because of increased technical complexities or potentially high remediation costs. The Responsible Party and Site Professional should understand that the regulator is more apt to require a peer review of those projects for which a Tier III approach is undertaken. This is often because the assessments at such sites are typically more technically complex and/or to ensure that the Tier III methods used conform to generally accepted technical practices.

The Tier I RBSL Tables and Tier II PSSL Tables contain mandatory requirements that must be met prior to their application. These are discussed further in Sections 3.3 and 3.4. Some of these requirements also apply at Tiers II and III.

The Tier II PSSL Tables for PHCs have been added by Atlantic PIRI as an intermediate option for Site Professionals between the Tier I RBSL Tables and the development of SSTLs using the Atlantic RBCA Tool Kit. The Tier II PSSL Tables in Appendix 4 may be used when the Site Professional can present information to show that some of the exposure pathways assumed to be present in the Tier I RBSL Tables are not complete. An example could be a property with no on-site buildings and hence no indoor air exposure.

For CVOCs, in the absence of Tier I RBSL tables, the Tier II PSSLs are used as initial screening values. A screening of potential exposure pathways is required in advance of applying the Tier II

PSSLs for PHCs and CVOCs to ensure the most critical (i.e., sensitive) exposure pathway is protected.

The Tier I RBSL and Tier II PSSL Tables may be updated independently of the user Guidance document. Users are advised to confirm on a regular basis that they are using the most current version by checking the website www.atlanticrbca.com.

In addition to the Tier II PSSL tables, Atlantic PIRI has developed Guidance for Vapour Intrusion Assessments (April 2019) for PHCs. This Tier III guidance includes a discussion of soil vapour and indoor air monitoring issues and provides screening levels for PHCs in soil vapour, sub-slab vapour and indoor air. Further discussion is provided in Section 3.5.2.

3.2 TOOL KIT PARAMETERS

The Tier I RBSL Tables (Appendix 3) and Tier II PSSL Tables (Appendix 4) for PHCs and the Tier II PSSL Tables (Appendix 4) for CVOCs were prepared using the Atlantic RBCA Tool Kit Version 3.2.2 for various mixes of agricultural, residential, commercial and industrial receptors, potable and non-potable groundwater and fine- and coarse-grained soils. As discussed previously, due to changes in toxicological reference values (TRVs) for CVOCs and Guidelines for Canadian Drinking Water Quality (GCDWQ) updates for ethylbenzene and xylenes, when using the Atlantic RBCA Toolkit for these parameters, it is important that the "Chem/Tox" database within the toolkit be updated as per Table 5, Appendix 5 (CVOCs) and the Technical Bulletin released in 2015 with respect to the revised GCDWQ.

The Tier I RBSL Tables assume that all exposure pathways evaluated by the model are complete. Atlantic PIRI selected default input parameters that were acceptable to the Provincial regulators and were considered representative of typical conditions in the Atlantic region. Some of these input parameters may be modified with sufficient site-specific data or professional judgment. Modifications to parameters will require full justification in the report.

For TPH, Tier I RBSLs, Tier II PSSLs and Tier II SSTLs are dependent on the ratio of the hydrocarbon fractions (mass fractions) contained within the hydrocarbon mixture being assessed. The ratio of hydrocarbon fractions used during Tier II risk assessments is obtained from site-specific hydrocarbon fractionation analyses of site soils and groundwater in the source areas. The ratio of hydrocarbon fractions used for calculation of the Tier I RBSL and Tier II PSSL Tables was based on raw product samples of the three types of common hydrocarbon mixtures including gasoline, diesel (#2 fuel oil) and #6 oil (lube oil). The raw product hydrocarbon fraction ratios used by Atlantic PIRI are provided in Table 6, Appendix 5.

The Atlantic RBCA input default parameters used for preparation of Tier I RBSL and Tier II PSSL tables are contained in the tool kit and, if changed by the user, are noted in bold print on the output sheets.

Appendix 5 contains a summary of the default input parameters used in preparation of the Tier I RBSL and Tier II PSSL Tables. Although characteristics have been provided for toddler, child, adult and construction worker in the Atlantic RBCA Tool Kit, the Tier I RBSL and Tier II PSSL Tables assume the toddler to be the default receptor at agricultural, residential and commercial sites, while an adult is assumed to be the default receptor at an industrial site. Tier II risk

assessments may use other site-specific receptors subject to full justification and acceptance by the Provincial regulators.

3.3 TIER I – RISK-BASED SCREENING LEVELS

The Tier I RBSL Table values can be used to screen sites for petroleum hydrocarbon impacts using a limited amount of professional expertise. The Tier I RBSLs for Version 3.1 (Appendix 4) were calculated with the Atlantic RBCA Version 3.2.2 Tool Kit using the Atlantic RBCA Version 3.1 Default Parameters in Appendix 5. These default parameters are typical of many sites in Atlantic Canada, are consistent with most CCME CWS (2008) assumptions, and are conservative and applicable for most locations. Tier I RBSLs are specific to the type of land use (i.e., agricultural, residential, commercial or industrial). Note that the guidelines developed using the Atlantic RBCA Tool Kit Version 3.2.2, including the Tier I RBSLs for PHCs, are based on the protection of human health and do not address potential ecological concerns.

A number of requirements must also be satisfied and site-specific decisions must be made before applying Tier I RBSLs. These are discussed in the sub-sections following.

Note that there are no Tier I RBSLs for CVOCs.

3.3.1 Tier I Default Assumptions

The Tier I RBSLs for PHCs were calculated using the Atlantic RBCA Version 3.2.2 Tool Kit. This tool kit requires input values specific to receptor and environmental characteristics. Therefore, the site conditions must be in reasonable conformity with the Atlantic RBCA Version 3.1 Default Parameters in Appendix 5 (Tables 7 & 8) before the Tier I RBSL can be applied to a site.

If the site conditions are not consistent with the Appendix 5 default parameters, it is necessary to advance to Tier II and calculate SSTLs with Version 3.2.2 of the Atlantic RBCA Tool Kit. This will permit site-specific receptor and environmental parameters to be entered in place of the default values used in the derivation of Tier I RBSL Tables from Appendix 4.

Atlantic RBCA Tool Kit input parameters that have a high level of influence on the RBSL, PSSL or SSTL values include, but are not limited to, soil type selected, depth to top of affected soils, thickness of affected soils, and building construction.

Users should recognize that the default building in the Tier I RBSL Tables is a slab-on-grade structure. The default residential structure is a two-story building. Residential properties will have to consider the number of stories and the presence of basements and will have to consider the relative elevation of the basement floor to the soil impacts and groundwater levels when determining conformity with the default parameters and applicability of the Tier I RBSL Tables.

Building factors that may preclude the use of the Tier I RBSL Tables include:

- Residential single storey house (i.e., no basement);
- Floor slab thickness less than 11.25 cm;
- Concrete floor with cracks exceeding the default crack fraction (default crack fraction is based on a good condition, modern style foundation);
- Dirt basement floors, sumps with dirt bottoms; and
- Basements where impacted soil higher than the applicable Tier I RBSL is in contact with the foundation walls.

In these cases, a Tier II site-specific risk assessment may be necessary. Other site details may also restrict the use of the Tier I RBSL Tables due to non-conformity with the default values used in its development.

3.3.2 Mandatory Requirements at Tier I

For acceptable use of the Tier I RBSLs:

1. Confirmation that the site assessment reflects best management practices (see Appendix 1);
2. Confirmation that the Default Parameters presented in Table 7 and Table 8 are appropriate for the site; and
3. Confirmation that the minimum site assessment, defaults, and mandatory conditions (Appendix 5) have been met, unless otherwise approved by the Provincial regulatory authority.

3.3.3 Selecting Receptors

The choice of receptor type is based on the current or anticipated future land use. Direction may be provided if municipal zoning is in place or from the type of recent land development in the immediate area. Selection of industrial or commercial receptors may limit future residential development. No changes are permitted for any of the receptor parameters related to exposures provided in Table 7, Appendix 6, with the exception of site-specific exposure frequencies, which will require justification and will be specified in the limitations section of the report. If the Site Professional intends to apply guidelines that are less restrictive than those for the current or expected future land use, Provincial regulators must be consulted in advance.

3.3.4 Selecting Groundwater Use

The classification of a site as potable or non-potable will generally be determined by the Site Professional based on applicable Provincial policies or, in the absence of a policy, the presence or absence of existing and/or anticipated municipal or other central water supplies in the immediate area. If the classification of a site is in doubt, the Site Professional should consult with the Provincial regulator having jurisdiction.

3.3.5 Selecting Soil Type

The Tier I RBSL Tables (see Appendix 3) provide RBSLs for two default soil types: fine-grained and coarse-grained. Coarse-grained and fine-grained soils are defined in Appendix 8 based on the results of grain size analyses. Table 8, Appendix 5 provides a description of the physical characteristics of the two default soil types.

In almost all cases, the coarse-grained soils have lower RBSLs indicating that if this soil type is selected, the RBSL will be conservative. If the fine-grained soil type is selected, the choice must be supported by a sieve analysis of the site soil.

One of the most sensitive soil characteristics associated with the coarse-grained soil types is the soil vapour permeability (kv). This characteristic significantly affects soil vapour migration to indoor air when advection is prominent (coarse-grained soils). The kv for coarse-grained soils typically ranges from 10^{-6} cm^2 (coarse sand/gravel) to 10^{-8} cm^2 (silty sand, silt). ***The applicability of the Tier I RBSL Tables to sites with coarse sands and gravels should be carefully reviewed when inhalation of indoor air is a potential concern to ensure that they are within this range. If outside of the range, the Tier I RBSLs may not be conservative for the site.***

3.3.6 Modified TPH Interpretation - PHCs

The Tier I RBSL Table contains values for benzene (B), toluene (T), ethylbenzene (E), xylene (X) and Modified TPH. Modified TPH is the sum of all PHCs from carbon number 6 (C_6) to carbon number 32 (C_{32}) minus BTEX.

$$\text{Modified TPH} = \text{Total TPH } (C_6\text{-}C_{32}) - \text{BTEX}$$

Laboratory reports provide values for BTEX and Modified TPH concentrations to permit direct comparison to the Tier I RBSL Table.

It should be noted that BTEX compounds are considered separately in Atlantic RBCA Tool Kit Version 3.2.2 which is consistent with CCME practice. Therefore, TEX values are not required to be added back into the Modified TPH to obtain Total TPH for comparison at Tier II.

3.3.7 Modified TPH Guidelines - PHCs

RBSLs for Modified TPH are provided in the Tier I RBSL Tables for three types of fresh, un-weathered petroleum products. These three products include:

- gasoline,
- diesel (same composition as #2 fuel oil or furnace oil) and
- #6 oil (same composition as crankcase or lubricating oil).

The four carbon ranges reported by the laboratory (C_6-C_{10}{less BTEX}, >C_{10}-C_{16}, >C_{16}-C_{21}, and >C_{21}-C_{32}) are not the same as these three petroleum product types and cannot be compared to the RBSL for Modified TPH. The laboratory results for the four carbon ranges must be added together and the total then compared to the applicable Modified TPH RBSL.

The selection of which Modified TPH RBSL product type applies to a site can be made using the following information:

- Historical petroleum storage and/or petroleum spill history;
- Laboratory comments, if they clearly indicate a single product type; or
- Comparison to the distribution of carbon fractions in fresh product.

A comparison of the distribution of carbon fractions in fresh product (Table 3) may be useful in cases where two products have been released but one is dominating the laboratory results. This approach may also be applicable when gasoline has weathered to the extent that it appears as diesel due to the mix of carbon fractions present. The product remaining in the environment has the same chemical and toxicological hazard as diesel when the C_6-C_{10} fraction in the gasoline has weathered so that it only forms 6% or less of the TPH in the sample.

An analysis of the distribution of fractions is valid since the selection of Modified TPH type is based on the carbon distribution supplied by the laboratory. The approach is approximate as long as the laboratory indicates a lower proportion of the more volatile fractions than those shown in Table 3-1.

TABLE 3-1: DISTRIBUTION OF CARBON FRACTIONS IN FRESH HYDROCARBON MIXTURES

	$C_6 – C_{10}$	$>C_{10} – C_{16}$	$>C_{16} – C_{21}$	$>C_{21} – C_{32}$	TOTAL
Gasoline	76	24	0	0	100
Diesel (#2 Fuel Oil)	6	63	26	5	100
#6 (Lube/heavy Oil)	1	26	33	40	100

When two product types are mixed on a site in proportions that exceed those shown in Table 3, the Tier I RBSL for the most conservative product type should be selected.

3.3.8 Consideration of Impacts Against Foundation Walls – Tier I

Petroleum hydrocarbon releases from tanks adjacent to foundation walls, such as residential furnace oil tanks, often result in PHC impacted soil against the foundation walls and below the basement floor.

The Tier I RBSL Table values for PHCs were derived assuming concentrations above Tier I RBSLs are not in contact with the foundation walls (within 0.3 m). Therefore, prior to applying Tier I RBSLs, if there are impacts (i.e., above Tier I RBSLs) in soil in the vicinity of the foundation walls (<0.3 m), the impacted soils must be removed to below the Tier I RBSLs.

Note that there are no Tier I RBSLs for CVOCs (refer to Section 3.4.5 for Tier II requirements).

3.3.9 Soil Guidelines for the Protection of Potable Groundwater – Tier I

The Tier I RBSLs are calculated based on the target risk-based exposure limit at the point of exposure (e.g., drinking water guideline, DW, from a potable well) and the natural attenuation factor (NAF) that defines the natural reduction in constituent concentrations during cross media transfer and/or lateral transport (i.e., RBSL, PSSL or SSTL = DW x NAF). The NAF used in the development of the soil guidelines for the protection of the potable groundwater pathway considers a number of different components.

1. Soil leaching partitioning (K_{sw}, see equation CM-7 in GSI, 2011). This factor uses equilibrium partitioning to estimate the appropriate soil guideline based on the allowable leachate concentration at the source.
2. Unsaturated zone soil attenuation factor (SAM, see equation CM-8 in GSI, 2011). This component accounts for the attenuation of the chemical due to sorption to clean intervening soils between the source zone and the groundwater. At the Tier I level, the contamination is assumed to be in contact with the groundwater and hence SAM = 1.
3. Leachate-groundwater dilution (LDF, see equation CM-9 in GSI, 2011). Once the leachate reaches the water table, it is diluted as it mixes with the clean groundwater. The area where this occurs is commonly referred to as the "mixing zone".
4. Lateral groundwater dilution (DAF, see equation LT-1 in GSI, 2011). As the plume moves away from the source area and towards the receptor, it is subject to dispersion, retardation, and decay, which results in a decrease in the plume concentration. At the Tier 1 level, the receptor is assumed to be immediately downgradient of the source area and hence DAF = 1.
5. Well dilution factor (WDF). Well dilution occurs when the screen (or open borehole) of a water well is open to non-uniform groundwater quality and contaminated groundwater from the source area is blended with clean groundwater as the well is pumped. This attenuation factor was new in Version 3 and is defined as the ratio of the average daily pumping rate from the water supply well to the average daily volumetric flow rate from the mixing zone.

In previous versions of Atlantic RBCA, the Tier I RBSLs were calculated based on meeting the drinking water quality guidelines within the mixing zone. However, it is recognized that groundwater flow within the mixing zone is typically not sufficient on its own to meet the water requirements of a typical domestic well. As a result, groundwater from the mixing zone is blended with clean groundwater at the well in order to meet the domestic demands. The Tier I RBSLs remain protective of the groundwater ingestion pathway, and are based on meeting drinking water quality guidelines, where available, (e.g., Guidelines for Canadian Drinking Water Quality) at the potable well.

3.4 TIER II – SITE-SPECIFIC RISK ASSESSMENT

3.4.1 Pathway Specific Screening Levels (PSSLs)

In general, a Tier II risk assessment will require use of the Atlantic RBCA Tool Kit. However, as noted in Section 3.1, Atlantic PIRI has produced Tier II PSSL Tables (Appendix 4) which, in application are similar to the Tier I RBSL Tables. The use of PSSLs for site assessment and remediation is intended to provide flexible clean-up levels where certain exposure pathways are not present on a site. For CVOCs, in the absence of Tier I RBSLs, the PSSLs are initial screening values. The use of the PSSL tables requires careful examination of the existing and potential future land and groundwater use and may result in a conditional site closure. Note that vapour assessment is required for CVOCs for delineation in the absence of PSSLs for soil for the indoor air exposure pathway.

The Tier II PSSL Tables were developed using the same default parameters as the Tier I RBSL Tables but unlike the RBSL Tables, they present values for all exposure pathways evaluated. The active exposure pathways in the Atlantic RBCA Tool Kit that were used when developing the Tier II PSSL Tables are shown in Figure 1, Appendix 5.

Atlantic PIRI did not calculate PSSLs for the outdoor air exposure pathway since this typically results in values that are >RES, >SOL or far in excess of what would be found at an impacted site. If the groundwater ingestion and indoor air exposure pathways are not complete but soil is available for human contact, the PSSLs for soil ingestion plus dermal contact are appropriate. If the soil exposure pathway is also incomplete due to an engineered cover, the calculated remedial levels are >RES and >SOL under default site conditions. In this instance, free product removal may be the only necessary remedial action.

The Tier II PSSL Table has mandatory conditions similar to the Tier I RBSL Table that must be satisfied prior to use, as noted in Sections 3.3.1 and 3.3.2. If the Tier II PSSL Table is not appropriate for use at the site, Tier II SSTLs may be calculated using the Atlantic RBCA Tool Kit Version 3.2.2.

The following conditions will also apply to the use of the Tier II PSSL Table, as noted in the checklist in Appendix 6:

- Atlantic regulators will require site professionals to explain the contaminant transport and exposure pathways that have been evaluated in relation to the receptors on- and off-site. Where exposure pathways have been eliminated, the report must explain in detail why these are not relevant.
- The elimination of the groundwater ingestion pathway must be made in conjunction with applicable Provincial policies. However, Atlantic regulators will require hydrogeological monitoring be conducted in support of any groundwater modeling.
- In cases where PSSL tables are used based on the elimination or control of a pathway that could be reopened by changes in site use, or land use, reports must specify these conditions as limitations.

- For CVOCs, in the absence of Tier II PSSLs for indoor air inhalation, vapour assessment (soil vapour, sub-slab vapour and/or indoor air) is required to assess the indoor air inhalation pathway and to delineate the extent of impacts.

3.4.2 Mandatory Requirements at Tier II

All of the same mandatory requirements that must be met at Tier I as noted in Section 3.3.2 apply at Tier II. These are also footnoted on the Tier I RBSL Tables in Appendix 3, the Tier II PSSL Tables in Appendix 4, and the Site Assessment and Tier I/II Checklist in Appendix 6.

3.4.3 Developing Site-Specific Target Levels

If the Tier I RBSLs or Tier II PSSLs are exceeded or not considered to be applicable for the site, soil and groundwater SSTLs can be calculated. This can usually be achieved for PHCs and CVOCs using the Atlantic RBCA Tool Kit software. The Atlantic RBCA Tool Kit contains equation sets for risk assessment (Baseline Risk) of the site (the "forward" calculation); and for development of SSTLs as part of risk management for the site (the "backward" calculation).

As discussed previously, due to changes in toxicological reference values (TRVs) for CVOCs and Guidelines for Canadian Drinking Water Quality (GCDWQ) updates for ethylbenzene and xylenes, when using the Atlantic RBCA Toolkit for these parameters, it is important that the "Chem/Tox" database within the toolkit be updated with the TRVs provided in Table 5, Appendix 5 (CVOCs) and the Technical Bulletin released in 2015 with respect to the revised GCDWQ (ethylbenzene and xylenes).

The Baseline Risk output sheet presents the level of risk posed by the site concentrations entered in the Tool Kit based on the forward risk calculation. Note that the target hazard quotient for CVOCs is 0.2 and for toluene, ethylbenzene and xylenes is 0.5 as shown in Table 1. The target hazard quotient for TPH is 1.0. The Cleanup Standards output sheet presents the SSTL or remedial levels in soil and groundwater necessary to reduce the site risk to an acceptable level using the backward calculation. Note that when the HQ differs from 1.0 (i.e., for toluene, ethylbenzene, xylene, and CVOCs), it is required to be manually updated in the Atlantic RBCA Toolkit prior to SSTL calculation.

In the case of CVOCs (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE and vinyl chloride), it is important that all parent compounds and theoretical degradation compounds of concern (i.e., daughter products) be assessed/analysed. Both parent and degradation compounds should be considered when calculating SSTLs even if degradation products are not present or are below screening levels, due to their increasing toxicity and possibility of increase in concentration over time. For instance, vinyl chloride may not be detected during initial sampling programs, however, may be detected at elevated concentrations once degradation takes place.

3.4.4 SSTLs for Direct Soil Contact Exposures – PHCs

For PHCs, it is necessary to set the inhalation pathway contribution of the heavy hydrocarbon fractions to zero to eliminate mathematical errors in the Tool Kit calculations for determining SSTLs for the indoor air pathway (additional details provided in Section 4.5.2). For heavier fuel types (diesel, heavy oil), this creates incorrect, high SSTL values when calculating SSTLs for the direct

contact soil exposure pathway if the “Air Exposure: Affected Surface Soils – Particulates to Ambient Outdoor Air” box is checked at the same time as the “Surface Soil Exposure: Direct Ingestion and Dermal Contact” box.

Therefore, when calculating SSTLs for fuel mixtures with heavy hydrocarbon fractions for exposure scenarios that are limited to direct contact soil exposure scenarios, only the “Surface Soil Exposure: Direct Ingestion and Dermal Contact” box should be checked on the Exposure Pathway Identification page. This is acceptable since the contribution of Volatiles and/or Particulates from heavy hydrocarbon fractions to ambient air is very small.

3.4.5 Consideration of Impacts Against Foundation Walls - Tier II

The Tier II PSSL Table values were derived assuming no soil impacts (i.e., PHC concentrations above Tier I RBSLs or detections of CVOCs in soil) in contact with the foundation walls. There are two approaches that can be used to address soil impacts within 0.3 m of the foundation walls including the following:

1. Direct measurement and monitoring of soil vapours and/or indoor air concentrations is an acceptable means of empirically assessing the potential risks posed by the subsurface vapours to indoor air pathway as an alternative to Tier II PSSL or SSTL calculations, as described in Section 3.5.2. Note that soil vapour and/or indoor air measurement is considered a Tier III approach.
2. If the Site Professional chooses or is unable to use soil vapour and indoor air monitoring, prior to use of Tier II PSSLs for indoor air exposure, soil in the vicinity of the foundation walls must be excavated to below the applicable Tier II PSSLs. This approach, also used in Limited Remedial Action, will result in a zone of clean soil at the soil-foundation interface, and is considered a Tier II approach.

For CVOCs, there are no Tier I RBSLs or Tier II PSSLs for soil for the indoor air inhalation exposure pathway, and therefore, any detection of CVOCs in soil within 0.3 m of the foundation will require additional assessment as noted above.

3.4.6 Soil Guidelines for the Protection of Potable Groundwater - Tier II

At Tier II, Site Professionals have the option of calculating an SSTL using the well dilution factor (WDF) or using the lateral dilution attenuation factor (DAF); however, the two cannot be used at the same time. Additional details regarding the WDF are provided in Section 3.3.9.

3.5 TIER III – SITE-SPECIFIC RISK ASSESSMENT

The Tier I RBSL tables, the Tier II PSSL tables, and the Atlantic RBCA Tool Kit (for SSTLs) are used to determine human health risks and appropriate remedial cleanup levels for PHCs and CVOCs at a site. Any additional considerations not included in these methodologies are considered a Tier III approach. For example, since the Atlantic RBCA Tool Kit cannot assess ecological risk, any site for which an ecological risk assessment is required following the Ecological Receptor Screening (Appendix 2) should be considered Tier III. Another example is the assessment of contaminants that have not been pre-approved within the Atlantic RBCA process, beyond comparison to national or Provincial generic criteria.

In some cases, parts of the human health risk assessment of various exposure pathways are completed using the Atlantic RBCA Tool Kit in combination with other methods. The Atlantic RBCA Tool Kit also includes soil leaching, groundwater transport, and groundwater discharge to surface water models that may be used in combination with other methods for ecological risk assessment. These other methods for assessment of human and ecological risk may include more complex models, air quality testing, data compared to published ecological guidelines, ecological risk assessment, or ecological toxicity testing. Supplemental or full use of other methods is considered Tier III. The Site Professional may require supporting professional expertise at Tier III.

Provincial regulators may require Peer Review of a Tier III approach, depending on the extent of supplemental method use and their familiarity with the methodology.

3.5.1 Guidance for Other Compounds

The Atlantic RBCA Tool Kit is based on the ASTM Standard E2081-00, which was designed to assess a wide range of chemicals in addition to PHCs and CVOCs. Consequently, the Atlantic RBCA Tool Kit contains physical, chemical and toxicological attributes for a wide range of chemical compounds which have been carried over from the United States version of the RBCA Tool Kit for Chemical Releases. Provincial regulators have only approved the Atlantic RBCA Tool Kit Version 3.2.2 for use with PHCs (BTEX/TPH) and CVOCs (PCE, TCE, *cis*-1,2-DCE, *trans*-1,2-DCE, 1,1-DCE and vinyl chloride).

Atlantic PIRI will be publishing Tier I Environmental Quality Standards (EQS) and Tier II Pathway-Specific Standards (PSS) for soil, groundwater, surface water and sediment for use in the Atlantic Provinces. Consistent with the Tier I RBSLs and Tier II PSSLs, EQS/PSS will be provided for agricultural, residential, commercial, industrial sites and for coarse grained and fine grained soils.

With the exception of PHCs and the select CVOCs, the EQS and PSS values are adopted values that have been derived by Canadian Council of Ministers of the Environment (CCME) and other regulatory authorities in Canadian or international jurisdictions. For contaminants other than PHCs and CVOCs, the general hierarchy used to select EQS and PSS is outlined below:

1. Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (http://ceqg-rcqe.ccme.ca/en/index.html).
2. Federal Environmental Quality Guidelines (e.g., https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/federal-environmental-quality-guidelines.html
3. As necessary, other Canadian jurisdictions (i.e., Alberta, British Columbia, Ontario) in specified orders of preference.
4. As necessary, United States Environmental Protection Agency (USEPA).
5. As necessary, select other U.S. and international jurisdictions.

It is expected that the four Atlantic Provinces will independently determine how and when to apply and implement the EQS and PSS within their individual provincial contaminated site management processes, programs and policy frameworks. Therefore, it is recommended to discuss assessment of other compounds with the Provincial Regulator, unless guidance has been provided.

Compounds in the Atlantic RBCA Tool Kit Version 3.2.2 database (other than the above referenced parameters) have chemical/toxicological attributes that may be based on United States data that may not be consistent with Health Canada policy. Fate and transport equations in the Atlantic RBCA Tool Kit are therefore not necessarily applicable to all types of compounds. A person with expertise in human health toxicology should ensure that toxicological data used for assessing other compounds are appropriate. ***If the Provincial regulator agrees to the use of the Atlantic RBCA Tool Kit for development of SSTLs for compounds other than PHCs and CVOCs, it is the responsibility of the Site Professional to confirm that applicable fate and transport equations and toxicological data sources are used, to the extent possible, in the risk assessment.***

Where EQS/PSS values are exceeded, a background environmental quality assessment should be considered to determine the concentrations of contaminants that may be present naturally in a non-impacted area of the site (or off site). Alternatively, background environmental quality information already in existence can be presented, along with justification for its use on the site.

Where background levels or screening levels are exceeded, and risks need to be evaluated further, published pathway specific guidelines can be used if applicable, or a Tier III approach implemented to assess the risk and manage the impacts.

Tier III quantitative risk assessments must follow the basic requirements as specified for all risk-based approaches in addition to providing the following information:

- Provide a detailed written and tabulated hazard, exposure and receptor assessments
- Include written documentation that provides the toxicological database dose-response relationship for those parameters carried forward in the risk assessment. This will include chemical, physical[2] and toxicological data. Sources of this information include, but may not be limited to the following:
    - Health Canada
    - Canadian Provincial jurisdictions
    - US Environmental Protection Agency (USEPA)
    - Jurisdictions outside of North America
- Provide written documentation and references for the toxicological values used, (in tabular format) for the following data[2]:

Physical/Chemical Data:	**Toxicological Data:**
Diffusion coefficients	Toxicological Reference Values
log Koc	Estimated Daily Intakes (EDIs)
Henry's Law Constant	Carcinogenicity Assessment
Vapour Pressure	Relative absorption factors
Solubility	Bioavailability

[2] The Atlantic RBCA Tool Kit chemical database has not been specifically developed for Canadian use and requires user modifications for any use except for PHCs and CVOCs. A Site Professional with expertise in human health toxicology should complete the selection of toxicological data for non-petroleum compounds

- The model or calculation method used for the risk assessment input calculations must be specified. Preference is given to an appropriately modified Atlantic RBCA Version 3.2.2, Johnson and Ettinger vapour intrusion model and/or CCME published methodology. The calculation equations must be shown for Tier III contaminant transport models. Assumptions such as biodegradation rates must be documented, supported, and shown to be appropriate for the study.
- The volatility of the chemical compounds must be quantitatively considered. If considered as volatile, these compounds must be assessed for any applicable air exposure pathways.
- For certain groups of compounds such as polycyclic aromatic hydrocarbons (PAHs) and dioxins/furans, a potency equivalency approach is preferred. For PAHs, Health Canada's benzo(a) pyrene potency equivalency scheme should be used.
- Site-specific conditions should be evaluated (relative to Atlantic RBCA defaults provided in Table 7 and Table 8) and documented in the report.
- In the case of groundwater assessments, realistic upper solubility limits must be used. For example, SSTLs should not exceed theoretical groundwater solubility limits for parameters.
- A comprehensive summary of the approach used and the results obtained for modelling or direct measurements must be provided. If the equations from the Atlantic RBCA Tool Kit are used, the summary should reference separate Atlantic RBCA Tool Kit runs in Appendices that are individually numbered or labelled, or otherwise clearly identified.
- Tier III SSTLs are to meet health targets of ILCR of $1x10^{-5}$ for carcinogens and a hazard quotient (HQ) of <0.2 for non-carcinogens in each media evaluated (e.g., soil, water) for non-carcinogenic compounds of concern. Provided reasonable efforts have been made to identify appropriate estimated daily intakes (i.e., exposures to all background sources), a HQ between 0.2 and 1.0 may be used; however, prior consultation and approval from Provincial regulators would be required prior to using this approach.
- The report must make a final comparison to the derived Tier III SSTLs to representative site concentrations, as described in Section 4.2.
- Risk management approaches must be supported with engineering controls or site limitations that are clearly identified in the report.

3.5.2 Soil Vapour Monitoring and Indoor Air Assessments

Tier I RBSLs are developed using the Atlantic RBCA Toolkit and reflect the lowest of the applicable PSSLs. PSSLs and RBSLs were calculated using the Atlantic RBCA Toolkit, with an assumed set of site conditions, representative of the Atlantic Canadian experience or from CCME defaults. Default assumptions about site conditions used to generate the Tier I RBSLs are deliberately conservative, to ensure safe management of sites.

Users of the PSSLs and RBSLs must decide whether the default assumptions are appropriate for the site. Where these assumptions do not apply, for example in the case of a basement with an earth floor, it may not be possible to apply the Tier I RBSLs or Tier II PSSLs/SSTLs at the site. In addition, the vapour transport model (Johnson & Ettinger, 1991) in the Tool Kit provides an

inherently conservative evaluation of vapour migration and infiltration. For these reasons, situations arise where an alternative approach is preferred or required.

Collection and interpretation of empirical site data is one means of replacing reliance on model calculations as part of a Tier III approach. Atlantic PIRI considers direct measurement and monitoring of soil vapours and/or indoor air concentrations an acceptable means of empirically assessing the potential risks posed by the subsurface vapours to indoor air pathway on a site-specific basis. For CVOCs, there is no soil Tier II PSSL for indoor air inhalation, and therefore, in addition to assessment of groundwater, direct measurement of soil vapour and/or indoor air concentrations is required to ensure a complete assessment of the site and delineation of impacts.

In 2016 (updated in 2019), Atlantic PIRI published the Guidance for Vapour Intrusion Assessments, which is available from the Atlantic RBCA website (www.atlanticrbca.com). The purpose was to provide specific guidance on the assessment and quantification of the subsurface vapours to the indoor air exposure pathway for PHCs. This guidance document also serves to simplify the process by presenting vapour intrusion screening levels for various types of vapour/air data.

The Guidance for Vapour Intrusion Assessments accommodates flexibility in approach, based on site-specific conditions, when supported by sound reasoning and professional judgement. The guidance document, which replaces the 2006 Guidance Document for Soil Vapour and Indoor Air Monitoring Assessments, includes VISLs for PHCs for soil vapour, sub-slab vapour and ambient air. It is recommended that the website be checked regularly to maintain current knowledge of related changes and updates.

3.6 LIMITED REMEDIAL ACTION

A site remediation process that may be less complex than the typical full contaminated site management process is frequently called a Limited Remedial Action (LRA), or some other similar term. The use of LRA is restricted to lower risk situations where the extent of information and professional judgment requirements are less demanding. Exposure pathways such as potable water consumption, indoor air quality and third party impacts should be deemed to be negligible prior to adopting an LRA approach. Typical scenarios include fresh domestic furnace oil spills without indoor air concerns and highway accident spills. Using an LRA approach, the extent of site assessment will be lower than the minimum level of effort described in Appendix 1. Remediation under LRA will normally be to the applicable Tier I RBSL. The level of remedial action required will often not involve more than immediate soil excavation and confirmation sampling of soil and perhaps groundwater.

Each province has its own LRA process and site-specific regulatory approval is required prior to using LRA. LRA may apply to only a part of a property, such as in a residential fuel oil spill. LRA may be used with or without a Site Professional, depending on the province.

Due to the complexities with assessment and remediation of sites impacted with CVOCs, the LRA approach is not accepted for these compounds.

4.0 THE ATLANTIC RBCA TOOL KIT (VERSION 3.2.2)

The Atlantic RBCA process offers the Site Professional the opportunity to collect additional data to justify changes to the default modeling parameters at Tier II and Tier III and to calculate SSTLs instead of using Tier I RBSLs or Tier II PSSLs. Some site circumstances may be complex or unique, thereby requiring Tier II or III because the RBSLs and PSSLs are not applicable. Each tier provides an equivalent level of environmental protection.

The use and application of the Atlantic RBCA Toolkit at Tiers II and III requires the Site Professional to enter information obtained from site-specific observations or testing.

Site Professionals are required to tabulate and summarize all of the site-specific data input used to produce the results of risk assessment modelling in reports submitted to regulators, which will include the following:

- the parameter
- the default value
- the site-specific value used
- the rationale and/or detailed written justification

As discussed previously, due to changes in TRVs for CVOCs and GCDWQ updates for ethylbenzene and xylenes, when using the Atlantic RBCA Toolkit for these parameters, it is important that the "Chem/Tox" database within the toolkit be updated as per Table 5, Appendix 5 (CVOCs) and the Technical Bulletin released in 2015 (revised GCDWQ).

Changes to default input parameters that are made without justification from site-specific data or literature references will normally be rejected by Provincial regulators.

4.1 SENSITIVE INPUT PARAMETERS

A limited number of the sensitive input parameters used at Tier II are discussed below.

Soil Type

Atlantic PIRI has validated two default soil types, coarse-grained soil and fine-grained soil. Selection of coarse-grained soil type can be made based on observation and does not have to be validated by grain size analysis. Selection of the fine-grained soil type requires confirmation through grain size analysis. Use of the other soil types in the Toolkit requires additional rationale to support the associated soil characteristic values. Default soil vapour permeability (kv) values of 10^{-8} cm^2 are not suitable for coarse sands and gravels, if encountered. More appropriate kv values for these soil types are 10^{-7} or 10^{-6} cm^2 and therefore, presence of coarse sands and gravels precludes the use of the Tier I RBSLs and PSSLs.

Default coarse-grained and default fine-grained soils are the only two soil types with associated parameters that have been validated for use by Atlantic PIRI. Use of soil types other than the two Atlantic PIRI default types requires validation of all associated soil parameters by the Site Professional.

Depth to Groundwater	Increasing the depth to groundwater parameter will not affect the soil SSTLs for the indoor air pathway, but will result in higher groundwater SSTLs. Transport of vapours to indoor air will occur more easily from the vadose zone than the saturated zone. ***When the groundwater table fluctuates seasonally, it is advisable to assess the sensitivity of this parameter using the extremes of the seasonal values.***
foc	Fraction of organic carbon (f_{oc}) is a sensitive variable for assessment of petroleum hydrocarbon impacted sites and has a direct numerical impact on SSTL calculations. Therefore, use of f_{oc} values other than the default must be supported by several site-specific test results. Samples for analysis must be collected from non-petroleum impacted areas of the site and from the zone (vadose or saturated) for which the data will be used. ***Vadose zone samples for foc are recommended at each petroleum hydrocarbon impacted site regardless of the Tier used.***
Crack Fraction	The foundation crack fraction is a sensitive variable and has a significant effect on SSTL calculations when inhalation of indoor air is the controlling pathway. The default crack fraction is based on a poured concrete foundation in good condition with very low visual evidence of cracks. ***If the site buildings do not meet this condition, site-specific measurements should be made and used as input.*** Heavily cracked floors, partial concrete floors, dirt floors or open bottomed sumps may result in large crack fraction values and erroneous results due to model equation limitations (i.e., negative convective air flow values). ***In these cases, a Tier III approach is recommended.***
Volume to Area Ratio	The "Volume to Area Ratio" is the ratio of the interior volume of a building to the area of the building footprint under which hydrocarbon impacts are present. For a residential property, the volume to area ratio is 3.6, which assumes partial mixing within a two story structure with a building height of 4.88 m. For a commercial property, the volume to area ratio is 3.0 assuming complete mixing in a single story commercial building. If the residential property is slab-on-grade with only one story the building volume/area ratio should be reduced to 2.44 meters. Building configurations that differ from these defaults will require appropriate adjustment. Adjustments to reflect the actual area of contamination for site-specific cases can be made provided the following conditions are met and reported: • the contaminated area is fully delineated to Tier I RBSLs • the site-specific calculations are provided to support a change in the building volume/area ratio Impacted soil exceeding Tier I RBSL that is within 0.3 m of the foundation wall must be removed if using a Tier I or Tier II approach.

Air Exchange Rate	The default Air Exchange Rate may be changed if a risk management plan includes an engineered control (such as mechanically assisted air exchange) and the long-term obligations are accepted by the stakeholders. ***Otherwise, this value should not be changed.***

4.2 REPRESENTATIVE CONCENTRATIONS

4.2.1 PHCs

PHC fractions used in the Tool Kit should be representative of the source zone (i.e., area where concentrations are greater than Tier I RBSLs). In cases where the risk is being assessed (forward calculation), worst case concentrations should be used. The concentrations used for TPH and BTEX parameters may be from different locations to simulate worst-case conditions. It is important to note that if an assessment of risk is required at a site, the representative site concentrations of TPH fractions must be entered into the Tool Kit.

A review of laboratory reports will show that Aromatic >C_7-C_8 is not reported but toluene is. These compounds are one and the same. Aromatic >C_8-C_{10} is reported minus ethylbenzene and xylenes (EX) since E and X are in this aromatic group. ***In this guidance document, and Atlantic RBCA Toolkit Version 3.2.2, toluene, ethylbenzene and xylene (TEX) are evaluated separately in accordance with CWS-PHC and should no longer be added to the aromatic >C_7-C_8 and Aromatic >C_8-C_{10} fraction when calculating SSTLs as was the case with Atlantic RBCA Version 2.***

Calculation of TPH SSTLs should be based on site-specific hydrocarbon fractionation by the Atlantic RBCA Tier II method whenever possible. Both groundwater and soil from the source areas should be analysed for the site-specific hydrocarbon fractions (i.e., Tier II Atlantic RBCA method). Higher concentration samples should be submitted for fractionation to minimize bias due to non-detect fraction reports from the laboratory. Raw product hydrocarbon fraction ratios from Table 5, Appendix 5 may be used on a limited basis for simpler sites or where sample collection for fractionation purposes was not practical.

If the laboratory reports a non-detectable concentration for a specific hydrocarbon fraction or any other assessed parameter, a value of ½ the Reportable Detection Limit (RDL) should be used as Tool Kit input.

4.2.2 CVOCs

For CVOCs, parent compounds and all theoretical degradation compounds must be assessed if CVOCs are suspected to be present at a site. Parent and degradation compounds should be assessed and monitored even if degradation products are not detected or are below screening levels, due to their increasing toxicity and possibility of increase in concentration over time. If an assessment of risk is required at the site, the worst case (maximum) concentrations should be used and both parent and degradation products must be assessed. The concentrations of each compound, used in the risk assessment, may be from different locations to simulate worst case conditions (i.e., the maximum concentrations may not all be in the same sample).

If the laboratory reports a non-detectable concentration for a specific parameter, a value of ½ the Reportable Detection Limit (RDL) should be used as Tool Kit input.

4.2.3 Upper Confidence Limits

When a sufficient number of source zone test results are available, 90 or 95% Upper Confidence Limits on the Mean (UCLM) as determined using an appropriate software program (e.g., US EPA Pro UCL, version 5.00 or later) may be used. A statistically significant number of samples (minimum of ten) must be used when calculating a UCLM. Alternatively, maximum site concentrations should be used. Site data from source zones and non-impacted areas (i.e., non-detect) cannot be combined when calculating a UCLM to represent exposure concentrations. It is important to note calculation of a UCLM may not be an applicable approach on all sites. For instance, if there is an indoor air concern, the maximum concentration in the vicinity of the building may be more applicable to use in a risk assessment.

In some jurisdictions, there is a regulatory requirement to compare RBSLs or SSTLs to maximum measured concentrations in order to obtain site closure. If uncertain, the Site Professional should consult with the Provincial regulator to confirm that the UCLMs are acceptable for obtaining regulatory closure for the site.

4.3 CONSIDERATION OF PHCS >C32

If the laboratory reports that hydrocarbons >C_{32} are present based on the chromatogram not returning to near baseline, the regulator may require that an alternate test method be used to quantify the C_{32}-C_{50} range. If the C_{32}-C_{50} fraction is required to be included in the risk assessment and SSTL calculation, it should be considered to be 20% aromatic and 80% aliphatic with the same physical, chemical and toxicological properties as the corresponding C_{21}-C_{32} groups.

4.4 ATLANTIC RBCA TOOL KIT LIMITATIONS

4.4.1 Earthen Floors

The Tier I RBSL and Tier II PSSL Tables do not apply to buildings without concrete floors due to the increased vapour infiltration in the absence of a concrete barrier. At this point, the Atlantic RBCA Version 3.2.2 software should not be used at the Tier II level for buildings with earthen floors.

Buildings with dirt floors can be assessed in another manner deemed appropriate (and justified) by the site professional, with prior approval from the Provincial Regulator. Alternatives to predictive modeling include engineered controls (e.g., pouring of concrete floors, which could allow the use of the Tier I RBSL and Tier II PSSL Tables) and indoor air testing and/or soil vapour sampling.

4.4.2 Inhalation Pathway – Heavy Petroleum Hydrocarbon Fractions

The US TPH Criteria Working Group (TPHCWG) series of reports, published between 1997 and 1999, was used as the data source for the chemical, physical and toxicological properties of the petroleum hydrocarbon fractions. They were not able to find inhalation toxicity data for the aromatic and aliphatic fractions between C_{16} and C_{35} due to the very low volatility of these groups. In order to account for the insignificant contribution to the inhalation pathway by these groups, Atlantic PIRI instructed the Tool Kit manufacturer set the contribution of these groups to the inhalation pathway at zero to eliminate mathematical errors that would have otherwise been generated by the Tool Kit.

4.4.3 Groundwater Transport Model

The Domenico groundwater transport equation used to assess site impacts on down-gradient groundwater wells is an analytical model. The equation cannot consider the influence of a pumping well on the aquifer flow patterns. This simplicity may be adequate for assessing low volume pumping by residential wells. Often regulators will require empirical data even in low yield receptor well scenarios to confirm predictions. ***However, the model should not be applied where pumping systems create complicated flow fields or where vertical gradients affect contaminant transport.*** If high volume down-gradient pumping wells (municipal or industrial) are being assessed, a more complex groundwater model or empirical data, or a combination of the two may be required for proper assessment.

The Domenico equation is sensitive to the use of "lateral distance off centerline" of the down-gradient well from the flow direction. ***A high level of confidence in year-round groundwater flow direction is required if an "off centerline" value is to be used.***

The Domenico equation is also sensitive to the vertical depth entered for the down-gradient receptor well ("depth below top of water-bearing unit"). The Tool Kit may indicate that a well with a deep casing that is located close to a source plume will not be affected. However, the Domenico equation does not consider the drawdown effects of pumping wells, which may negate the protective effect of the deep casing. ***Therefore, the vertical depth in the Tool Kit ("depth below top of water-bearing unit") should be left as zero, unless the user can demonstrate that vertical gradients due to pumping receptor wells do not influence contaminant transport.***

4.5 ADJUSTMENT FACTOR FOR THE INDOOR AIR PATHWAY

Modifications to several model input parameters have been made based on changes to the 2008 CWS PHC, supported by recent scientific literature. Although the objective of these modifications is to increase the degree of realism and defensibility of the model assumptions, the modifications, in fact, result in less attenuation of hydrocarbon vapours than is observed from site data at actual hydrocarbon contaminated sites.

The Johnson and Ettinger (1991) model has been shown to predict indoor air concentrations relatively well for chemicals that do not undergo significant biodegradation, such as CVOCs. The model predictions are considered less reliable for substances that undergo significant biodegradation in the vadose zone, such as PHCs.

Therefore, based on the available empirical data, an Adjustment Factor (AF) of 10x has been applied to the PSSLs for the indoor air pathway and thereby incorporated into the RBSLs, and should be applied (manually) to the calculated SSTLs for the indoor air pathway. The adjustment factor applies to both soil and groundwater and should be applied after the SSTL has been calculated. ***Use of the AF applies only to petroleum hydrocarbon mixtures and BTEX compounds (i.e., does not apply to CVOCs).***

Application of an Adjustment Factor for other organic compounds, should they be approved for use with the Atlantic RBCA Tool Kit Version 3.2.2, must be supported with appropriate documentation.

4.6 CUMULATIVE RISK

If multiple contaminants are included in the risk assessment at Tier II or III (assuming approval from the Provincial Regulator), it may be necessary to consider the cumulative effects in the derivation of SSTLs. Different compounds may act on different body organs, thereby affecting the compounds that need to be considered as having cumulative effects. Assistance of a human health toxicologist may be required.

Note that the cumulative effect of the various non-carcinogenic petroleum hydrocarbon fractions is automatically considered within the TPH calculator that derives the TPH SSTLs.

5.0 CONTROLS

Both institutional and engineered controls can be effective in eliminating the exposure pathway between the source and the receptor.

Institutional controls include municipal zoning and site-specific land use controls that state what type of receptors may inhabit the impacted lands. They essentially eliminate certain types of receptors from exposure to the site. Typically, this is achieved by a municipal or site-specific, documented statement that the land is designated for Agricultural, Residential, Commercial or Industrial use. Human occupancy buildings may be excluded from all or part of the site to eliminate unacceptable indoor air exposure risk. Potable groundwater wells may be prohibited or restricted to a non-impacted area of the site. In some cases, a site-specific institutional control may state no human occupancy or a limited number of occupancy days per year based on reasonable expectations of land use to be controlled by the site owner.

Engineered controls are man-made systems that require some degree of maintenance to remain effective. Engineered controls interrupt the pathway between the source and the receptor while allowing both the source and the receptor to remain on the site. Engineered controls can be passive or active mechanical systems. Examples of passive engineered systems include soil, asphalt and concrete covers and building sub-floor ventilation. Examples of active mechanical systems include air exchange units, groundwater pumping systems, and potable groundwater treatment systems.

In some cases, both institutional and engineered controls may be combined on a site. When controls that limit the flexibility of the property use or have long-term obligations are placed on a site to minimize risk, the regulatory authorities and the affected stakeholders must be in agreement with the specific controls.

6.0 REPORTING

Although no specific report format is required, if a Site Professional is requesting acknowledgement of site closure for a contaminated site that has been assessed using the Atlantic RBCA process, regulators in Atlantic Canada require certain minimum site information be included in closure reports. It is recognized that site closure requirements vary slightly throughout the four Atlantic Provinces; however, to ensure consistency in the region, a Site Closure Checklist must be completed and submitted with other closure documents. The Site Closure Checklist is provided in Appendix 7.

7.0 REFERENCES

Atlantic PIRI, 2006 with 2012 Errata. Atlantic RBCA (Risk-Based Corrective Action). Version 2.0. For Petroleum Impacted Sites in Atlantic Canada. User Guidance. Guidance for Soil Vapour and Indoor Air Monitoring Assessments.

Atlantic PIRI, 2019. Atlantic RBCA (Risk-Based Corrective Action), Version 3.0 For Impacted Sites in Atlantic Canada Guidance for Vapour Intrusion Assessments.

Atlantic RBCA Laboratory Method and Guidelines for Laboratories (www.atlanticrbca.com).

British Columbia Ministry of Environment, 2009. Protocol 13, Screening Level Risk Assessment.

Canadian Council of Ministers of the Environment (CCME), 1999. Canadian Environmental Quality Guidelines (updated subsequently) (http://ceqg-rcqe.ccme.ca/).

CCME, 2006. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. Winnipeg, MB.

CCME, 2008. Canada-wide Standard for Petroleum Hydrocarbons (PHC CWS) in Soil (https://www.ccme.ca/en/resources/contaminated_site_management/phc_cws_in_soil.html)

CCME, 2001. Reference Method for the Canada Wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method.

CCME, 1996. Ecological Risk Assessment Framework.

Federal Contaminated Sites Action Plan (FCSAP), 2012. Ecological Risk Assessment Guidance.

FCSAP, 2018. Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours, Version 6.1.

Government of Canada, Various Years. Federal Environmental Quality Guidelines (e.g., https://www.canada.ca/en/health-canada/services/chemical-substances/fact-sheets/federal-environmental-quality-guidelines.html

Groundwater Services Inc. (GSI). 2011. Software Guidance Manual RBCA Tool Kit for Atlantic Canada Version 3.1 (https://www.gsi-net.com/en/).

Health Canada. 2010a. Federal Contaminated Site Risk Assessment in Canada. Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0., September 2010.

Interstate Technology & Regulatory Council (ITRC). 2015. Integrated DNAPL Site Characterization and Tools Selection (ISC-1). Washington, D.C. www.itrcweb.org/DNAPL-ISC_tools-selection.

ITRC, 2003 An Introduction to Characterizing Sites Contaminated with DNAPLs https://www.itrcweb.org/GuidanceDocuments/DNAPLs-4.pdf

ITRC, 2018. TPH Risk Evaluation at Petroleum-Contaminated Sites.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG). 1999. Total Petroleum Hydrocarbon Criteria Working Group series: Volumes 1-5 (https://www.scribd.com/fullscreen/42789364?access_key=key-29jwkkdylyk663co8v6w)

United States Environmental Protection Agency (USEPA) Integrated Risk Information System (IRIS), various years. https://www.epa.gov/iris.

APPENDIX 1

Atlantic RBCA Version 3.1

BEST MANAGEMENT PRACTICES

FOR

ENVIRONMENTAL SITE ASSESSMENT OF IMPACTED SITES

IN ATLANTIC CANADA

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

INTRODUCTION

This document presents the best management practices (BMPs) for conducting an environmental site assessment on PHC and CVOC impacted sites in the Atlantic Provinces. This document has been established under the mandate of the Atlantic Partnership in Risk-Based Corrective Action (RBCA) Implementation (PIRI) and is to be used in conjunction with the current version of the Atlantic RBCA Tool Kit and relevant supporting documentation (www.atlanticrbca.com). It also applies to sites that will be evaluated with other risk-based models or programs.

The Site Professional must confirm site conditions relative to the default input assumptions used for deriving the Tier I RBSL and Tier II PSSL Tables. The Atlantic Provincial regulators consider an increased level of professionalism directed towards assessments to be essential for their endorsement of site-specific, risk-based remediation goals.

If there are significant variations to the approaches, and requirements outlined as Best Management Practices are not achieved, the appropriate regulatory agency reserves the right to reject any submission.

It is understood that assessments are completed in various phases; this is consistent with the RBCA process, which will typically require re-visitation and ongoing enhancement of assessment information. Furthermore, since the basis of the RBCA process in Atlantic Canada must be strongly grounded in scientific principles, assessments will be required to evaluate the limits of contaminant migration to ensure the protection of human health and sensitive ecological receptors. This may require assessment and delineation of contaminant impacts across property lines to off-site properties. Notification requirements for third parties of impacts on their property will vary by Provincial jurisdiction.

Assessment of CVOCs and PHCs require different approaches, with assessment of CVOCs generally involving additional planning at the initiation stage and throughout the assessment process. The design of the investigative program must reflect the fate and transport properties of the contaminant of potential concern (CoPC). During all environmental investigations, precautions should be taken to avoid potential spreading of contamination (i.e., dragging down in multilevel monitoring wells, puncturing aquitards, etc.)

The physical properties of CVOCs make them extremely difficult to assess and remediate. This is particularly the case if free phase product (LNAPL/DNAPL) is present at the site. PHCs are lighter than water, allowing free phase product to float on the surface of the groundwater. CVOCs are heavier than water (i.e., denser); therefore, if free phase product is present, it would tend to sink, spreading until it reaches confining layers (e.g., clay lenses, aquitards, bedrock). Due to the complex nature of DNAPLs (i.e., free phase), they often can be undetected when using conventional tools and investigative strategies. Understanding LNAPL/DNAPL flow and behavior allows an adequate site conceptual model to be developed that helps guide characterization efforts of the LNAPL/DNAPL and dissolved phase impacts.

When assessing a petroleum hydrocarbon impacted site, monitoring wells would be screened across the water table to confirm presence/absence of free product and to assess dissolved groundwater plumes. Since PHCs aerobically degrade, the extent of dissolved plumes and vapour plumes would be more limited than chlorinated solvent plumes. Since CVOCs are DNAPLs, product would typically sink and deeper aquifers could become contaminated. Vertical movement of DNAPLs is controlled by soil stratigraphy or bedrock fractures. Also, since biodegradation of CVOCs is anaerobic and proceeds much more slowly, dissolved plumes and vapour plumes tend to be much more extensive, with some dissolved plumes extending several kilometers or more from the source of their release.

During assessment of CVOCs, it is important to assess both the parent and daughter products (PCE, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE and vinyl chloride). It is important to note that daughter products may be more toxic than the parent chlorinated solvent. During drilling, caution must be used to not puncture through an aquitard, which could cause further plume migration vertically and horizontally.

The extent of PHC impacts in soil, groundwater (dissolved or LNAPL) and soil vapour should be delineated to the applicable Tier I RBSLs for the site. For CVOCs, there are no Tier I RBSLs. In this instance, the extent of impacts is to be delineated to the most stringent Tier II PSSL. Tier II PSSLs are not available for soil for the indoor air inhalation exposure as derived values are not attainable by current laboratory methods or due to insufficient toxicological data. Where there is a potential for indoor air exposure, soil vapour or subslab testing is required. In this case, the extent of PHC impacts shall be delineated through soil vapour and groundwater data or another means deemed appropriate by the Site Professional and Provincial Regulator. It is recommended that soil vapour sampling be conducted regardless of proximity of site buildings, to determine if there are building restrictions and to assist with vapour plume delineation.

In general, based on the characteristics of CVOCs, dissolved plumes and vapour plumes would be expected to migrate further than CVOC impacts in soil. As such, it is considered acceptable to delineate to the Tier II PSSLs for indoor air inhalation for groundwater. The analytical results for vapour should be compared to the applicable reference concentrations (RfC) or risk specific concentrations (RSC), a calculated VISL, or another guideline deemed appropriate by the Site Professional and Provincial Regulator. Note that the acceptable RfCs and slope factors used in calculation of RSCs for CVOCs, are provided on Table 5, Appendix 5.

PURPOSE

The purpose of this document is to describe the recommended level of effort for assessing impacted sites in Atlantic Canada. It provides guidance for data required to generate Atlantic RBCA Tier I RBSLs, Tier II PSSLs and Tier II SSTLs.

The objectives of collecting assessment data are to characterize: 1) the nature and extent of soil and groundwater contamination in three dimensions 2) potential migration pathways and 3) potential receptors. These characterizations must be achieved with an acceptable level of certainty.

The BMPs presented herein are intended to be the **minimum level of effort** for collection of such data at typical sites; ***for more complicated or sensitive sites it may be necessary to increase the scope of the assessment to achieve an acceptable level of certainty. Note that for chlorinated solvent sites, a large amount of data may be required to fully characterize the impacts.***

BEST MANAGEMENT PRACTICES - REPORTING

It is acknowledged that assessment report formats may vary between individual companies. However, regardless of format, certain content is expected at a minimum and there may be additional requirements in each province.

The report should commence with a detailed executive summary. The body of the report will present the assessment information and will typically contain the following sections.

Basic Site Information

The following background site information is to be included in an assessment report:

Site Location

- ❑ Province
- ❑ City/Town
- ❑ Street Address
- ❑ Property Identification Number, where available

Land Use, Buildings & Underground Services (obtained through non-intrusive site inspection and available site information)

- ❑ On-Site
- ❑ Off-Site
  - For PHCs within 200 m unless sensitive human or ecological features exist at greater distance
  - For CVOCs, the off-site assessment is dependent on the extents of the plume, therefore, on-going assessment of land uses, buildings and underground services may have to expand in area throughout the delineation process.
- ❑ Depth, location and type of underground services (i.e., natural gas, sewer, water, telephone, cable TV, fibre optic cables, etc.)
- ❑ Reasonable foreseeable future land use (on-site)

Historical Information (obtained from available information). This would include:

- ❑ Previous owners and uses of properties
- ❑ Historical summary of chemical (i.e., petroleum and chlorinated solvent) handling practices at the site
- ❑ Details on petroleum product (gasoline, diesel, furnace oil, used oil, etc.), CVOCs (dry cleaning fluids, degreasers), and other potential contaminants stored at the site.
- ❑ Age, type and construction of petroleum or chlorinated solvent storage and distribution systems (single/double wall, steel/fiberglass, monitoring equipment, etc.)
- ❑ Location of previous storage and distribution equipment (aboveground and underground)
- ❑ Ownership of storage and distribution equipment (current and historical)
- ❑ Previous spills or leaks
- ❑ Previous remediation activities, including regulatory status

Regional Drainage, Geology, Hydrogeology (obtained from site investigations or available regional information sources)

- ❑ Surface drainage pattern
- ❑ Surficial and bedrock geology
- ❑ Groundwater flow regimes (directions, position of site in relation to regime, etc.)
- ❑ Groundwater recharge/discharge zones
- ❑ Aquifer types (bedrock, sand & gravel, confined, unconfined, etc.)
- ❑ Regional groundwater and surface water use

Local Drainage, Geology and Hydrogeology and Water Use (obtained through non-intrusive site inspection, intrusive site investigation and available site information)

- ❑ Surface drainage pattern
- ❑ Surficial and bedrock geology (specific physical characteristics that may affect contaminant migration to be included, including orientation of bedrock fractures if impacts suspected in bedrock)
- ❑ Groundwater flow regimes (directions, position of site in relation to regime, etc.)
- ❑ Groundwater recharge/discharge zones
- ❑ Aquifer types (bedrock, sand & gravel, confined, unconfined, etc., to a sufficient depth to which CVOCs may extend)
- ❑ Groundwater and surface water use in the local area
- ❑ Grain size analyses (if proposing fine-grained soil values)
- ❑ Water table depth and elevations (relative to local datum)
- ❑ Groundwater hydraulic gradient
- ❑ Presence of aquitards

Known or Potential Receptors (obtained through on-site and off-site investigation)

- ❑ On-Site
- ❑ Off-Site
  - For PHCs within 200 m unless sensitive human or ecological features exist at greater distance
  - For CVOCs, on-going assessment of receptors must continue throughout the delineation process (i.e., dependent on plume extent).
- ❑ Sensitive (incl. private and municipal drinking water, buildings with dirt bottomed sumps, sensitive surface waters, sensitive ecological habitat, etc.)

Extent of Contamination (obtained through intrusive testing)

- ❑ Free product (LNAPL/DNAPL) assessment
- ❑ Soil chemistry
- ❑ Groundwater chemistry
- ❑ Lateral and vertical extent of impacts exceeding Tier I RBSLs (PHCs) and Tier II PSSLs (CVOCs). As a default for chlorinated solvent assessment, shallow and deep monitoring wells will be required as most CVOCs are dense and if DNAPL is present, it will sink until it reaches a confining layer such as an aquitard or clay layer.
- ❑ Vapours (if measured or otherwise reported). For CVOCs in soil, vapour sampling is required to delineate impacts.
- ❑ Sediment chemistry (where potentially impacted aquatic receptor has been identified)
- ❑ Surface water chemistry (where potentially impacted aquatic receptor has been identified)

BEST MANAGEMENT PRACTICES – ENVIRONMENTAL SITE ASSESSMENT

Intrusive Testing Locations and Information

- ❑ Testing methods and techniques are expected to be consistent with current-day industry standards. Regardless of the method/techniques used, all efforts should be made to minimize the spread of contamination as a result of activities conducted during the site assessment. Although a concern with all assessments, a specific concern when assessing chlorinated solvent impacts is puncturing deep aquitards (confining layers), as this could cause further vertical and horizontal migration of impacts, especially if DNAPL is present.
- ❑ Field screening techniques are considered to be acceptable if they are well founded in theory, capable of calibrating measurements to relative or absolute levels of contamination, verifiable in regard to procedures and results and finally, if results of such techniques can be correlated to laboratory results.

- Test locations should provide an adequately detailed understanding of the nature, extent and fate of chemicals of potential concern in three dimensions. They should also provide information on potential subsurface migration pathways of chemicals of potential concern. The following should be considered minimum specifications:
  - Initial assessment phase: Minimum of one (1) borehole or test pit per potential source area - typically at least 3-5 locations except for very small sites. Potential source test areas may include, but are not limited to tanks, lines, drains, loading areas, drum filling areas or any areas with visible impacts (i.e., stained areas). Soil vapour assessment may be considered at this time based on the judgment of the Site Professional.
  - Any soil and groundwater plume(s) of chemicals of potential concern associated with the site should be delineated to a concentration that is protective of the health of identified receptors (human and ecological) considering current land uses or reasonably foreseeable future land uses. PHCs are to be delineated to the Tier I RBSLs or ESLs. CVOCs are to be delineated to the lowest of human health and ecological guidelines for groundwater and acceptable vapour intrusion screening levels for soil vapour.
  - On sites where it cannot be confirmed through historical records that previous tanks and lines have been removed, an appropriate survey (geophysical or otherwise) may be required prior to drilling, to determine whether such tanks and lines may be present.
  - Sufficient test locations to determine the direction of groundwater flow on-site. ***Minimum of three (3) groundwater monitoring wells or piezometers installed in drilled boreholes.*** Shallow wells are to be screened across the water table to intercept floating product. Bedrock monitoring wells may be required to assess potable water sources and multilevel installation of piezometers to assess vertical groundwater gradient may be advisable in some circumstances. For CVOCs, a minimum of three groundwater monitoring wells or piezometers ***per hydrogeological unit*** (i.e., shallow and deep wells) is recommended to allow for shallow and deep groundwater sampling, as well as description of potential confining layers (as noted above, care must be taken during drilling to ensure that confining layers are not breached in a manner that will create pathways for additional migration of CVOCs). Construction standards are to follow current-day professional standards. In that regard, while it was considered an acceptable practice in the past, monitoring wells should no longer to be installed in test pits.
  - All soil test locations should extend to the bottom of the contaminated soil zone, to the seasonal low water table level, or to bedrock, whichever is shallower. In the case of CVOCs, analyses of shallow and deep soil samples are recommended.
  - Soil samples should be collected continuously to allow for complete soil characterization (e.g., continuous split spoon sampling method).
  - All wells should be monitored for the presence of free product. Note that if it is DNAPL (CVOCs), this may prove to be difficult given that free product would sink until it reaches a confining layer and; therefore, is hard to identify.
  - In the instance of CVOCs, collect sufficient soil vapour samples to characterize potential indoor air inhalation concerns and to aid in delineation of CVOCs. The number of soil vapour samples is highly dependent on the size of the plume, site conditions and the number and size of buildings where soil vapour intrusion is of potential concern.

- ❑ Check on-site and off-site manholes and interceptors (or other similar pathways) for hydrocarbons or CVOCs (liquid, vapours).

Sample Analysis

- ❑ All soil samples will be screened in the field for soil VOC measurements. Visual and olfactory observation information shall be recorded on well logs, which are to be included in the report(s).
- ❑ Typically, chemical analyses are to be conducted on at least one (1) soil sample per test pit or borehole location. In the case of CVOCs analyses of shallow and deep samples are recommended.
- ❑ Chemical analyses are to be conducted on at least one groundwater sample from each available well including any on-site water supply wells. (Note: sampling may also be required for any nearby, off-site potable water wells).
- ❑ Depending on the potential source, chemical analyses will include the following on all samples, as a minimum:
  - o For PHCs - benzene, toluene, ethylbenzene, xylenes (BTEX) and modified total petroleum hydrocarbons (TPH)
  - o For CVOCs – chlorinated VOCs on all samples, including parent and degradation compounds.
- ❑ Analysis for site-specific parameters may be required, depending on past or present use (e.g., Polycyclic Aromatic Hydrocarbons at sites impacted with heavy end hydrocarbons such as creosote, bunker C, motor oil, etc.).
- ❑ Depending on the particular province the assessment is being completed in; analysis of MTBE in groundwater samples may be required.
- ❑ For petroleum impacted sites, TPH fractionation may be necessary in those instances where single values for TPH are exceeded. In those cases, one sample (highest concentration) per release event or source, if different type, should be submitted for fractionation.

  For PHCs, chemical analyses are to be completed following the Atlantic RBCA Guidelines for Laboratories Tier I and Tier II Petroleum Hydrocarbon Methods, Version 3.0 (www.atlanticrbca.com). For CVOCs, chemical analyses are to be completed following the USEPA 8260B/5035 and USEPA 624/8260B or accredited modified SOPs.

- ❑ Grain size analyses are to be conducted on at least one sample per hydrogeologic unit if the fine-grained soil values are to be applied.

Quality Assurance / Quality Control

- ❑ Except for small batches of soil samples (less than five samples), at least one blind duplicate should be analyzed per batch of samples submitted for quality assurance/quality control (QA/QC) purposes. For larger batches (greater than 10 samples), 10% duplicates should be analyzed. The QA/QC results should be presented/interpreted in the report.

- ❑ For groundwater, a blind duplicate and field blank sample (trip blank) should be collected and analyzed with each batch of samples, regardless of the number of samples tested.

- ❑ For soil vapour samples, a blind duplicate should be collected and analyzed with each batch of samples, regardless of the number of samples tested.

- ❑ Sampling and sample handling protocol must be consistent with accepted practices. In particular, samples for volatile organic compounds must be collected such that there is no headspace in water samples and a minimum headspace in soil samples. Samples should be kept cool until they are delivered to the laboratory. ***Sample handling procedures should be verified with the receiving laboratory.***

Occupational Health and Safety

Safety practices should be consistent with the requirements of the responsible party (e.g., Site owner, etc.) and/or relevant Provincial requirements. As a minimum, it is expected that:

- ❑ Field personnel must have adequate protective clothing such as hard hat, steel toe boots and gloves.

- ❑ Field personnel must have a working knowledge of the physical and chemical properties of the chemical hazards expected.

- ❑ Electrical hazards such as electrical wires, buried cables; natural gas lines must be identified before any assessment activities.

Please be aware that intrusive testing for chemical parameters such as PHCs and CVOCs has intrinsic risk to personal Health and Safety. As such, intrusive testing should only be undertaken by those with the appropriate training.

DATA TO SUPPORT CHANGES TO DEFAULTS

For sites where the Tier I RBSLs and/or Tier II PSSLs are exceeded, the site proponent may elect to generate Tier II SSTLs. Site-specific data must replace default parameter values to support this approach. Replacement of any default values will require technical justification. Following are some examples of parameters that may be considered for replacement of default parameters.

- ❑ In general, data used to describe the specific fate and transport characteristics of the site and data used to characterize the natural attenuation processes are required within the Atlantic RBCA Tool Kit. Specific parameters are listed within the Tool Kit output and are also found in several relevant references.

- ❑ A minimum of one hydraulic conductivity test must be conducted for **each hydrogeologic unit** to support changes to hydrogeological default parameters.

- ❑ Meteorological data collected at the site or the closest meteorological station to the site must be used to support changes to default climate parameters.

- ❑ Actual site measurements/knowledge must be provided to support changes to building or receptor characteristics and exposure parameters.

APPENDIX 2

Atlantic RBCA Version 3.1

ECOLOGICAL SCREENING PROTOCOL

FOR IMPACTED SITES IN ATLANTIC CANADA

ATLANTIC PARTNERS IN RBCA IMPLEMENTATION

July 2012, updated June 2019

Acknowledgements

In 2012, Atlantic PIRI updated the Ecological Screening approach for Atlantic RBCA. PIRI would like to acknowledge and thank the following people for their contributions of time, comments and expertise in the preparation of that 2012 version:

ATLANTIC PIRI TASK GROUP COORDINATOR
Rita Mroz, Environment Canada

MEMBERS OF THE EcoRBCA TASK GROUP
Ulysses Klee, Stantec (formerly Dillon Consulting Ltd).
Peter Miasek, Imperial Oil
Malcolm Stephenson, Stantec
Rob Willis, Dillon Consulting (formerly Intrinsik Inc.)

Atlantic PIRI also wishes to thank Chris Allaway (Environment Canada, Ottawa), Ken Doe (formerly Environment Canada, Moncton), and Thomas Parkerton (Exxon Mobil, New Jersey, US) for their significant contributions to, and critique of, the draft reports.

Funding for the work in 2012 was provided primarily in-kind by the contributors, with funding for the toxicity testing provided by Atlantic PIRI.

In 2019, in conjunction with the update of the Atlantic RBCA User Guidance document, Atlantic PIRI updated the Ecological Screening Protocol by including select chlorinated volatile organic compounds (CVOCs).

Preface

Since its initiation in 1996, Atlantic PIRI is committed to the continuous improvement of the Risk Based Corrective Action (RBCA) tool, its associated guidance and overall implementation of processes. As stated in the Memorandum of Understanding (MOU) between the four Atlantic Provinces, a key objective for Atlantic PIRI is "to monitor, evaluate and integrate into the Atlantic RBCA process appropriate advances in risk assessment and risk management techniques for contaminated sites. Specific to this objective is to ensure that the Atlantic RBCA process provides equivalent, or better protection than the CCME Canada Wide Standard for Petroleum Hydrocarbons in soil" (MOU, 2008). In order to achieve this level of equivalency, both human and ecological receptors need to be considered in the Atlantic RBCA process.

In the first two versions of the Atlantic RBCA User Guidance (1998 and 2007), potential risks to ecological receptors and habitat due from exposure to petroleum hydrocarbons were qualitatively assessed with a series of questions. With improvements in science and the subsequent development of other tools related to the assessment and remediation of petroleum hydrocarbons (*e.g*. CCME's Canada Wide Standards for Petroleum Hydrocarbons), Atlantic PIRI undertook the task to update their ecological screening process. In 2006, a multi-stakeholder Task Group was created, bringing together experts in the field of ecological risk assessment and petroleum hydrocarbons. This protocol and its supporting rationale document is the culmination of the work of this Task Group.

In keeping with other Canadian approaches and to parallel the human-health based Atlantic RBCA process, the Task Group's first step was to include ecologically-based screening levels, or benchmarks, to which site assessment data could be compared. In most instances, the Task Group reviewed and then adopted existing Canadian petroleum hydrocarbon guidelines where possible (*e.g*. eco-soil contact screening levels from CWS, groundwater contact from Alberta Environment). However, for some pathways, such as surface water and sediment, a decision was made to derive new screening levels. Using the latest available model, PETROTOX (Ver 3.06), surface water screening levels were developed for BTEX and TPH fractions. These derived criteria were compared to a broad range of existing surface water criteria used in Canada and other countries, and found to be reasonable.

For groundwater, two approaches were used to develop screening levels for petroleum hydrocarbons. The first was based on the above derived surface water criteria. Consistent with other Canadian jurisdictions, it was assumed that groundwater will be attenuated or diluted by 10-fold prior to contact with surface water such that the surface water screening value was then multiplied by a factor 10 to be the proposed groundwater screening value. The second approach involved compilation of undiluted acute toxicity values to establish a second set of criteria. The more stringent of the two criteria was used to set the Tier 1 screening levels. These apply within 10 meters of a suitable aquatic body. For sites at greater distances from the water body, screening levels were calculated at varying distances from the surface water (*e.g*. 50 m, 100 m, 150 m and 200 m).

Undertaking the development of new screening levels for sediment was also necessary as there were no existing criteria to adopt. The surface water screening levels were used to calculate sediment quality screening levels using the principles of Equilibrium Partitioning (EqP). As the sediment screening levels were derived based on modelled data, a toxicity testing program was undertaken to validate these proposed sediment values. Results of the testing indicated a good

agreement between predicted sediment concentration and toxicity, supporting the recommend screening levels. Future activities by the Task Group may include further validation of the surface water and sediment criteria.

The Task Group also established guidance as to when suitable ecological habitat or receptors are present, in accordance with Atlantic PIRI principles on ecological protection, by establishing questions to determine if potential exposure pathways exist between identified ecological receptors/habitat and site petroleum hydrocarbons at concentrations exceeding screening levels.

In 2019, consist with an update to the overall Atlantic RBCA User Guidance, the following select chlorinated volatile organic compounds (CVOCs) were added to the Ecological Screening Protocol: cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, tetrachloroethylene, 1,1-dichloroethylene, trichloroethylene and vinyl chloride. The ecological screening levels were adopted from existing guidelines in Canada; international sources were adopted when no Canadian guidelines were available. The screening protocol includes guidelines for soil, surface water, groundwater and sediment (where possible).

OVERVIEW

This document provides guidance for ecological screening for petroleum hydrocarbons (PHC) and select chlorinated volatile organic compounds (CVOC) at potentially impacted sites in Atlantic Canada.

The ecological screening protocol is intended to determine whether chemical hazards, ecological receptors and/or exposure pathways are present at a given site. Completion of the protocol does not suggest that an ecological risk assessment (ERA) has been completed. Rather, the outcome of the protocol is a determination of whether or not an ERA or remediation/risk management should be conducted, and whether or not additional site data are required to conduct an ERA, or proceed with risk management options.

This screening protocol is intended to be used in conjunction with Appendix 1 of the Atlantic RBCA Version 3 User Guidance (*i.e.*, "Best Management Practices for Environmental Assessment of Petroleum Impacted Sites in Atlantic Canada"). These guidelines should be met prior to the evaluation of any site using this protocol.

The three Parts of this ecological screening protocol are:

Part I. Identification of petroleum hydrocarbon or select CVOC hazards[1] in site media or site-influenced media;
Part II. Identification of habitat[2] and ecological receptors[3] on or near a site;
Part III. Identification of exposure pathways[4] by which ecological receptors could come into contact with site petroleum hydrocarbons.

---

1 Presence of PHCs or CVOCs above Tier 1 Ecological Screening Levels in environmental media.
2 Areas where ecological receptors occur, live, breed or forage.
3 Non-human organism, species, population, community, or ecosystems that are potentially exposed to substances originating from an impacted site.

Many items in this ecological screening protocol are based on existing screening level ERA and contaminated site assessment guidance from Ontario Ministry of the Environment, British Columbia Ministry of the Environment, Alberta Environment, and other provinces as well as the American Society for Testing and Materials (2002), and are consistent with the recommended tiered approach for ERA in Canada as developed by the Canadian Council of Ministers of the Environment (*i.e.*, CCME, 1996).

It is intended that the ecological screening protocol be completed for all petroleum hydrocarbon and CVOC impacted sites that are assessed within the Atlantic RBCA process. The outcome of the screening process should be documented in writing, and submitted to the responsible regulatory authority in conjunction with other reports prepared under the Atlantic RBCA process. All items should be addressed, with adequate supporting rationale provided.

This protocol was developed in keeping with the following guiding principles related to the protection of ecological receptors, which have been developed by Atlantic PIRI:

- **Principle 1** – Both human health and ecological health are important considerations in the overall health and sustainability of our environment (including natural ecosystems and built environments).
- **Principle 2** – Society recognizes and accepts differences between natural ecosystems and built/urban environments (areas which result from the development and expectations of society).
- **Principle 3** – Ecological values should be maintained in those areas where they are determined to be important to the health and sustainability of the environment, particularly where this is of value to society.
- **Principle 4** – It follows that for some land uses or situations, ecologically driven remediation may be of varying value or importance. Environmental standards for the protection of ecological receptors should be applied where the maintenance of their abundance and diversity is considered to be a priority, reflecting appropriate choices relative to land use. The application of ecological standards should also consider long-term integrity and sustainability planning of our environment.

Important factors to consider when using the ecological screening protocol include the following:

- Provincial jurisdictions may provide additional clarification regarding the use of Tier 1 ecological screening levels within a regulatory or policy regime.

- The Summary Table in Appendix A of this protocol collates the results of this screening process. This completed table should be included with all documentation submitted to the regulators for review. Site professionals/practitioners are expected to complete this summary table by following the detailed guidance provided in this document.

- This protocol is applicable ~~only~~ to sites with petroleum hydrocarbon and CVOCs impacts. It should not be used for sites where other potential contaminants of concern

[4] The means by which a receptor may come into contact with chemical contaminants in environmental media.

(*e.g.*, PCBs, PAHs, dioxins/furans, metals/ metalloids, nutrients, pesticides, *etc*.) have been identified, as screening levels for such potential contaminants of concern have not been provided. However, it is acknowledged that some elements of the protocol could potentially be applied to sites where the principal contaminants are not exclusively petroleum hydrocarbons or CVOCs. Use of this protocol or aspects of this protocol, in such situations should be discussed with the responsible regulatory authority before proceeding.

- If petroleum hydrocarbons and/or CVOCs are present in site media at concentrations below screening levels that are derived to be protective of ecological receptors, or if no ecological receptors or exposure pathways are evident, then an ERA is not necessary in most circumstances. However, if professional judgment suggests some degree of ERA is warranted, then this ecological screening protocol should not be construed as limiting.

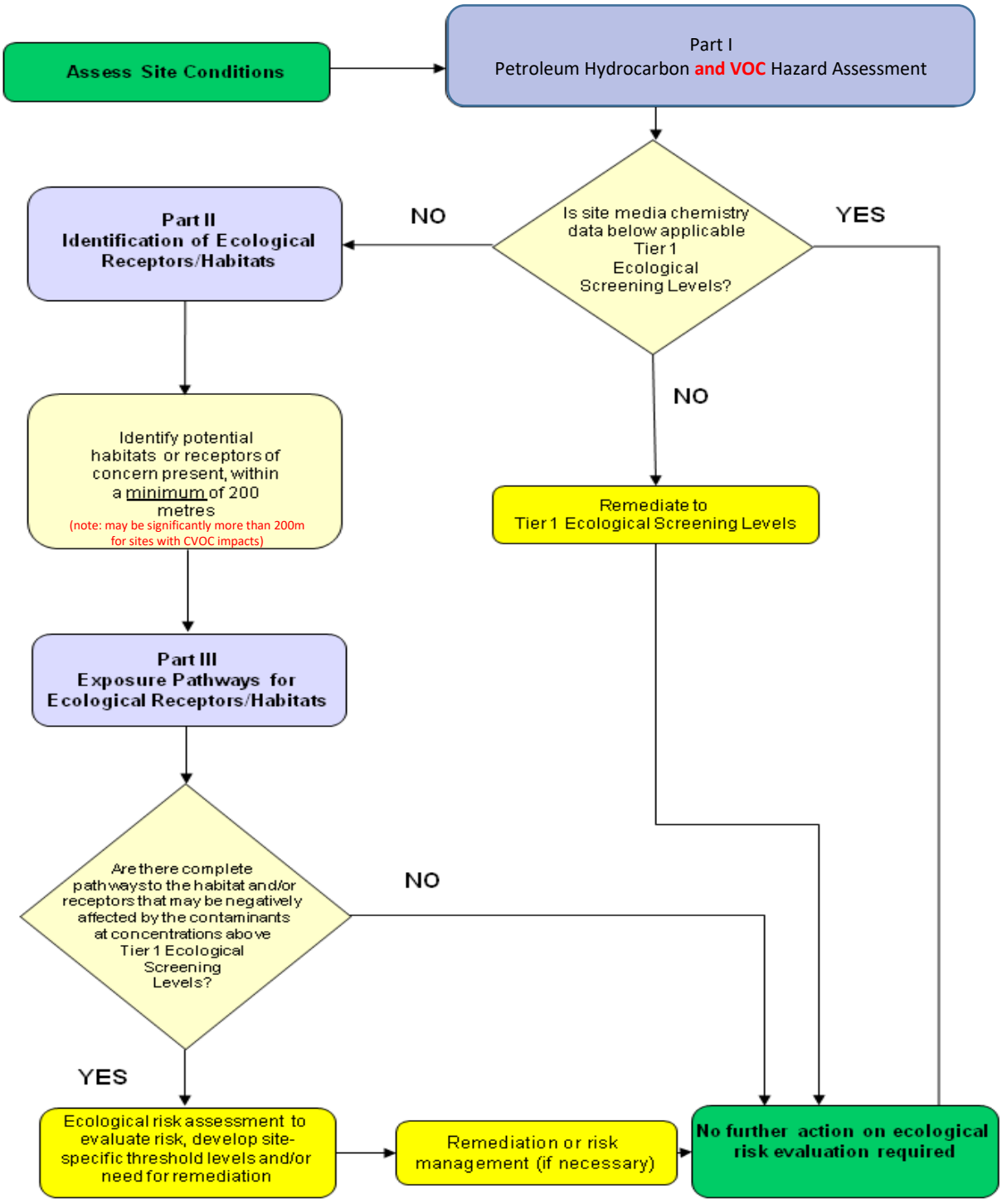
- The protocol is intended to provide the user with steps beyond a traditional Tier 1 evaluation (which is often limited to comparing site media chemistry data to environmental quality benchmarks). By considering habitat, receptors and exposure pathways (in addition to media chemistry and benchmark comparisons), the protocol includes some elements that are common to ERAs, and allows the user to potentially exclude sites from further ecological investigation even if petroleum hydrocarbon and/or CVOC concentrations in ~~site~~ media ~~(or media on adjacent properties)~~ exceed the Tier 1 ecological screening level values. The regulatory regime for such exclusions may vary and should be reviewed in each jurisdiction.

- The ecological screening protocol should be completed by individuals familiar with, and experienced in, ecological assessment and/or ecological risk assessment. Regulatory authorities may specify qualifications for persons completing this ecological screening ~~at petroleum hydrocarbon impacted sites~~. Unless otherwise specified by Provincial requirements, it is the responsibility of the Site Professionals to confirm that the ecological screening protocol be completed by suitably qualified individuals who have training and experience in such disciplines as ecological risk assessment, environmental toxicology, environmental biology, ecology and related disciplines. The name of the individual completing the ecological screening should be noted in the Closure Report and the submission of *Curriculum vitae* for the individuals that complete the ecological screening protocol may be requested.

- Key technical terms contained in this protocol are further defined and explained in User Guidance, Appendix 8, Acronyms and Definitions.

- The sources and rationale for the screening levels referred to in Part I of this document are described under separate cover, in a document entitled *Scientific Rationale to Support the Adoption/ Development of Tier 1 Screening Levels for Soil, Surface Water, Groundwater and Sediment.*

Figure 1 illustrates the three main parts of the ecological screening protocol in a flowchart format. The specific questions that comprise Parts I, II and III of the ecological screening protocol follow this organisational strategy.


Assess Site Conditions
Part I
Petroleum Hydrocarbon and VOC Hazard Assessment
Is site media chemistry data below applicable Tier 1 Ecological Screening Levels?
NO
YES
Part II
Identification of Ecological Receptors/Habitats
NO
Identify potential habitats or receptors of concern present, within a minimum of 200 metres
(note: may be significantly more than 200m for sites with CVOC impacts)
Remediate to Tier 1 Ecological Screening Levels
Part III
Exposure Pathways for Ecological Receptors/Habitats
Are there complete pathways to the habitat and/or receptors that may be negatively affected by the contaminants at concentrations above Tier 1 Ecological Screening Levels?
NO
YES
Ecological risk assessment to evaluate risk, develop site-specific threshold levels and/or need for remediation
Remediation or risk management (if necessary)
No further action on ecological risk evaluation required

Part I – Identification of Petroleum Hydrocarbon and/or Chlorinated Volatile Organic Compound Hazards in Site Media or Site-influenced Media

1. **Soil** Do existing site characterization data, based on the best management practices outlined in Appendix 1 of the User Guidance, indicate the presence of petroleum hydrocarbon concentrations and/or CVOCs in site surface soil above available ecological screening levels derived for the protection of soil invertebrates and /or vegetation (direct contact), as well as for the protection of avian and mammalian wildlife and livestock (soil/food ingestion)? **Consult Tables 1a and 1b.**

Supporting Information

For TPH, both "direct contact" and "soil ingestion" pathways were considered and the more conservative of the two was selected as the most appropriate screening value, to be protective of both pathways. All the screening levels in **Table 1a** are based on CCME's direct contact (protecting plants and soil invertebrates) with the exception of benzene for agricultural land uses, which is based on Alberta Environment for soil ingestion pathway. ~~There are currently no regulatory soil quality screening levels available for petroleum hydrocarbons are protective of soil ingestion and dermal contact pathways for mammalian, avian or herptile receptors, for residential, commercial, and industrial land uses. Alberta Environment (2010) has developed livestock and wildlife soil and food ingestion soil quality guidelines for BTEX and the CCME petroleum hydrocarbon fractions (F1, F2, F3, F4) for agricultural and natural areas land use categories. While Atlantic PIRI does not currently recognize a natural areas land use, the Alberta Environment screening levels have been adopted for the agricultural land use category (Table 1b).~~

Similarly, for CVOCs, both direct contact and soil/food ingestion pathways were considered. For the purpose of this screening approach, the more conservative of the two pathways were selected as the Tier 1 criteria. **(Table 1b)**

The depth of soil contamination (based on the soil sampling that was conducted for the site) is an important consideration when comparing site soil concentrations to soil quality screening levels. For example, soil invertebrates generally colonize the top 5 to 10 cm of the soil profile (but may also occur at depths as low as 30 cm), while the roots of some plants (especially trees) may extend to depths of >1 m. Ideally, the soil sampling program for a given site should consider the depths that are relevant to key ecological receptor groups so that appropriate comparisons between soil concentrations and soil quality screening levels can be made. Where practical, the soil sampling program at a given site should be designed to sample from various soil horizons so that appropriate data are collected that enable delineation of contamination, as well as generating soil data that can be appropriately compared to human health soil quality screening levels, ecological soil quality screening levels, and if necessary, be used in a Human Health Risk Assessment and/or Ecological Risk Assessment.

However, in recognition of widely varying definitions of surface and subsurface soils in North American regulatory guidance, it is assumed for the purposes of this screening protocol that a soil depth of ≤1.5 m represents surface soil, while a depth of >1.5 m represents subsurface soil. This depth cut-off is consistent with current CCME Canadian Soil Quality Guidelines for the Protection of Human and Environmental Health.

2. **Groundwater (plants/invertebrates):** Do existing site characterization data, based on the best management practices outlined in Appendix 1 of the User Guidance, indicate the presence of petroleum hydrocarbon and/or CVOC concentrations in shallow site groundwater above applicable ecological screening levels derived for the protection of terrestrial plants and soil invertebrates in contact with site groundwater? **Consult Table 2**.

Supporting Information
The depth to groundwater is an important consideration when comparing site groundwater concentrations to these screening levels. As described in the Rationale document, the direct contact pathway of shallow groundwater with plants and soil invertebrates is only applicable when groundwater is present within 3.0 m of the ground surface.

Groundwater (aquatic life): Do existing site characterization data, based on the best management practices outlined in Appendix 1 of the User Guidance, indicate the presence of petroleum hydrocarbon concentrations and/or CVOCs in site groundwater above applicable ecological screening levels derived for the protection of aquatic receptors? **Consult Table 3a** (petroleum hydrocarbons) **or Table 3b (CVOCs)**. If the site soil characteristics (fine or coarse grain) and the approximate distance from the groundwater source zone to the downgradient aquatic habitat are known, then **Consult Table 3c**, which provides screening levels that have been adjusted to compensate for these site-specific characteristics.

3. **Surface water (aquatic life):** Do existing site characterization data, based on the best management practices outlined in Appendix 1 of the User Guidance, indicate the presence of petroleum hydrocarbon or VOC concentrations in on-site or adjacent surface water bodies above applicable ecological screening levels derived for the protection of aquatic receptors? **Consult Table 3a** (petroleum hydrocarbons) or **Table 3b** (CVOCs**).**

Supporting Information
Relevant surface water bodies to consider would include any permanent or temporary body that is aquatic habitat, or is hydrologically or hydrogeologically connected to aquatic habitat. The term “aquatic habitat” implies any water body that supports the presence of populations of freshwater, estuarine or marine pelagic and benthic species. Aquatic habitat can be considered analogous to the definition of “fish habitat” under the Fisheries Act (R.S., 1985, c. F-14). For example, in the Act, fish habitat is defined as: “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes”. It is important to recognize that under the Act, “fish” refers to all life stages of finfish, shellfish, crustaceans,

and marine animals, as well as any "parts" of fish, shellfish, crustaceans and marine mammals. In general, any sites evaluated under the Atlantic RBCA process that may be impacting surface water bodies, or have the potential to impact surface water bodies, should be evaluated with respect to potential compliance issues with the Fisheries Act. While the screening levels used in Table 3 did consider the federal Fisheries Act (see Scientific Rationale), it may be necessary or desirable to obtain advice and guidance on this issue from the appropriate federal regulatory authority (Environment Canada and/or Fisheries and Oceans Canada).

4. **Sediment:** Do existing site characterization data, based on the best management practices outlined in Appendix 1 of the User Guidance, indicate the presence of petroleum hydrocarbon or CVOC concentrations in on-site or adjacent sediments above available ecological screening levels derived for the protection of aquatic receptors? **Consult Table 4a** (petroleum hydrocarbons) **or Table 4b** (CVOCs).

Supporting Information

Table 4 cites ecological screening levels for "typical" sediment sites and "other" sediment sites. These two categories are defined below.

Typical sediment sites are defined as those where the sediment is used as habitat for sensitive components of freshwater, marine or estuarine aquatic ecosystems, including:

- Habitats used by endangered or threatened species, or Species of Special Concern under the Species at Risk Act (S.C. 2002, c. 29).
- Watercourses, wetlands, forested riparian areas, mudflats and intertidal zones that are important to preservation of fish and wildlife.
- Reaches of aquatic habitats that are important to fish spawning or serve as important rearing habitat for fish.
- Reaches of aquatic environments encompassing, and/or bordering habitat compensation or restoration sites, or other areas that are intended or designed to create, restore or enhance biological or habitat features.
- Areas of unique habitat that are identified in federal, provincial or municipal land use plans.
- Reaches of the aquatic environment that exists within federal and provincial marine parks, federal and provincial parks, or ecological reserves.
- Areas and aquatic habitat included within provincial Wildlife Management Areas.
- Areas covered under conservation agreements and areas designated as "Environmentally Sensitive" in municipal land use plans or strategies.

Other sediment sites are those sites where the sediment is not classified as typical such as ditches, industrial-influenced receiving areas, working harbours, *etc*.

It is advised that all sediments be screened using the "typical" screening levels. The site professional must provide a sufficient rationale for applying the "other" screening levels.

Following the completion of Part I, if the answer is **"No"** to ALL questions, then no further action on ecological risk evaluation is required. If the answer to any one question is **"Yes"**, then proceed to Parts II and III, or remediate to Tier 1 ecological screening levels.

Part II – Identification of Habitat and Ecological Receptors on or Near a Site

The focus of the following set of questions is on lands or aquatic areas that could provide habitat to ecological receptors and the receptors that may be present. In most cases, the lands or aquatic areas that provide potential habitat will have limited anthropogenic structures, groundcovers (such as paving, concrete, gravel) or utilities (above or below ground), and the presence of either bare or vegetated soils.

Habitat

1. Are the following habitat types or conditions present on the site or proximate to the site?

    a) Wetland habitats such as marshes, swamps, tidal flats, beaches?
    b) Aquatic habitats such as rivers, lakes, streams, estuaries, marine water bodies?
    c) Forested habitats?
    d) Grassland habitats?
    e) Provincial/National parks or ecological reserves?
    f) Known rare, threatened or endangered species populations?
    g) Other known critical or sensitive habitat for wildlife (such as breeding or nesting areas for migratory species)?
    h) Are there other local or regional receptor or habitat concerns that need to be addressed or considered?

For items 1(a) to 1(g), a minimum distance of 200 m should be considered when determining whether or not habitat and/or ecological receptors are proximate to the site.

Supporting Information

200 metres was selected as the minimum distance to consider for the assessment fo a petroleum hydrocarbon impacted site. It relates primarily to the distance a typical groundwater petroleum hydrocarbon plume will travel. In a study of 500 TPH sites in California by Shih et al. (2004), graphs of cumulative TPH plume length indicate that the maximum distance TPH will travel in groundwater is approximately 185 metres. Based on this information, Atlantic PIRI recommends a minimum distance of 200 metres for considering the presence of ecological habit/receptors on or near a petroleum impacted sites. For sites with potential VOC contamination, particularly in groundwater, the actual scope of the site assessment (including consideration of receptors and habitat) may extend much greater than the minimum 200m specified for petroleum hydrocarbons. Factors such as the extent of CVOC plumes (eg up to 2,000m (MacKay et al, 2000; USAF, 2000), persistence of this class of contaminants, potential degradation products, presence of dense non-aqueous phase liquid (DNAPL), hydraulic conductivity and fractured bedrock need to be considered as they may contribute to the movement of CVOCs through media to more distal habitats (EPA, 2018).

For question 1a), the goal is to determine if obvious, suspected or designated wetlands are present. If not obvious or designated, wetlands may be suspected if the site meets one or more of the following conditions: lies adjacent to a permanent water body, occurs on a floodplain, has standing water present, has dark, wet soils, has mud cracks, has

clear debris lines or visible water marks, has vegetation characteristic of wetlands, or is tidally influenced such that parts of the site are submerged for a portion of the tidal cycle. Users should refer to their provincial jurisdictions for a definition of wetlands.

Managed urban "green spaces" (such as lawns, playgrounds, school yards, fairgrounds, sports fields, zoos, biking and walking trails, picnic areas, vegetable gardens) may not be productive or viable ecological habitat. While these areas can be colonized and utilized by ecological receptors (including vegetation, invertebrates, birds, mammals and herptiles), the presence/absence of receptors, the degree to which receptors utilize these spaces, and the quality of the habitat are all determined by the human use and management of these areas. Also, in many cases, the habitat these spaces provide has been substantially altered from its original state and may no longer support the native flora and fauna. It is considered reasonable that in some cases different, less stringent protection goals be applied to these types of spaces then those applied to the habitat types listed above. This concept is consistent with Atlantic PIRI Principles 2 and 4 (see Overview). Conversely, some "green spaces" such as parks are managed, in part, for the purpose of providing habitat and such habitat must be considered in that context. Full justification by the site professional is needed if a given site or portion of a site may be excluded from further ecological consideration. Consultation with the responsible regulatory authority is strongly recommended.

In determining if identified terrestrial habitat (whether on the site or proximate to the site) is significant (*i.e.*, of sufficient size to support wildlife populations), the following spatial guidelines based on ASTM (2002) should be considered (note: no spatial criteria are suggested for aquatic habitat or for site vegetation and soil invertebrate communities).

- Small areas (<1 hectare) may contain individual foraging and breeding areas of small mammals, birds, and herpetofauna; however, this spatial scale usually does not support local populations of wildlife. However, the presence of small areas that are special habitats, such as vernal pools for amphibians, or other discrete areas that support specific species should be determined prior to concluding that spatial scale is too small to be significant. In addition, the presence or absence of wildlife corridors[5] should be determined. Corridors can be spatially small yet still be important for maintaining the presence of individuals or populations within local habitat.

- Moderate to large areas (>1 to 80 hectares). In addition to the description for the small areas, this spatial scale may contain individual foraging and breeding areas for medium sized mammals and birds. This scale is also large enough to support or contain local populations of small mammals, birds, and herpetofauna.

- Larger areas (>80 hectares). In addition to the description for the moderate to large areas, this spatial scale may contain individual foraging and breeding areas for larger wildlife and birds of prey. These scales are also large enough to include local

[5] Wildlife corridors are segments of undeveloped land connecting to additional undeveloped lands on- or off-site, and may consist of rights-of-way, easements, or other closely spaced small areas that connect two or more areas of potential habitat.

populations of medium-sized mammals and birds, and may contain local populations of larger wildlife species.

Receptors

2a. Are there indications of stressed vegetation on the site? [see additional information below 2c]

2b. Is there evidence that the site vegetation community differs from what would be expected (*e.g.*, presence of pollution or stress-tolerant plants as the dominant vegetation type; absence or low abundance of typical or expected plants on the site)? [see additional information below 2c]

2c. Are there indications that the site soil cannot support a soil invertebrate community?

Supporting Information

Questions 2a, 2b and 2c can be addressed through qualitative site observations made during site characterization activities (*e.g.* presence/absence/abundance of soil organisms during soil sampling activities), and can also include consideration of whether or not these observations are typical or expected for the site. However, if deemed appropriate, plant and soil invertebrate community surveys may also be used. A number of survey tools and techniques exist that vary in their level of effort, scale, complexity and the degree of qualitative versus quantitative information that is obtained. The size of the site and its habitat type will also influence the choice of plant and invertebrate survey tools that could potentially be applied.

3. Is there evidence that terrestrial plants in the habitats listed above are likely to be in root contact with site groundwater with concentrations of TPH or CVOCs above screening levels?

4. Would mammalian, avian, or herptile terrestrial wildlife receptors be expected to forage on or near the contaminated areas of the site, such that oral or dermal exposure to contaminated soils, water, plants, prey items *etc*. could occur?

It must be recognized that the distance and spatial criteria described in Part II represent general guidance that may not be applicable for all sites under investigation, particularly for sites with CVOCs present. Site-specific conditions and professional judgment must be considered in determining the likelihood that ecological receptors and/or ecological habitat are present on or proximate to the site, and/or would be impacted by site petroleum hydrocarbon and/or CVOC contamination.

Proceed to Part III. Part II should be considered as background information necessary to identify potential exposure pathways identified in Part III.

Part III – Identification of Exposure Pathways for Ecological Receptors

The focus of the following questions is to determine if potential exposure pathways exist between identified ecological receptors/habitat and site petroleum hydrocarbon and/or CVOC impacts. In answering these questions, the answers previously provided in Part II should be referred to and considered. However, it is recognized that the distance guidelines noted in Part II may not be appropriate for all sites, thus the following questions about potential exposure pathways should consider the likelihood that an exposure pathway may be operable even if the distance between the site and receptors or habitat is greater than that noted in Part II.

In general, depth to contamination is a key consideration in determining if terrestrial ecological exposure pathways are operable. As mentioned previously, this protocol assumes that a depth of ≤1.5 m represents surface soil, while a depth of >1.5 m represents subsurface soil. In most situations, it can be assumed that exposure of terrestrial receptors to contamination present at or below 1.5 m in soil is unlikely to occur. However, there may be occasional exceptions to this, such as large trees having roots extending beyond a depth of 1.5 m.

1a) Is it reasonable to conclude that site petroleum hydrocarbons and /or CVOCs in surface soil, with concentrations exceeding soil screening levels in **Table 1a** (petroleum hydrocarbons) or **Table 1b** (CVOCs), will come into contact with terrestrial plants and invertebrates in a suitable habitat?

~~2.~~ Is it reasonable to conclude that dissolved petroleum hydrocarbons in site groundwater, with concentrations exceeding groundwater screening levels that are protective of terrestrial plants or soil invertebrates in **Table 2** will come into contact with plants or soil invertebrates in a suitable habitat per Part II?

3. Is it reasonable to conclude that dissolved petroleum hydrocarbons in site groundwater with concentrations exceeding groundwater screening levels (**Table 3a, Table 3c** (petroleum hydrocarbons) and/or **Table 3b** (CVOCs) will come into contact with aquatic receptors or aquatic receptor habitat?

4. Is it reasonable to conclude that site petroleum hydrocarbon contamination could impact aquatic receptors or aquatic habitat in surface water bodies via the following:
    a. surface runoff (*e.g*. erosion, windblown contaminants)
    b. preferential overland flow pathways (*e.g*. drainage ditch, slope, swale)
    c. preferential subsurface flow pathways (*e.g*. culvert, trench, sewer line, pipelines, swales)

    such that aqueous media concentrations would potentially exceed surface water and/or sediment quality screening levels (**Table 3a, Table 3b, Table 4a** and/or **Table 4b)?**

If the answer to any of questions 1 to 4 in Part III is "**YES**", then further action is required. Additional data should then be gathered to enhance the knowledge of the site-specific hazards, receptors and exposure pathways. Remediation may be conducted at this stage if so desired. If ecological risk assessment is considered as an alternative, it should begin with a screening level tier and proceed as necessary, to a preliminary quantitative and/or detailed quantitative tier. Further assessment may also include, but not necessarily be limited to, fate and transport modeling, habitat or ecological surveys and other types of biological/ecological assessment, and ecotoxicity tests.

Further Assessment/Delineation

If a site is deemed to require further action following Part III of the protocol, further site delineation requirements need to be considered by the Site Professional. At the start of the protocol, it is not necessary for a site to be delineated to Tier 1 ecological screening levels because the protocol considers site specific habitat, receptors and exposure pathways which can allow the site professional to potentially exclude sites from further ecological investigation even if petroleum hydrocarbon concentrations and/or CVOCs in ~~site~~ media ~~(or media on adjacent properties)~~ exceed the Tier 1 ecological screening levels. However, if completion of Parts II and III cannot exclude the presence of habitat, receptors or operable exposure pathways, then further site characterization activities to delineate the extent of contaminant impacts above the Tier 1 ecological screening levels is considered the appropriate best management practice (BMP), consistent with Appendix 1 guidance.

Guidance for delineation to the Tier 1 ecological screening levels cited in this protocol is as follows[6]:

- Soil: At sites where terrestrial exposure pathways have the potential to be complete (*i.e.*, terrestrial receptors present in suitable habitat within the appropriate distance(s)), delineate to soil ecological screening levels (Tables 1a, 1b).

- Groundwater: At sites where groundwater pathway(s) have the potential to be complete (*i.e.*, terrestrial or aquatic receptors present within appropriate distance(s)), delineate to groundwater ecological screening levels (Tables 2 and 3).

- Surface water: At sites where surface water pathways have the potential to be complete or surface water habitat is known to be impacted above Tier 1 screening levels, delineate to surface water ecological screening levels (Table 3).

- Sediment: At sites where sediment pathways have the potential to be complete or sediment is known to be impacted above Tier 1 screening levels, delineate to sediment ecological screening levels (Table 4).

Once delineation is complete, an ERA may be required although such guidance is beyond the scope of this protocol. While there is no single widely accepted ERA approach for PHCs or VOCs, there are various models and guidance documents that can be utilized such as CCME Framework (CCME, 1996), FCSAP Ecological Risk Assessment (FCSAP 2012) and TPH Risk Evaluation at Petroleum-Contaminated Sites (ITRC, 2018).

Remediation

[6] It is recommended that consultation occur with regulators if it is suspected that site petroleum hydrocarbon and/or CVOC contamination could be originating from more than one source or site.

Remediation may be selected as an option before or after proceeding with an ERA or gathering additional site data. If remediation is deemed necessary on the basis of ecological protection, it is suggested that careful consideration should be given to the selecting the most appropriate option(s). For example, if site vegetation and/or soil invertebrate communities appear healthy and typical for the type of site, but the soil ecological screening levels for these receptors are exceeded, a remedial option that involves removal of site vegetation and surface soil, this may not be warranted if it is these receptors that the remediation program is intended to protect. As petroleum hydrocarbons are organic substances, they undergo various biotic and abiotic degradation processes, and can be used as a carbon source by microbes, and some plant species; enhancing such processes could also be considered among the various remedial and risk management options as an effective remedial option (eg. monitored natural attenuation) (FCSAP, 2018). In contrast, chlorinated-solvent contaminated sites may present more challenges to achieve any established remedial objectives given their chemical characteristics – typical timeframes in remediating such sites are much longer than PHC contaminated sites.

There are numerous online resources related to PHC and CVOC remediation (eg Government of Canada's Guidance and Orientation for the Selection of Technologies (GOST), EPA's Clu-in.org, and ITRC).

It should also be recognized that there may be regulatory considerations that will also be important to site owners when considering contaminated site remedial actions and approaches. If remediation is deemed necessary at a site, consultation is suggested between site owners, site professionals and regulators to determine the most sustainable and efficient means of remediating the contamination ~~mitigating petroleum hydrocarbon contamination~~ for the purposes of ecological protection.

Table 1a: Tier 1 Petroleum Hydrocarbon Soil Ecological Screening Levels for the Protection of Plants and Soil Invertebrates; Direct Soil Contact and the Protection of Wildlife and Livestock; Soil Ingestion (mg/kg dry weight)

Land Use	Soil Grain Type	Substance							
		Benzene	Toluene	Ethyl Benzene	Xylenes	F1 C6-C10	F2 C10-C16	F3 C16-C34	F4 C34-C50
Agricultural	Coarse	~~31~~ 18	75	55	95	210	150	300	2800
	Fine	~~60~~ 18	110	120	65	210	150	1300	5600
Residential	Coarse	31	75	55	95	210	150	300	2800
	Fine	60	110	120	65	210	150	1300	5600
Commercial	Coarse	180	250	300	350	320	260	1700	3300
	Fine	310	330	430	230	320	260	2500	6600
Industrial	Coarse	180	250	300	350	320	260	1700	3300
	Fine	310	330	430	230	320	260	2500	6600

Source: CCME Canadian Environmental Quality Guidelines (CCME 1999) and CCME CWS (CCME 2008).

a) All screening levels in Table 1a are for surface soils.
b) CWS fractions (F1 to F4) vary from the Atlantic RBCA Tier I reported fractions; however, soil data obtained from laboratories in Atlantic Canada can be combined to be reported as the CWS fractions and compared directly to the values in this table (Atlantic PIRI, 2010).
c) Unless vegetation or soil invertebrate presence below 1.5 m is demonstrated, these screening levels apply to the top 1.5 m of the soil profile.
d) Benzene: Alberta Environment & Parks (AEP, 2019) wildlife soil ingestion

Table 1b: Tier 1 CVOC Soil Ecological Screening Levels for the Protection of Plants and Soil Invertebrates; Soil Contact and the Protection of Wildlife and Livestock; Soil Ingestion (mg/kg dry weight)

Land Use	Soil Grain Type	Substance					
		cis-1,2-Dichloroethylene	trans-1,2-Dichloroethylene	Tetrachloroethylene	1,1-Dichloroethylene	Trichloroethylene	Vinyl Chloride
Agricultural	Coarse	84 [a]	84 [a]	0.1 [a]	50 [b]	0.1 [a]	3.4 [b]
	Fine	84 [a]	84 [a]	0.1 [a]	63 [b]	0.1 [a]	4.3 [b]
Residential	Coarse	84 [a]	84 [a]	5.0 [a]	50 [b]	5.0 [a]	3.4 [b]
	Fine	84 [a]	84 [a]	5.0 [a]	63 [b]	5.0 [a]	4.3 [b]
Commercial	Coarse	940 [a]	940 [a]	50 [a]	100 [b]	50 [a]	6.8 [b]
	Fine	940 [a]	940 [a]	50 [a]	130 [b]	50 [a]	8.5 [b]
Industrial	Coarse	940 [a]	940 [a]	50 [a]	100 [b]	50 [a]	6.8 [b]
	Fine	940 [a]	940 [a]	50 [a]	130 [b]	50 [a]	8.5 [b]

Source:
a) OMOE, 2011 soil/food ingestion
b) BCMOE, 2017 soil contact
c) OMOE, 2011 soil contact
d) CCME, 1999; updated 2017 soil contact

~~Table Tier 1 Soil Ecological Screening Levels for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion (mg/kg dry weight)~~ Combined with Table 1a

~~Land Use~~	~~Substance~~							
~~Agricultural [b]~~	~~18~~	~~980~~	~~640~~	~~2600~~	~~11000~~	~~9800~~	~~16000~~	~~8400~~

~~Source: Alberta Environment (AENV, 2010).~~
~~a) All screening levels in Table 1b are for both fine and coarse grained surface soils.~~
~~b) Livestock and/or wildlife soil and food ingestion soil quality guidelines only exist for the agricultural land use category (AENV, 2010). Rather than include both livestock and wildlife screening levels, the values in this table are for the protection of wildlife, which are more conservative than the AENV (2010) livestock criteria (see Rationale document for further details).~~

Table 2: Tier 1 Petroleum Hydrocarbon Groundwater Ecological Screening Levels for Plant and Invertebrate Direct Contact with Shallow Groundwater (mg/L)

Land Use	Soil Grain Type	Substance					
		Benzene	Toluene	Ethyl Benzene	Xylenes	F1 C6-C10	F2 C10-C16
Agricultural	Coarse	61	59	20	31	7.1	1.8
	Fine	100	82	42	21	6.5	1.8
Residential/ Parkland	Coarse	61	59	20	31	7.1	1.8
	Fine	100	82	42	21	6.5	1.8
Commercial	Coarse	350	200	110	120	11	3.1
	Fine	540	240	150	74	9.9	3.1
Industrial	Coarse	350	200	110	120	11	3.1
	Fine	540	240	150	74	9.9	3.1

Source: Alberta Environment & Parks (AEP), 2019

- AEP fractions F1 and F2 vary slightly from the Atlantic RBCA Tier I reported fractions; however, groundwater data obtained from laboratories in Atlantic Canada can be combined to be reported as the CWS fractions and be compared directly to the values in this table (Atlantic PIRI, 2010).
- These screening levels are applicable only if groundwater is present within 3 metres of ground surface.
- There is no screening level for F3 and F4 as these fractions are considered insufficiently soluble to migrate to groundwater from soil.

Table 3a: Tier 1 Petroleum Hydrocarbon Surface Water and Groundwater Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life (mg/L)

Water Type	Substance						
	Benzene	Toluene	Ethyl Benzene	Xylenes	Modified TPH		
					Gas	Diesel/#2	#6 oil/lube
Surface Water	2.1	0.77	0.32	0.33	1.5	0.10	0.10 [b]
Groundwater[a]	4.6	4.2	3.2	2.8	13	0.84	0.48

Source: PETROTOX Ver 3.06 See Rationale document for full derivation of these values.

a) Groundwater screening levels can be used for evaluating groundwater quality at locations greater than 10 metres from a freshwater or marine water body. It is recommended that surface water screening levels should be applied directly (or unadjusted) when evaluating groundwater quality at locations within 10 metres of a freshwater or marine surface water body.

b) This screening level set to the RDL for #6 oil/lube (actual derived screening level = 0.06 mg/L)

Table 3b Tier 1 CVOC Surface Water and Ground Water Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life (mg/L)

Water Type		Substance					
		cis-1,2-Dichloroethylene	trans-1,2-Dichloroethylene	Tetrachloroethylene	1,1-Dichloroethylene	Trichloroethylene	Vinyl Chloride
Surface Water	Fresh Water	0.20 [a]	0.20 [a]	0.11 [a]	0.04 [a]	0.021 [b]	0.60 [a]
	Marine Water	224 [c]	224 [c]	0.11 [d]	224 [c]	0.020 [d]	NGA
Ground Water (>10metres from surface water body)	Daylighting to Fresh Water [f]	2.0 [e]	2.0 [e]	1.1 [e]	0.40 [e]	0.21 [e]	6.0 [e]
	Daylighting to Marine Water [g]	2,240 [e]	2,240 [e]	1.1 [e]	2,240 [e]	0.20 [e]	NGA

a) MOEE, 1999
b) CCME, 1999, updated 201
c) New Hampshire DES, 2016
d) BC Schedule 3.2
e) 10x surface water screening level, as per Atlantic PIRI Environmental Quality Standards for Contaminated Sites (draft)

f) Groundwater screening levels can be used for evaluating groundwater quality at locations greater than 10 metres from a freshwater body. It is recommended that freshwater surface water screening levels should be applied directly (or unadjusted) when evaluating groundwater quality at locations within 10 metres of a freshwater surface water body.

g) Groundwater screening levels can be used for evaluating groundwater quality at locations greater than 10 metres from a marine water body. It is recommended that marine surface water screening levels should be applied directly (or unadjusted) when evaluating groundwater quality at locations within 10 metres of a marine surface water body.

Table 3c Tier 1 Petroleum Hydrocarbons Groundwater Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life (mg/L), adjusted for distance to receiving aquatic environment and soil type

Distance to Surface Water [a]	Benzene (mg/L)		Toluene (mg/L)		Ethyl benzene (mg/L)		Xylenes (mg/L)		Modified TPH					
									Gasoline (mg/L)		Diesel (mg/L)		Lube Oil (mg/L)	
(m)	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
10	4.6		4.2		3.2		2.8		13		0.84		0.48	
20	5	4.6	4.6	4.2	3.5	3.2	3	2.8	13	13	0.85	4.5	1.3	18
30	7.6	4.8	6.9	4.4	5.3	3.4	4.6	2.9	13	14	1.3	24	2.2	113
40	12	5.6	11	5.1	8.0	3.9	7	3.4	15	37	2.9	178	4.9	1070
50	17	6.7	15	6.1	11	4.7	10	4.1	22	86	6	>sol	22	>sol
60	22	8.1	20	7.4	15	5.6	14	5.5	37	495	14	>sol	56	>sol
70	29	9.7	26	8.8	20	7.5	17	7.5	55	>sol	21	>sol	85	>sol
80	36	11	33	10	25	9.9	22	11	75	>sol	28	>sol	117	>sol
90	43	13	39	14	30	13	26	18	92	>sol	39	>sol	161	>sol
100	51	16	47	17	36	20	31	30	114	>sol	85	>sol	511	>sol
110	59	19	54	21	41	28	36	49	139	>sol	207	>sol	1243	>sol
120	68	23	62	27	47	45	42	92	171	>sol	333	>sol	1996	>sol
130	77	29	71	35	54	76	47	>sol	207	>sol	436	>sol	2615	>sol
140	87	44	79	69	60	130	53	>sol	467	>sol	>sol	>sol	>sol	>sol
150	97	45	88	70	67	>sol	59	>sol	750	>sol	>sol	>sol	>sol	>sol
200	150	250	140	>sol	100	>sol	91	>sol	>sol	>sol	>sol	>sol	>sol	>sol
Solubility (SOL)[b]	1,780		515		150		160		TDB		TDB		TDB	

Source: PETROTOX Ver 3.06 See Rationale document for full derivation of these values.

a) This table should not be used if preferential pathways exist at the site. If such pathways exist, use screening levels in Table 3a.

b) SOL is the groundwater concentration representing the solubility limit for the compound. Beyond this point, a separate, non-aqueous phase liquid layer will begin to form. Above SOL concentrations, NAPL will form and will initially be non-mobile, but at higher concentrations will be subject to gravitational forces, be measurable and become mobile (Atlantic PIRI, 2012)

Table 4a: Tier 1 Petroleum Hydrocarbon Sediment Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life (mg/kg dry weight)

Sediment Type	Substance							
	Benzene	Toluene	Ethyl Benzene	Xylenes	Modified TPH			
					Gas	Diesel/#2	#6 oil/lube	Max
Typical[a]	1.2	1.4	1.2	1.3	15 [b]	25 [b]	43 [b]	500[c]
Other[a]	5.4	6.1	5.0	5.5	67 [b]	110 [b]	190 [b]	500[c]

Source: PETROTOX Ver 3.06 (See Rationale document for full derivation of these values.)

a) Typical and other sediments are defined in Part I of this Protocol.

b) Based on sediment f_{oc} = 0.01. Except for Max TPH, the screening levels change proportionally with the f_{oc}. For example, with f_{oc}= 0.04, the values increase by 4-fold.

c) This value does not change with sediment f_{oc}. While the product-specific screening values can vary with f_{oc} and could potentially exceed 500 mg/kg, this value represents the maximum screening level for Modified TPH, regardless of sediment f_{oc}. This Max TPH screening value is analogous to a management limit.

Table 4b: Tier 1 CVOC Sediment Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life (mg/kg dry weight)

Sediment Type	Substance					
	cis-1,2-Dichloroethylene	trans-1,2-Dichloroethylene	Tetrachloroethylene	1,1-Dichloroethylene	Trichloroethylene	Vinyl Chloride
Freshwater	NGA	NGA	0.41 [a]	NGA	0.22 [a]	NGA
Marine	NGA	NGA	NGA	NGA	NGA	NGA

a) USEPA, 2008

References Cited

Alberta Environment and Parks (AEP). 2019. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Land Policy Branch, Policy and Planning Division. 198 pp.

Atlantic PIRI, Atlantic RBCA (Risk-Based Corrective Action), Version 3 User Guidance (updated 2012)

ASTM. 2002. Standard Guide for Risk-Based Corrective Action for Protection of Ecological Resources. 2205 – 02. ASTM International.

Canadian Council of Ministers of the Environment. 1996. A Framework for Ecological Risk Assessment : General Guidance. CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. March 1996.

Canadian Council of Ministers of the Environment. 2006. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. PN 1332. http://www.ccme.ca/assets/pdf/sg_protocol_1332_e.pdf

Canadian Council of Ministers of the Environment. 2008. Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil. Technical Supplement. January 2008.

Canadian Council of Ministers of the Environment. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg. Available online: http://ceqg-rcqe.ccme.ca (viewed 2019-06-18)

Environmental Protection Agency. 2018. Examples of Groundwater Remediation at NPL Sites. EPA 542-R-18-002. Available online: https://www.epa.gov/sites/production/files/2018-05/documents/examples_of_groundwater_remediation_at_npl_sites.pdf

Federal Contaminated Sites Action Plan. 2012. Ecological Risk Assessment Guidance - March 2012. Ottawa: Her Majesty the Queen in Right of Canada. ISBN 978-1-100-22282-0.

Federal Contaminated Sites Action Plan. To be published. Guidance on Monitored Natural Attenuation in Soil and Groundwater for Federal Contaminated Sites.

Government of Canada. Species At Risk Act. 2002. 2002, c-29. http://laws.justice.gc.ca/eng/S-15.3/page-1.html

Government of Canada. Fisheries Act. 1985. R.S., 1985, c. F-14. http://lois.justice.gc.ca/eng/F-14/index.html

Interstate Technology & Regulatory Council. 2011. Integrated DNAPL Site Strategy. Prepared by The Interstate Technology & Regulatory Council Integrated DNAPL Site Strategy Team Available online: https://www.itrcweb.org/guidance/getdocument?documentid=35

Interstate Technology & Regulatory Council. 2018. TPH Risk Evaluation at Petroleum-Contaminated Sites. Prepared by The Interstate Technology & Regulatory Council (ITRC) Total Petroleum Hydrocarbon Risk Evaluation Team. Available online: https://tphrisk-1.itrcweb.org/

Memorandum of Understanding on An Atlantic Partnership in Risk-Based Corrective Action (RBCA) Implementation (Atlantic PIRI) Between the New Brunswick Department of Environment, the Nova Scotia Department of Environment, the Newfoundland and Labrador Department of Environment can Conservation, the Prince Edward Island Department of Environment Energy and Forestry (April 2008). http://www.atlanticrbca.com/eng/committee.html.

McNab, W., D. Rice and C. Tuckfield. 2000. Evaluating Chlorinated Hydrocarbon Plume Behavior Using Historical Case Population Analyses. Contract for U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory. Contract No. W-7405-Eng-48.

MOEE. 1999. Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy. Ontario. 1994. Reprinted February 1999.

Shih, T., Y. Rong, T Harmon and M. Suffet. 2004. Evaluation of the Impact of Fuel Hydrocarbons and Oxygenates on Groundwater Resources. Environ. Sci. Technol. 38,:42-48

USAF. 2000. BIOCHLOR Chlorinated Solvent Plume Database Report. Air Force Center for Environmental Excellence. Available online: https://clu-in.org/download/contaminantfocus/tce/BIOCHLOR-plume-database.pdf

USEPA. 2008. United States Environmental Protection Agency, 2008. Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Compendium of Tier II Values for Nonionic Organics. EPA/600/R-02/016 PB2008-107282. March, 2008.

Appendix A: Summary Table

SUMMARY TABLE - RESULTS OF ECOLOGICAL SCREENING PROTOCOL FOR PETROLEUM IMPACTED SITES

Instructions to Practitioners: This table is intended to summarize the results of the Ecological Screening Protocol and must be completed in consultation with guidance provided in the protocol. Users should include this completed table in their Environmental Assessment or Closure Report. Details and explanations are to be provided in the body of the Report.

Ecological Screening Component	Yes or No	Report name and location of details and explanations
Part I - Identification of petroleum hydrocarbons in media		
1. Do site characterization data indicate the presence of petroleum hydrocarbons and/or CVOCs in site surface soil (depth < 1.5 m) above the appropriate screening levels in Tables 1a and 1b?		
2. Do site characterization data indicate the presence of PHC in shallow site groundwater (depth < 3.0 m) above appropriate ecological screening levels that were derived for the protection of terrestrial plants and soil invertebrates in contact with site groundwater in Table 2?		
3. Do existing site characterization data indicate the presence of PHC and/or CVOCs in site groundwater above appropriate ecological screening levels derived for the protection of aquatic receptors in Table 2a/2b/2c?		
4. Do site characterization data indicate the presence of PHC and/or CVOCs in site surface water above the appropriate screening levels in Table 2a/2b?		
5. Does site characterization indicate the presence of PHC and or CVOCs in on-site or adjacent sediments above the appropriate screening levels in Table 4a/4b?		Also indicate here if "typical" or "other" sediment criteria used (note: "typical" is the default screening level)
IF ALL ANSWERS IN PART I ARE"NO" THEN NO FURTHER ACTION IS REQUIRED		
Part II - Identification of habitat and ecological receptors		
1. Are the following habitat types or conditions present on the site or proximate to site within a minimum of 200 metres? • wetland habitats • aquatic habitats • forested habitats • grassland habitats • provincial/national parks or ecological reserves • known rare, threatened or endangered species • other known critical or sensitive habitat • other local or regional receptor or habitat concerns		

Ecological Screening Component	Yes or No	Report name and location of details and explanations
2a. Are there visible indications of stressed vegetation on the site?		
2b. Is there evidence that the site vegetation community differs from what would be expected?		
2c. Are there indications that the site soil cannot support a soil invertebrate community?		
3. Is there evidence that terrestrial plants in the habitats above are likely to be in root contact with site groundwater above screening levels?		
4. Would wildlife receptors be expected to forage on or near the contaminated areas of the site?		
Part III - Identification of exposure pathways for ecological receptors		
1a. Is it reasonable to conclude that site hydrocarbons and/or CVOCs in surface soil with concentrations exceeding applicable screening levels, will come into contact with terrestrial plants and invertebrates in a suitable habitat?		
1b. Is it reasonable to conclude that site hydrocarbons and/or CVOCs in surface soil with concentrations exceeding applicable screening levels, will come into contact with mammalian, avian or herptile terrestrial receptors within an agricultural land use in a suitable habitat?		
2. Is it reasonable to conclude that dissolved hydrocarbons and/or CVOCs in site groundwater with concentrations exceeding applicable screening levels will come into contact with plants or soil invertebrates in a suitable habitat?		
3. Is it reasonable to conclude that dissolved hydrocarbons and/or CVOCs in site groundwater with concentrations exceeding applicable screening levels will come into contact with aquatic receptors or aquatic receptor habitat?		
4. Is it reasonable to conclude that site petroleum hydrocarbon and/or CVOCs contamination could impact aquatic receptors or aquatic habitat in surface water bodies via the following: a. surface runoff (*e.g*. erosion, windblown contaminants) b. groundwater flow c. preferential overland flow pathways (*e.g*. drainage ditch, slope, swale) d. preferential subsurface flow pathways (*e.g*. culvert, trench, sewer line, pipelines, swales) such that aqueous media concentrations would potentially exceed surface water and/or sediment quality screening levels?		
Are there site specific conditions present, which were not considered in any section above that should require further ecological assessment?		
IF ALL ANSWERS IN PART III ARE"NO" THEN NO FURTHER ACTION IS REQUIRED		

APPENDIX 3

Atlantic RBCA Version 3.1

ATLANTIC CANADA TIER I

RISK-BASED SCREENING LEVEL (RBSL) TABLES

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

TABLE 3a - TIER I RISK BASED SCREENING LEVELS FOR SOIL (mg/kg)

Land Use	Groundwater Use	Soil Type	Compound of Concern						
			Benzene	Toluene	Ethyl-benzene	Xylene	Modified TPH (TPH-BTEX)		
							Gasoline	Diesel/ No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Agricultural	Potable	Coarse Grained	0.042	0.35	0.043	0.73	74	270	1,100
		Fine Grained	0.094	0.74	0.089	1.5	1,900	4,700	10,000
	Non-Potable	Coarse Grained	0.099	77	30	8.8	74	270	1,100
		Fine Grained	2.3	10,000	9,300	210	2,100	8,600	10,000
Residential	Potable	Coarse Grained	0.042	0.35	0.043	0.73	74	270	1,100
		Fine Grained	0.094	0.74	0.089	1.5	1,900	4,700	10,000
	Non-Potable	Coarse Grained	0.099	77	30	8.8	74	270	1,100
		Fine Grained	2.3	10,000	9,300	210	2,100	8,600	10,000
Commercial	Potable	Coarse Grained	0.042	0.35	0.043	0.73	870	1,800	10,000
		Fine Grained	0.094	0.74	0.089	1.5	1900	4,700	10,000
	Non-Potable	Coarse Grained	2.5	10,000	10,000	110	870	4,000	10,000
		Fine Grained	33	10,000	10,000	10,000	10,000	10,000	10,000
Industrial	Potable	Coarse Grained	0.042	0.35	0.043	0.73	870	1,800	10,000
		Fine Grained	0.094	0.74	0.089	1.5	1,900	4,700	10,000
	Non-Potable	Coarse Grained	2.5	10,000	10,000	110	870	4,000	10,000
		Fine Grained	33	10,000	10,000	10,000	10,000	10,000	10,000
Residual Saturation (RES)		Coarse Grained	890	450	240	340	TBD	TBD	TBD
		Fine Grained	1000	480	250	360	TBD	TBD	TBD

Notes:

1. Upper Concentration Limit (UCL) of 10,000 mg/kg is applied to any calculated soil concentration that is >RES or exceeds 10,000 mg/kg.
2. RES values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the soil at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >RES are considered an indicator of the potential presence of free product. If site concentrations are >RES, the presence of free product must be specifically addressed by the Site Professional.

To apply the RBSL values in the Tier I Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

TABLE 3b - TIER I RISK BASED SCREENING LEVELS FOR GROUNDWATER (mg/L)

Receptor	Groundwater Use	Soil Type	Compound of Concern						
			Benzene	Toluene	Ethyl-benzene	Xylene	Modified TPH (TPH-BTEX)		
							Gasoline	Diesel/ No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Agricultural	Potable	Coarse Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	2.6	20	20	20	20	20	20
		Fine Grained	13	20	20	20	20	20	20
Residential	Potable	Coarse Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	2.6	20	20	20	20	20	20
		Fine Grained	13	20	20	20	20	20	20
Commercial	Potable	Coarse Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	20	20	20	20	20	20	20
		Fine Grained	20	20	20	20	20	20	20
Industrial	Potable	Coarse Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	20	20	20	20	20	20	20
		Fine Grained	20	20	20	20	20	20	20
Solubility (SOL)			1,780	515	150	160	TBD	TBD	TBD

Notes:

1. Upper Concentration Limit (UCL) of 20 mg/L is applied to any calculated concentration that is >SOL or exceeds 20 mg/L.
2. SOL values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the groundwater at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >SOL are considered an indicator of the potential presence of free product. If site concentrations are >SOL, the presence of free product must be specifically addressed by the Site Professional.

To apply the RBSL values in the Tier I Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

APPENDIX 4

Atlantic RBCA Version 3.1

ATLANTIC CANADA TIER II

PATHWAY-SPECIFIC SCREENING LEVEL (PSSL) TABLES

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

TABLE 4a - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR SOIL (mg/kg)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern						
				Benzene	Toluene	Ethyl-benzene	Xylene	Modified TPH (TPH-BTEX)		
								Gasoline	Diesel/No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Agricultural	Potable	Coarse Grained	Indoor Air *	0.099	77	30	8.8	74	270	1,100
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	0.042	0.35	0.043	0.73	940	1,800	15,000
		Fine Grained	Indoor Air *	2.3	>RES	>RES	210	2,100	10,000	60,000
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	0.094	0.74	0.089	1.5	1,900	4700	>RES
	Non-Potable	Coarse Grained	Indoor Air *	0.099	77	30	8.8	74	270	1,100
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	2.3	>RES	>RES	210	2,100	10,000	60,000
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
Residential	Potable	Coarse Grained	Indoor Air *	0.099	77	30	8.8	74	270	1,100
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	0.042	0.35	0.043	0.73	940	1,800	15,000
		Fine Grained	Indoor Air *	2.3	>RES	>RES	210	2,100	10,000	60,000
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	0.094	0.74	0.089	1.5	1900	4700	>RES
	Non-Potable	Coarse Grained	Indoor Air *	0.099	77	30	8.8	74	270	1,100
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	2.3	>RES	>RES	210	2,100	10,000	60,000
			Soil Ingestion	66	20,000	9,300	140,000	15,000	8,600	14,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
Residual Saturation		Coarse Grained		890	450	240	340	TBD	TBD	TBD
		Fine Grained		1000	480	250	360	TBD	TBD	TBD

Notes:

1. * 10 X Adjustment Factor (AF) has been applied.
2. RES values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the soil at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >RES are considered an indicator of the potential presence of free product. If site concentrations are >RES, the presence of free product must be specifically addressed by the Site Professional.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

TABLE 4a - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR SOIL (mg/kg)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern						
				Benzene	Toluene	Ethyl-benzene	Xylene	Modified TPH (TPH-BTEX)		
								Gasoline	Diesel/No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Commercial	Potable	Coarse Grained	Indoor Air *	2.5	>RES	>RES	110	870	4,000	23,000
			Soil Ingestion	360	31,000	14,000	210,000	22,000	13,000	21,000
			Soil Leaching	0.042	0.35	0.043	0.73	940	1,800	15,000
		Fine Grained	Indoor Air *	33	>RES	>RES	>RES	78,000	>RES	>RES
			Soil Ingestion	360	31,000	14,000	210,000	22,000	13,000	21,000
			Soil Leaching	0.094	0.74	0.089	1.5	1900	4,700	>RES
	Non-Potable	Coarse Grained	Indoor Air *	2.5	>RES	>RES	110	870	4,000	23000
			Soil Ingestion	360	31,000	14,000	210,000	22,000	13,000	21,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	33	>RES	>RES	>RES	78,000	>RES	>RES
			Soil Ingestion	360	31,000	14,000	210,000	22,000	13,000	21,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
Industrial	Potable	Coarse Grained	Indoor Air *	2.5	>RES	>RES	110	870	4,000	23,000
			Soil Ingestion	360	110,000	49,000	730,000	77,000	47,000	74,000
			Soil Leaching	0.042	0.35	0.043	0.73	940	1,800	15,000
		Fine Grained	Indoor Air *	33	>RES	>RES	>RES	78,000	>RES	>RES
			Soil Ingestion	360	110,000	49,000	730,000	77,000	47,000	74,000
			Soil Leaching	0.094	0.74	0.089	1.5	1900	4,700	>RES
	Non-Potable	Coarse Grained	Indoor Air *	2.5	>RES	>RES	110	870	4,000	23,000
			Soil Ingestion	360	110,000	49,000	730,000	77,000	47,000	74,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	33	>RES	>RES	>RES	78,000	>RES	>RES
			Soil Ingestion	360	110,000	49,000	730,000	77,000	47,000	74,000
			Soil Leaching	Not Applicable for Non-Potable Scenarios						
Residual Saturation		Coarse Grained		890	450	240	340	TBD	TBD	TBD
		Fine Grained		1000	480	250	360	TBD	TBD	TBD

Notes:

1. * 10 X Adjustment Factor (AF) has been applied.
2. RES values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the soil at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >RES are considered an indicator of the potential presence of free product. If site concentrations are >RES, the presence of free product must be specifically addressed by the Site Professional.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

TABLE 4b - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR GROUNDWATER (mg/L)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern						
								Modified TPH (TPH-BTEX)		
				Benzene	Toluene	Ethyl-benzene	Xylene	Gasoline	Diesel/ No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Agricultural	Potable	Coarse Grained	Indoor Air *	2.6	>SOL	>SOL	68	34	200	1,100
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	Indoor Air *	13	>SOL	>SOL	330	2,100	30,000	>SOL
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	Indoor Air *	2.6	>SOL	>SOL	68	34	200	1100
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	13	>SOL	>SOL	330	2,100	30,000	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
Residential	Potable	Coarse Grained	Indoor Air *	2.6	>SOL	>SOL	68	34	200	1100
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	Indoor Air *	13	>SOL	>SOL	330	2,100	300,000	>SOL
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	Indoor Air *	2.6	>SOL	>SOL	68	34	200	1,100
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	13	>SOL	>SOL	330	2,100	30,000	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Solubility'		1780	515	150	160	TBD	TBD	TBD

Notes:

1. * 10 X Adjustment Factor (AF) has been applied.
2. SOL values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the groundwater at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >SOL are considered an indicator of the potential presence of free product. If site concentrations are >SOL, the presence of free product must be specifically addressed by the Site Professional.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

TABLE 4b - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR GROUNDWATER (mg/L)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern						
								Modified TPH (TPH-BTEX)		
				Benzene	Toluene	Ethyl-benzene	Xylene	Gasoline	Diesel/ No. 2 Fuel Oil	No. 6 Oil/ Lube Oil
Commercial	Potable	Coarse Grained	Indoor Air *	30	>SOL	>SOL	390	3,700	39,000	>SOL
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	Indoor Air *	150	>SOL	>SOL	>SOL	>SOL	>SOL	>SOL
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	Indoor Air *	30	>SOL	>SOL	390	3,700	39,000	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	150	>SOL	>SOL	>SOL	>SOL	>SOL	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
Industrial	Potable	Coarse Grained	Indoor Air *	30	>SOL	>SOL	390	3,700	39,000	>SOL
			Ingestion	150	0.024	0.0016	0.02	4.4	3.2	7.8
		Fine Grained	Indoor Air *	140	>SOL	>SOL	>160	>SOL	>SOL	>SOL
			Ingestion	0.005	0.024	0.0016	0.02	4.4	3.2	7.8
	Non-Potable	Coarse Grained	Indoor Air *	30	>SOL	>SOL	390	3,700	39,000	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Fine Grained	Indoor Air *	150	>SOL	>SOL	>SOL	>SOL	>SOL	>SOL
			Ingestion	Not Applicable for Non-Potable Scenarios						
		Solubility'		1780	515	150	160	TBD	TBD	TBD

Notes:

1. * 10 X Adjustment Factor (AF) has been applied.
2. SOL values for TPH to be determined (TBD).
3. The numbers in this table are based on the protection of human health. While these concentrations may not be physically realistic in the environment, it remains that the models indicate that chemicals present in the groundwater at concentrations below these values do not present a potential concern for human health if exposure occurs through the specified pathway.
4. Concentrations >SOL are considered an indicator of the potential presence of free product. If site concentrations are >SOL, the presence of free product must be specifically addressed by the Site Professional.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual hydrocarbons must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

Updated September 2015

TABLE 4c - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR SOIL - CVOCs (June 2019)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern					
				Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	1,1-Dichloroethene	Vinyl Chloride
			Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Agricultural	Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching	0.27	0.061	0.42	0.58	0.17	0.021
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching	0.57	0.13	1.0	1.4	0.38	0.060
	Non-Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
Residential	Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching	0.27	0.061	0.42	0.58	0.17	0.021
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching	0.57	0.13	1.0	1.4	0.38	0.060
	Non-Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	220	19	74	740	1900	57
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			

Notes:

1. In the absence of Tier I RBSL, the site professional shall apply the most conservative guideline applicable to the site.
2. *NGA* - Guidelines are not available for soil for indoor air exposure as derived values are not attainable by current laboratory methods. Where there is a potential for indoor air exposure, soil vapour or subslab testing is required to assess the potential for unacceptable risks. The extent of chlorinated solvent impacts shall be delineated through soil vapour and groundwater data or another means deemed appropriate by the Site Professional and Provincial Regulator. Refer to guidance document for further guidance.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater (i.e. light or dense)
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free liquid phase product.
d. Residual impacts must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

TABLE 4c - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR SOIL - CVOCs (June 2019)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern					
				Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	1,1-Dichloroethene	Vinyl Chloride
			Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Commercial	Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	340	28	110	1100	2800	170
			Soil Leaching	0.27	0.061	0.42	0.58	0.17	0.021
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	340	28	110	1100	2800	170
			Soil Leaching	0.57	0.13	1.0	1.4	0.38	0.060
	Non-Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	340	28	110	1100	2800	170
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	340	28	110	1100	2800	170
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
Industrial	Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	4300	360	1400	14000	36000	310
			Soil Leaching	0.27	0.061	0.42	0.58	0.17	0.021
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	4300	360	1400	14000	36000	310
			Soil Leaching	0.57	0.13	1.0	1.4	0.38	0.060
	Non-Potable	Coarse Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	4300	360	1400	14000	36000	310
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*	*NGA*
			Soil Ingestion	4300	360	1400	14000	36000	310
			Soil Leaching			**Not Applicable for Non-Potable Scenarios**			

Notes:

1. In the absense of Tier I RBSL, the site professional is to apply the most conservative guideline applicable to the site.
2. *NGA* - Guidelines are not available for soil for indoor air exposure as derived values are not attainable by current laboratory methods. Where there is a potential for indoor air exposure, soil vapour or subslab testing is required to assess potential for unacceptable risks. The extent of chlorinated solvent impacts is to be delineated through soil vapour and groundwater data or another means deemed appropriate by the Site Professional and Provincial Regulator. Refer to guidance document for further discussion.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual impacts must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

TABLE 4d - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR GROUNDWATER - CVOCs (June 2019)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern					
				Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	1,1-Dichloroethene	Vinyl Chloride
			Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Agricultural	Potable	Coarse Grained	Indoor Air	0.21	0.019	*NGA*	*NGA*	0.94	0.017
			Ingestion	0.01	0.005	0.07	0.1	0.014	0.002
		Fine Grained	Indoor Air	0.99	0.091	*NGA*	*NGA*	4.5	0.081
			Ingestion	0.03	0.005	0.07	0.1	0.014	0.002
	Non-Potable	Coarse Grained	Indoor Air	0.99	0.091	*NGA*	*NGA*	4.5	0.081
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	0.99	0.091	*NGA*	*NGA*	4.5	0.081
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
Residential	Potable	Coarse Grained	Indoor Air	0.21	0.019	*NGA*	*NGA*	0.94	0.017
			Ingestion	0.01	0.005	0.07	0.1	0.014	0.002
		Fine Grained	Indoor Air	0.99	0.091	*NGA*	*NGA*	4.5	0.081
			Ingestion	0.03	0.005	0.07	0.1	0.014	0.002
	Non-Potable	Coarse Grained	Indoor Air	0.21	0.019	*NGA*	*NGA*	0.94	0.017
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	0.99	0.091	*NGA*	*NGA*	4.5	0.081
			Ingestion			**Not Applicable for Non-Potable Scenarios**			

Notes:

1. In the absense of Tier I RBSL, the site professional is to apply the most conservative guideline applicable to the site.
2. *NGA:* No guideline available at this time. Insufficient toxicological data available for the inhalation exposure pathway for these parameters.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater (i.e, light or dense)
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free phase product.
d. Residual impacts must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

TABLE 4d - TIER II PATHWAY SPECIFIC SCREENING LEVELS FOR GROUNDWATER - CVOCs (June 2019)

Receptor	Groundwater Use	Soil Type	Exposure Pathway	Compound of Concern					
				Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	1,1-Dichloroethene	Vinyl Chloride
			Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Commercial	Potable	Coarse Grained	Indoor Air	1.2	0.11	*NGA*	*NGA*	5.5	0.2
			Ingestion	0.01	0.005	0.07	0.1	0.014	0.002
		Fine Grained	Indoor Air	5.8	0.54	*NGA*	*NGA*	27	0.93
			Ingestion	0.03	0.005	0.07	0.1	0.014	0.002
	Non-Potable	Coarse Grained	Indoor Air	1.2	0.11	*NGA*	*NGA*	5.5	0.2
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	5.8	0.54	*NGA*	*NGA*	27	0.93
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
Industrial	Potable	Coarse Grained	Indoor Air	1.2	0.11	*NGA*	*NGA*	5.5	0.2
			Ingestion	0.01	0.005	0.07	0.1	0.014	0.002
		Fine Grained	Indoor Air	5.8	0.54	*NGA*	*NGA*	27	0.93
			Ingestion	0.01	0.005	0.07	0.1	0.014	0.002
	Non-Potable	Coarse Grained	Indoor Air	1.2	0.11	*NGA*	*NGA*	5.5	0.2
			Ingestion			**Not Applicable for Non-Potable Scenarios**			
		Fine Grained	Indoor Air	5.8	0.54	*NGA*	*NGA*	27	0.93
			Ingestion			**Not Applicable for Non-Potable Scenarios**			

Notes:

1. In the absense of Tier I RBSL, the site professional is to apply the most conservative guideline applicable to the site.
2. *NGA* : No guideline available at this time. Insuficient toxicological data available for the inhalation exposure pathway for these parameters.

To apply the PSSL values in the Tier II Soil and Groundwater Tables, the following mandatory criteria must be satisfied.

a. Non-aqueous phase liquids must not be present in groundwater.
b. Potable water must be free of objectionable taste and odour.
c. Soils must not contain liquid and/or free petroleum product.
d. Residual impacts must not create objectionable odours or explosive conditions in indoor or outdoor air.
e. Surface soils must not be stained.
f. The site characteristics and exposure scenarios must be compatible with the Atlantic RBCA default values.

APPENDIX 5

Atlantic RBCA Version 3.1

ATLANTIC RBCA DEFAULT PARAMETERS

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

TABLE 5: TRVs USED IN DERIVATION OF TIER II PSSLs – CVOCS

Name	Oral/ Dermal RfD (mg/kg-d)	Source	Inhalation RfC (mg/m^3)	Source	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$	Source	Inhalation URF $(mg/m^3)^{-1}$	Source
Trichloroethylene (TCE)	5.00E-04	IRIS, 2011	0.002	IRIS 2011	0.046	IRIS, 2011	4.10E-03	IRIS, 2011
Tetrachloroethylene (PCE)	0.006	IRIS, 2012	0.04	IRIS, 2012	0.0021	IRIS, 2012	2.60E-04	IRIS, 2012
cis-1,2-Dichloroethylene	0.002	IRIS, 2010	0.00852	-	-	-	-	-
trans-1,2-Dichloroethylene	0.02	IRIS, 2010	0.08518	-	-	-	-	-
1,1-Dichloroethylene	0.05	IRIS, 2002	0.2	IRIS, 2002	-	-	-	-
Vinyl chloride	0.003	IRIS, 2000	0.1	IRIS, 2000	0.26	HC, 2010	0.0044	IRIS, 2000

Notes:
RfC: Inhalation reference concentration
RfD: Oral/Dermal Reference Dose
URF: Unit Risk Factor
The PSSL tables may be updated outside of this guidance document. Refer to www.atlanticrbca.com for the most up to date version of the Tier II PSSL tables.

References:

1. IRIS 2002, 2010, 2011, 2012: United States Environmental Protection Agency (USEPA) Integrated Risk Information System (https://www.epa.gov/iris)
2. HC 2010: Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0.

TABLE 6: FRESH PRODUCT HYDROCARBON FRACTION RATIOS

Raw Product Hydrocarbon Fraction Ratios Used in Development of the Tier I RBSL Table			
Carbon Fraction	**Gasoline (BTEX Excluded)**	**Diesel (No. 2 Fuel Oil)**	**No. 6 Oil (Lube Oil)**
Aliphatic Fractions			
>C05-C06	0.27	0	0
>C06-C08	0.27	0	0
>C08-C10	0.16	0.05	0.01
>C10-C12	0.12	0.19	0.05
>C12-C16	0	0.26	0.17
>C16-C21	0	0.17	0.26
>C21-C34	0	0.03	0.32
Aromatic Fractions			
>C07-C08	0	0	0
>C08-C10	0.06	0.01	0
>C10-C12	0.12	0.06	0.01
>C12-C16	0	0.12	0.03
>C16-C21	0	0.09	0.07
>C21-C34	0	0.02	0.08

Notes:

1. Carbon fractions are based on equivalent carbon numbers that relate to travel time in the gas chromatograph.
2. Benzene, toluene, ethylbenzene and xylene are evaluated separately
3. Fraction ratios may be entered directly as concentrations in the Atlantic RBCA Tool Kit to determine SSTLs for fresh product mixtures.

TABLE 7: ATLANTIC RBCA VERSION 3.2.2 DEFAULT EXPOSURE FACTORS

PARAMETER	DEFAULT VALUE [1]			
Receptor Parameters				
	Agricultural	Residential	Commercial	Industrial
Receptor (non-carcinogen/carcinogen)	Toddler/Composite	Toddler/ Composite	Toddler/Adult	Adult/Adult
Body Weight	Toddler = 16.5 kg	Toddler = 16.5 kg	Toddler = 16.5 kg	Adult = 70.7 kg
Exposure duration – non-carcinogens	4 years	4 years	4 years	35 years
Exposure duration – carcinogens	80 years	80 years	35 years	35 years
Exposure frequency (indoor air)	365 days	365 days	100 days [2]	100 days [2]
Exposure frequency (soil ingestion)	365 days	365 days	240 days [2]	240 days [2]
Exposure Frequency (potable water ingestion)	365 days	365 days	365 days	365 days
Averaging Time for non-carcinogens	4 years	4 years	4 years	35 years
Averaging time for carcinogens	80 years	80 years	80 years	80 years
Ingestion rate of water – non-carcinogens	0.6 L/d	0.6 L/d	0.6 L/d	1.5 L/d
Ingestion rate of water – carcinogens	blended rate over the 80 year exposure duration		1.5 L/d	1.5 L/d
Ingestion rate of soil – non-carcinogens	80 mg/d	80 mg/d	80 mg/d	20 mg/d
Ingestion rate of soil - carcinogens	blended rate over the 80 year exposure duration		20 mg/d	20 mg/d
Inhalation Rate	Not used. Risk calculations based on Reference Concentrations (RfC)			
Skin surface area – non-carcinogens [3]	3000 cm^2	3000 cm^2	3000 cm^2	3400 cm^2
Skin surface area - carcinogens	blended rate over 80 year exposure		3400 cm^2	3400 cm^2
Soil to skin adherence factor	0.1			
Risk Targets				
Target ILCR (Incremental Lifetime Cancer Risk)	1 in 100,000 (1 x 10^{-5}) Cumulative effects based on the most restrictive exposure pathway			
Target Hazard Index (Hydrocarbon mixtures excluding TEX)	1.0 Cumulative effects based on the most restrictive exposure pathway			
Target Hazard Quotient (TEX only)	0.5 (Based on CCME 2004)			
Target Hazard Quotient (CVOCs)	0.2 (Based on CCME 2004)			
Tool Kit Parameters				
Outdoor Air Volatilization Model	ASTM surface & subsurface models			
Indoor Air Volatilization Model	Johnson & Ettinger model with advection			
Soil Leaching Model	ASTM model			
Soil Attenuation Model (SAM)	Yes			

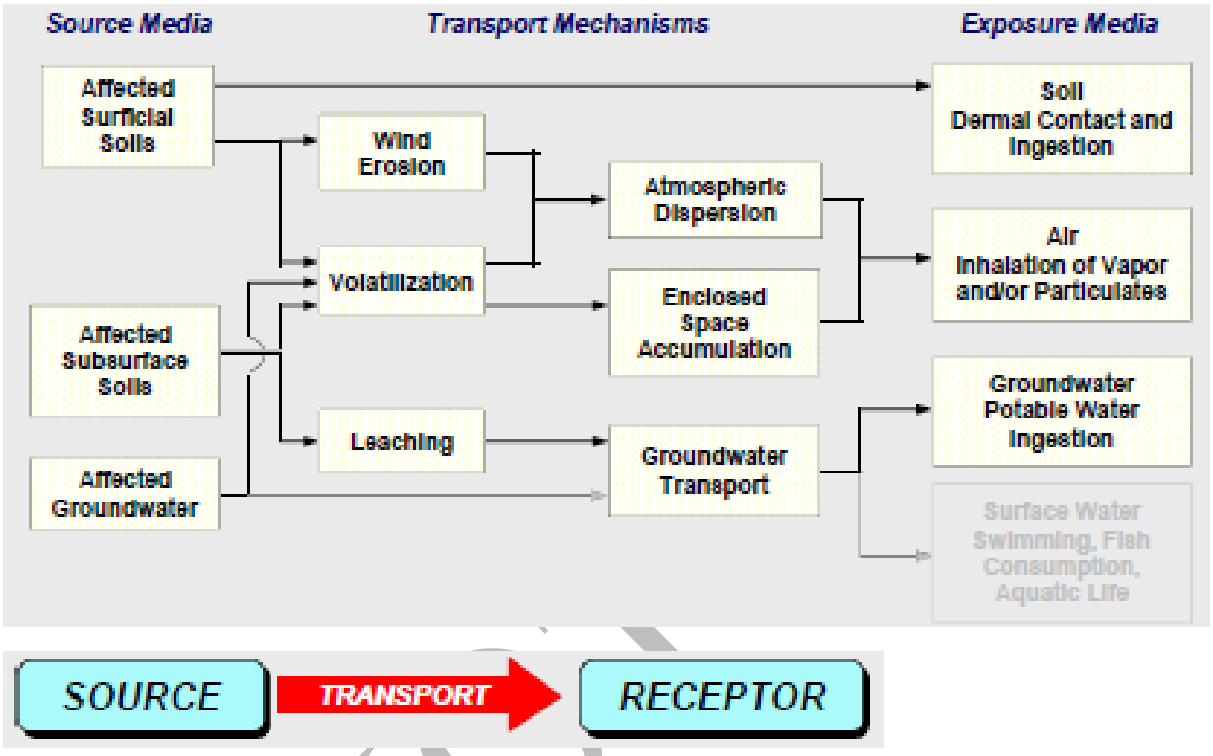
Notes: 1. Default receptor parameters based on Health Canada (2009), except as indicated
2. 240 days = 5 days/week x 48 weeks/year and 100 days = (240 days/year x 10 hours/day) / (24 hours/day), as per CCME CWS (2008)
3. Default parameter from CCME CWS (2008)

TABLE 8: ATLANTIC RBCA DEFAULT PARAMETERS

PARAMETER	DEFAULT VALUE [1]	
	Coarse-grained soils	Fine-grained soils
Surface Soil Parameters		
Soil source zone area (m^2)	100	
Length of source zone area parallel to wind (m)	10	
Length of source zone area parallel to GW flow (m)	10	
Ambient air velocity in mixing zone (m/s)	5	
Air mixing zone height (m)	2	
Areal particulate emission rate ($g/cm^2/s$)	6.9×10^{-14}	
Soil Column Parameters		
Capillary zone thickness (m)	0.05	0.3
Vadose zone thickness (m)	2.95	2.7
Soil bulk density	1.7	1.4
Fraction of organic carbon (vadose zone)	0.005	
Soil total porosity	0.36	0.47
Vertical hydraulic conductivity (cm/s)	1.0×10^{-4}	1.0×10^{-5}
Vapour permeability (m^2)	5.0×10^{-12}	1.0×10^{-13}
Depth to groundwater (m)	3	
Depth to top of affected soils (m)	0 (0.3m for indoor air calculations)	
Depth to base of affected soils (m)	3	
Thickness of affected soils (m)	3	
pH of Soil	5.5	
Volumetric water content, vadose zone	0.119	0.168
Volumetric air content, vadose zone	0.281	0.132
Volumetric water content, capillary fringe	0.36	0.27
Volumetric air content, capillary fringe	0.04	0.03
Foundation volumetric water and air content	Same as coarse-grained soils	
Building Parameters	**Agricultural/Residential**	**Commercial/Industrial**
Building volume/area ratio (m)	3.6 [2]	3
Foundation area (m^2)	150	300
Foundation Perimeter (m)	49	70
Building air exchange rate (1/s)	1.4×10^{-4}	2.5×10^{-4}
Foundation thickness (m)	0.1125	
Depth to bottom of foundation slab (m)	0.1125	
Foundation crack fraction	0.00067	0.00062
Indoor – outdoor pressure differential ($g/cm/s^2$)	40	20
Convective air flow through slab (m^3/s)	1.18×10^{-4}	7.8×10^{-6}
Adjustment Factor for Indoor Air Pathway	10 X for all Indoor Air Calculations	
Groundwater Parameters	**Coarse-grained soils**	**Fine-grained soils**
Groundwater mixing zone depth (cm)	72	276
Net groundwater infiltration rate (cm/yr)	28	20
Groundwater Darcy velocity (cm/s)	2.8×10^{-5}	2.8×10^{-6}
Groundwater seepage velocity (cm/s)	7.0×10^{-5}	9.3×10^{-6}
Saturated hydraulic conductivity (cm/s)	1.0×10^{-3}	1×10^{-4}
Groundwater gradient	0.028	
Width of GW source zone (m)	10	
Depth of (to) GW source zone (m)	3	
Effective porosity in water-bearing unit	0.4	0.3
Fraction of organic carbon (saturated zone)	0.001	
pH of Groundwater	5.5	

Notes:
1. Default values from CCME CWS (2008)
2. Assumes partial air mixing between two floors. For a residential, slab-on-grade building construction, ratio of 2.44 is considered the default (based on a floor height of 2.44 m).

FIGURE 1: ACTIVE PATHWAYS USED IN CALCULATION OF TIER II PSSLs



Note 1: Swimming and fish consumption pathways were not active.
Note 2: Tier I RBSL values were calculated with all exposure pathways active except swimming and fish consumption.
Note 3: The groundwater ingestion pathway was active or closed when stated as potable or non-potable.

APPENDIX 6

Atlantic RBCA Version 3.1

SITE ASSESSMENT AND TIER I/II CHECKLIST

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

SITE ASSESSMENT & TIER I/II TABLE CHECKLIST

		Method Used	
Site Location:		Tier I RBSL	
Site Professional:		Tier II PSSL	
Date:		Tier II SSTL	
Contaminants of Concern at site:			
Minimum Site Assessment Requirements		Other	
Issue		**Yes or No***	**Comment**
PID, owner, location identified			
Current and anticipated future land use identified			
Review of underground services as conduits			
Historical review completed			
Local groundwater use identified			
Adjacent land uses and receptors identified			
Ecological screening completed			
Soil and groundwater samples from all source areas obtained			
For CVOCs, all hydrogeologic units assessed (i.e., shallow/deep)			
Impacts delineated to acceptable levels (Refer to Section 2.2.2 of guidance document), vertically and horizontally, for potential receptors (adjacent property receptor may have lower screening levels)			
Groundwater flow direction and gradient established			
Combination of surface and sub-surface soil samples analysed			
Vapour samples collected and analysed, if applicable			
Free product observations made in soil and groundwater			
Low lab detection level for benzene in soil if potable water area			
Grain size and organic carbon analysis completed on soil			
TPH fractionation done on soil and water if calculating Tier II SSTL for TPH			
All CVOCs (including parent and biodegradation (daughter) products) assessed			
Scaled site plan showing all relevant site features			
Receptor building characteristics obtained (stories, floor condition, ceiling height, building size, etc)			
Mandatory Conditions			
Issue		**Yes or No***	**Comment**
Non-aqueous phase liquids not present in groundwater			
Potable water free of objectionable taste and odour			
Soils do not contain liquid and/or free petroleum product			
Residual hydrocarbons do not create objectionable odours or explosive conditions in indoor or outdoor air			
Surface soils are not stained			
No dirt basement floors, sumps with dirt bottoms, etc.			
Confirmed that correct TPH type selected in RBSL or PSSL Table			
Confirmed that correct soil type selected in RBSL or PSSL Tables			
Default Site Characteristics and Exposure Scenarios			
Issue		**Yes or No***	**Comment**
Depth to groundwater approximately 3.0 metres			
Impacted soil thickness is less than 3.0 metres			
Default foundation crack fraction is appropriate			
Default foundation thickness is appropriate			
Two floors exist if using a residential scenario			
PHC impacts in soil above Tier I RBSL and detectable concentrations of CVOCs in soil, are not within 0.3 m of foundation walls or floor slab			
Confirmed that RBSL or PSSL Table values is correct for adjacent property receptors (i.e. use residential at property line if adjacent property is residential)			
Where exposure pathways have been eliminated at Tier II, detailed explanation provided in report explain why pathways are not relevant			
Where PSSLs tables are used based on elimination or control of a pathway that could be reopened by changes in site use, this condition is specified as a limitation in the report			
Where Tier II SSTLs have been calculated by changing default values, the report includes the parameter changed, the default value, the site-specific value used, and the rationale and/or detailed written justification			

* If No, indicate in comment section if and where in report the issue is addressed.
Consult the Best Management Practices (Appendix 1) for additional details.

APPENDIX 7

Atlantic RBCA Version 3.1

ATLANTIC RBCA SITE CLOSURE CHECKLIST

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

APPENDIX 7

ATLANTIC RBCA SITE CLOSURE CHECKLIST

Provide contact and mailing information for all relevant submitting parties.

Current Site Owner	**Mailing Address:** Company Name: Address: City: Postal Code: Contact Name: Phone: Fax: E-mail:
Approved Agent (if different than above)	**Mailing Address:** Company Name: Address: City: Postal Code: Contact Name: Phone: Fax: E-mail:
Site Professional	**Mailing Address:** Company Name: Address: City: Postal Code: Contact Name: Phone: Fax: E-mail:

Part 1. Site Information

Site Name, Civic Address and Community:	
Property Identification Number:	
Atlantic RBCA Tier : (Check the highest that applies):	Tier I ☐ Tier II ☐ Tier III ☐
Submission date :	
Name of Managing Site Professional:	

Part 2. Documents Summary

List all known contaminated sites management documents completed for the site that are relevant to the regulatory site closure submission. This should include site previous investigation reports (all phases), notification reports, screening level and quantitative risk assessment studies, remediation plans, confirmation of remediation reports (including monitoring) and any other supporting correspondence for the subject site and all affected off-site or third-party impacted properties. All listed documents must be submitted to the regulator.

#	**Document Title**	**Author/Company**	**Document Date d/m/yr**	**Submission Date d/m/yr:**
1				
2				
3				
4				
Add table rows as is necessary to list all relevant documents				

Part 3. Site Closure Checklist with Minimum Submission Requirements

The following checklist information is typically required by provincial regulators in order to process "site closure" of a contaminated site. However, additional requirements may also apply. Check with your provincial jurisdiction. All applicable and/or required reports must be provided to the Department of Environment prior to consideration of site closure.

If the information is contained in more than one document, this information must be cross-referenced to the applicable document (from Part 2 above) in the checklist below. **Please note that it is highly preferred if all required information for site closure is provided in one comprehensive summary report.**

Required Information	Reference Document(s)		
	Document #	Section	Page number
1. Location details of the source property and affected third party properties			
2. Description of previous environmental work (ESAs, Remedial Actions, etc.) completed at the site			
3. Description of source property information, including site use, water/sewer, building details, historical information, any preferential pathways for contaminant migration.			
4. Description of third property information, including site use, water/sewer, building details, and historical information			
5. A completed Summary Table of the Ecological Screening Protocol as provided in Appendix 2A of the Atlantic RBCA User Guidance			
6. A completed "Site Assessment and Tier I/II Table Checklist" as provided in Appendix 6 of the Atlantic RBCA User Guidance			
7. Site plan(s) clearly showing the following information as a minimum: • Relevant buildings and roadways (both on and off-site) • Surrounding natural features • Identified underground/above ground services • Groundwater flow information • Sampling locations (TPs, BHs, MWs, bulk samples, etc.) • Original area of contamination as delineated in affected soil, sediment, groundwater and surface water • Limits of excavation, if applicable • Remediation confirmatory sample locations			
8. Physical site characteristics including descriptions of topography, soils, geology, hydrogeology, surface water features, etc.			
9. When site contamination is the result of a petroleum product release, information on: • Date of spill/leak • Quantify of product • Type of product • Summary of Emergency response, including dates.			
10. Field procedures – Description of all testing and sampling methods on the source and third party properties (soil, groundwater, vapour, etc)			

Required Information	Reference Document(s)		
	Document #	Section	Page number
11. Monitoring well, test pit and borehole logs			
12. Laboratory analytical certificates (including fine grained soil sieve analysis, petroleum hydrocarbon analyses, TPH fractionation etc.) and hydraulic conductivity tests results, if conducted.			
13. Description of contaminant delineation in soil, sediment, groundwater or surface water			
14. Identification of chemicals of concern, exposure pathways and receptors for Tier II/III			
15. Remedial numerical criteria developed for source property and affected third party properties			
16. Summary of inputs used for Tier II RBCA or other (Tier III) risk assessment modeling, including justification for changing Atlantic RBCA defaults, if applicable			
17. Tier II RBCA or other (Tier III) risk assessment modeling runs, if applicable.			
18. Details of remediation technologies/methodologies used at the source property and affected third party properties			
19. Dates for implementation, milestones, and completion			
20. Details of confirmatory soil sampling – locations, logs, laboratory analytical certificates			
21. Confirmation that applicable remedial numerical criteria have been achieved for all affected site(s) /OR confirmation of applicable site management controls			
22. Details of monitoring program, if applicable (frequency, methodologies, results, reporting dates)			
23. Detailed conclusions and recommendations regarding site closure			
24. Correspondence indicating third party notification information and agreements, if applicable			
25. All necessary stakeholder written agreements regarding any required institutional or engineered controls.			
26. Written agreement from the Owner/Responsible Party regarding the decommissioning of monitoring wells, when applicable and subsequent to acknowledgment of site closure.			
27. Name of Site Closure managing site professional, names of significant contributors (ie. Risk Assessor, Site Assessor etc.) and professional stamps on significant documents where required by each jurisdiction (this information may be in a Site Closure report if one has been prepared, or may be supplied in a separate cover document)			
28. Completed Record of Site Condition or Certificate of Compliance (or other similar jurisdictional regulatory document)			

APPENDIX 8

Atlantic RBCA Version 3.1

ACRONYMS AND DEFINITIONS

ATLANTIC PARTNERSHIP IN RBCA IMPLEMENTATION

June 2019

Aliphatic hydrocarbon: Hydrocarbons in which the carbon-hydrogen groupings are arranged in open chains that may be branched. The term includes paraffins and olefins and provides a distinction from aromatics and naphthenes, which have at least some of their carbon atoms arranged in closed chains or ring.

Absorption factor: The percent or fraction of a chemical in contact with an organism that becomes absorbed into the receptor.

Absorption: The uptake of a chemical by a cell or an organism, including the flow into the bloodstream following exposure through the skin, lungs, and/or gastrointestinal tract.

Acute toxicity: The development of symptoms of poisoning or the occurrence of adverse health effects after exposure to a single dose or multiple doses of a chemical within a short period of time.

Acute exposure: The single large exposure or dose to a chemical, generally occurring over a short period.

Adsorption: The physical process of attracting and holding molecules of other substances or particles to the surfaces of solid bodies with which the former are in contact.

Acceptable risk: A risk level that is considered by society or regulatory agencies as tolerable.

Alkanes: Hydrocarbons that contain only single bonds. The chemical name indicates the number of carbon atoms and ends with the suffix “ane”.

Alkenes: Hydrocarbons that contain carbon-carbon double bonds. The chemical name indicates the number of carbon atoms and ends with the suffix 'ene'.

Alkyl groups: A group of carbon and hydrogen atoms that branch from the main carbon chain or ring in a hydrocarbon molecule. The simplest alkyl group, a methyl group, is a carbon atom attached to three hydrogen atoms.

Analyte: The chemical for which a sample is tested, or analyzed.

Aquatic habitat: any water body that supports the presence of populations of freshwater, estuarine or marine pelagic and benthic species. Aquatic habitat can be considered analogous to the definition of “fish habitat” under the Fisheries Act (R.S., 1985, c. F-14).

Aquifer: An underground layer of water-bearing permeable rock, rock fractures or unconsolidated materials (gravel, sand, or silt) from which groundwater can be extracted using a water well.

Aquitard: a zone that restricts the flow of groundwater from one aquifer to another. A completely impermeable aquitard is called an aquiclude or aquifuge.

Aromatic: A compound containing one or more conjugated rings that also may contain sulfur, nitrogen, and oxygen.

ASTM: American Society for Testing and Materials, responsible for many of the standard methods used in industry.

Background level: The normal ambient environmental concentration levels of a chemical.

Bioaccumulation: The retention and concentration of a chemical in the tissues of an organism or biota.

Bioconcentration factor: A measure of the amount that a selected chemical substance accumulates in humans or in biota. It is the ratio of the concentration of substances in an organism to the concentration of the substance in surrounding environmental media.

Bioconcentration: The accumulation of a chemical in tissues of organisms to levels greater than levels in the surrounding media for the organism's habitat; often used synonymously with bioaccumulation.

Boiling point: A characteristic physical property of a liquid at which the vapour pressure is equal to that of the atmosphere and the liquid is converted to a gas.

BTEX: Benzene, toluene, ethylbenzene, and the xylene isomers.

Bunker fuel: Heavy residual oil also called bunker C, bunker C fuel oil, or bunker oil.

Cancer: A disease characterized by malignant, uncontrolled invasive growth of body tissue cells.

Carcinogen: A chemical or substance capable of producing cancer in living organisms.

Carcinogenic: Tending to produce or incite cancer in living organisms.

Carcinogenicity: The ability of a chemical to cause cancer in a living organism.

Chlorinated Volatile Organic Compounds (CVOCs): volatile organic compounds generally constructed of a simple hydrocarbon chain to which at least one chlorine atom is covalently bonded. They have properties that make them useful for degreasing fats, oils, waxes, and resins. They tend to have high vapour pressure such that they are volatile under normal indoor atmospheric conditions of temperature and pressure. At high concentrations, they form dense non-aqueous phase liquids (DNAPLs) due to their high densities and low water solubility. The CVOCs included in the Atlantic PIRI User Guidance are associated with dry cleaning operations and include perchloroethylene (PCE, also known as tetrachloroethylene), trichloroethylene (TCE), cis-1,2-dichloroethylene (cis-1,2-DCE), trans-1,2-dichloroethylene (trans-1,2-DCE), 1,1-dichloroethylene (1,1-DCE), and vinyl chloride.

Chromatogram: The resultant electrical output of sample components passing through a detection system following chromatographic separation. A chromatogram may also be called a trace.

Chronic: Pertaining to the long term (i.e., of long duration).

Chronic exposure: The long-term, low-level exposure to chemicals, i.e., the repeated exposure or doses to a chemical over along period of time. It may cause latent damage that does not appear until a later period in time.

Chronic toxicity: The occurrence of symptoms, diseases, or other adverse health effects that develop and persist over time, after exposure to a single dose or multiple doses of a chemical delivered over a relatively long period of time.

Chronic daily intake: The exposure, expressed in mg/kg-day, averaged over a long period of time.

Coarse-grained soil: A coarse-grained soil is defined as material having greater than 50% (by dry weight) particles equal to or greater than 75 microns (200 mesh) in diameter.

Confidence interval (CI): Pertaining to a range and the probability that an uncertain quantity falls within this range.

Confidence limits: The upper and lower boundary values of a range of statistical probability numbers that define the confidence interval.

Critical or Sensitive habitat: Ecological habitat that is essential for the occurrence of ecological receptors and/or maintenance of key ecological functions and processes (e.g.,

designated conservation areas, Provincial and Federal parks, areas of scientific or natural significance, and wetlands).

Cycloalkane: A class of alkanes that are in the form of a ring.

Cycloparaffin: An example of a cycloalkane.

Degradation: The physical, chemical, or biological breakdown of a complex compound into simpler compounds and byproducts.

Delineation: The process of identifying or determining the spatial extent of environmental media contamination

Dermal exposure: Exposure of an organism or receptor through skin absorption.

Diesel fuel: That portion of crude oil that distills out within the temperature range approximately 200-370 oC. A general term covering oils used as fuel in diesel and other compression ignition engines.

Distillation range: A single pure substance has one definite boiling point at a given pressure. A mixture of substances, however, exhibits a range of temperatures over which boiling or distillation commences, proceeds and finishes. This range of temperatures, determined by means of standard apparatus, is termed the `distillation' or `boiling' range.

Ditch: A constructed channel for the purpose of diverting or conveying water flow; may undergo regular maintenance to remove vegetation and soil and provide a continuous grade in order to maintain positive gravity drainage, without ponding, in the specified flow direction.

DNAPL or Dense Non-Aqueous Phase Liquids: chemicals or mixtures of chemicals that are denser than water at concentrations above water aqueous solubility limits. These chemicals can move vertically through soil and groundwater until encountering a sufficiently resistant layer that will impede further vertical movement and allow the liquid to pool. CVOCs are an example of a DNAPL.

Dose: That amount of a chemical taken in by potential receptors on exposure; it is a measure of the amount of the substance received by the receptor, as a result of exposure, expressed as an amount of exposure (in mg) per unit body weight of the receptor (in kg).

Dose-response: The quantitative relationship between the dose of a chemical and an effect caused by exposure to such substance.

Dose-response evaluation: The process of quantitatively evaluating toxicity information and characterizing the relationship between the dose of a chemical administered or received and the incidence of adverse health effects in the exposed population.

Dose-response curve: A graphical representation of the relationship between the degree of exposure to a chemical substance and the observed or predicted biological effects or response.

Ecological Reserve: A designated area for which development and human activities are restricted or prevented in order to preserve sensitive animal and/or plant communities, populations, or ecosystems

Ecological Risk Assessment (ERA): The process of evaluating the potential adverse effects on non-human organisms, populations or communities in response to human-induced stressors. ERA entails the application of a formal framework, analytical process, or model to estimate the effects of human actions on natural organisms, populations or communities and interprets the significance of those effects in light of the uncertainties identified in each study component (Federal FCSAP guidance, 2012)

Ecosystem: The interacting system of a biological community and its abiotic (i.e., nonliving) environment.

Ecotoxicity assessment: The measurement of effects of environmental toxicants on indigenous populations of organisms within an ecosystem.

Effect (systemic): The response produced due to a chemical that requires absorption and distribution of the chemical and tends to affect the receptor at sites away from the entry point(s).

Effect (local): The response produced due to a chemical that occurs at the site of first contact.

Environmental fate: The ultimate and intermediary destinies of a chemical after release into the environment and following transport through various environmental compartments.

EQL: Estimated Quantitation Limit is the minimum concentration that can be reliably reported.

Estimated Daily Intake (EDI): The estimated daily intake of a chemical made by Health Canada from environmental sources during normal living activity not related to a contaminated site. This amount may be subtracted from the Tolerable Daily Intake (TDI) for that chemical when determining allowable concentrations to remain on a site.

Exposure pathway: The course a chemical or physical agent takes from a source to an exposed population or organism; it describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site.

Exposure route: The avenue by which an organism contacts a chemical, such as inhalation, ingestion, and dermal contact.

Exposure scenario: A set of conditions or assumptions about hazard sources, exposure pathways, levels of chemicals, and potential receptors that aids in the evaluation and quantification of exposure in a given situation.

Exposure: Receiving a dose of a chemical substance (or physical agent) or coming in contact with a hazard.

Extrapolation: The estimation of an unknown value by projecting from known values.

Flame ionization detector (FID): A detector for a gas chromatograph that measures anything that can burn.

Fine-grained soil: A fine-grained soil is defined as material having greater than 50% (by dry weight) particles equal to or less than 75 microns (200 mesh) in diameter.

Foc (fraction of organic carbon): the fraction of the soil made up of organic carbon matter. The higher the foc, the greater the ability of the soil to adsorb organic contaminants.

Foraging and Breeding Areas: Locations where ecological receptors obtain food items or breed

Free Product: Product that is present as a separate, observable, or measurable NAPL phase (LNAPL or DNAPL). Free product may be mobile or immobile.

Fuel oil: A general term applied to oil used for the production of power or heat. In a more restricted sense, it is applied to any petroleum product that is used as boiler fuel or in industrial furnaces. These oils are normally residues, but blends of distillates and residues are also used as fuel oil. The wider term, `liquid fuel' is sometimes used, but the term `fuel oil' is preferred.

Fugitive dust: Atmospheric dust arising from disturbances of granular matter exposed to the air.

Gas chromatography: An analytical technique, employing a gaseous mobile phase, which separates mixtures into their individual components.

Gasoline (petrol): Refined petroleum distillate, normally boiling within the limits of 30-220'C, which, combined with certain additives, is used as fuel for spark-ignition engines. By extension, the term is also applied to other products that boil within this range.

Grasslands: Terrestrial ecozone whose predominant vegetation consists of grasses and/or shrubs. Open, grassy areas such as fields or meadows.

Grease: A semisolid or solid lubricant consisting of a stabilized mixture of mineral, fatty, or synthetic oil with soaps, metal salts, or other thickeners.

Groundwater Source Zone: Location within a groundwater unit where a contamination source is present

Habitat: The physical location or type of environment in which an organism(s) lives or occurs

Hazard: The inherent adverse effect that chemical or other object poses. It is that which has the potential for creating adverse consequences.

Herpetofauna/Herptile: Collective term for amphibians and reptiles hydrologically or hydrogeologically connected Implying that a site feature is either connected to surface water bodies or groundwater resources.

Heating oil: Gas oil or fuel oil used for firing the boilers of central heating systems.

Human health risk: The likelihood (or probability) that a given exposure or series of exposures to a hazardous substance will cause adverse health impacts on individual receptors experiencing the exposures.

Hydraulic fluid: A fluid supplied for use in hydraulic systems. Low viscosity and low pour-point are desirable characteristics. Hydraulic fluids may be of petroleum or nonpetroleum origin.

Hydrocarbons: Molecules that consist only of hydrogen and carbon atoms.

Hydrogeological Unit: Any soil or rock unit or zone which has a distinct influence on the storage or movement of groundwater, due to hydraulic properties

Hydrogeology: The study of groundwater flow in aquifers and the characterization of aquifers.

Immobile Free Product: Product delineated on sites for which the product plume has been assessed as stable or diminishing in size, and has demonstrated limited mobility due to its chemical makeup, the soil matrix, and age. The potential risks associated with product volatility may need to be separately evaluated.

Individual lifetime cancer risk (ILCR): An upper-bound estimate of the increased cancer risk, expressed as a probability that an individual receptor could expect from exposure over a lifetime; it is a statistical concept and is not dependent on the average residency time in an area.

Ingestion: An exposure type whereby chemical substances enter the body through the mouth and into the gastrointestinal system.

Inhalation: The intake of a substance by receptors through the respiratory tract system.

Inhalation Reference Concentration (RfC): An estimate of continuous inhalation exposure that is likely to be without unacceptable risk of adverse effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors applied to

reflect data limitations (i.e., acceptable concentrations for indoor air inhalation non-carcinogenic contaminants)

Intake: The amount of material inhaled, ingested, or dermally absorbed during a specified time period. It is a measure of exposure, expressed in mg/kg-day.

Integrated Risk Information System (IRIS): A U.S. EPA database containing verified reference doses (RfDs) and slope factors (SFs) and up-to-date health risk and EPA regulatory information for numerous chemicals. It serves as an important source of toxicity information for health and environmental risk assessment.

Jet fuel: Kerosene or gasoline/kerosene mixture for fueling aircraft gas turbine engines.

Kd: Soil/water partition coefficient, provides a soil- or sediment-specific measure of the extent of chemical partitioning between soil or sediment and water, unadjusted for the dependence on organic carbon.

Kerosene: A refined petroleum digitate intermediate in volatility between gasoline and gas oil. Its distillation range generally falls within the limits of 150 and 300'C. Its main uses are as a jet engine fuel, an illuminant, for heating purposes and as a fuel for certain types of internal combustion engines.

Koc: Organic carbon adsorption coefficient provides a measure of the extent of chemical partitioning between organic carbon and water at equilibrium.

Kow: Octanol/water partition coefficient provides a measure of the extent of chemical partitioning between water and octanol at equilibrium.

Kw: Water/air partition coefficient, provides a measure of the distribution of a chemical between water and air at equilibrium.

Leachate: A contaminated liquid resulting when water percolates, or trickles, through waste materials and collects components of those wastes; leaching usually occurs at landfill and may result in hazardous chemicals entering soils, surface water, or groundwater.

LNAPL or Light non-Aqueous Phase Liquids: chemicals or mixtures of chemicals that are less dense than water and exist as a separate phase (i.e., at concentrations above solubility limits). LNAPL remains on the top of the groundwater table. Gasoline, diesel, lube oils and similar materials are examples of LNAPLs.

Lifetime risk: Risk that results from lifetime exposure to a chemical substance.

Lifetime average daily dose: The exposure, expressed as mass of a substance contacted and absorbed per unit body weight per unit time, averaged over a lifetime.

Lifetime exposure: The total amount of exposure to a substance that a human receptor would be subjected to in a lifetime.

Lowest Observable Adverse Effect Level (LOAEL): That chemical dose rate causing statistically or biologically significant increases in frequency or severity of adverse effects between the exposed and control groups. It is the lowest dose level, expressed in mg/kg body weight/day, at which adverse effects are noted in the exposed population.

Lowest Observed Effect Level (LOEL): The lowest exposure or dose level to a substance at which effects are observed in the exposed population; the effects may or may not be serious.

Liquid chromatography: A chromatographic technique that employs a liquid mobile phase.

Mass spectrometer: An analytical technique that "fractures" organic compounds into characteristic fragments based on functional groups that have a specific mass to charge ratio.

Mineral hydrocarbons: PHCs considered "mineral" because they come from the earth rather than from plants or animals.

Maximum contaminant level (MCL): A legally enforceable maximum chemical concentration standard that is allowable in drinking water, issued by the U.S. EPA under the SDWA authorities.

Mobile Free Product: "Mobile Free Product" (or mobile NAPL) occurs when sufficient NAPL is present in soil pores such that capillary retention forces are less than the gravitational forces and the pure phase product becomes mobile.

Modeling: Use of mathematical algorithms to simulate and predict real events and processes.

Monitoring: Measurement of concentrations of chemicals in environmental media or in tissues of humans and other biological receptors/organisms over time.

Natural Area Land Use: Land use category that corresponds to areas that are not significantly influenced by human habitation and activities; wildlands areas

Natural Ecosystems: an ecosystem that is not significantly influenced by human habitation or activities

Non-Aqueous Phase Liquid (NAPL): A separate liquid chemical product phase that is immiscible in water and occurs at concentrations above water aqueous solubility limits. It may be present adsorbed in soil, in soil pores, in bedrock fractures or in bedrock porosity. The density of NAPL will determine where it may occur in the subsurface. If lighter than water (most PHCs) NAPL could be present near, or at the top of, the groundwater saturated zone (LNAPL). If denser than water it could sink below the water table through permeable soils and rock until it reaches a layer of relatively impermeable material (DNAPL).

No Observed Adverse Effect Level (NOAEL): The highest chemical intakes at which there are no statistically or biologically significant increases in frequency or severity of adverse effects between the exposed and control groups (meaning statistically significant effects are observed at this level, but they are not considered to be adverse). It is a dose level, expressed in mg/kg body weight/day, at which no adverse effects are noted in the exposed population.

NOEL, or No Observed Effect Level: That dose rate of chemical at which there are no statistically or biologically significant increases in frequency or severity of any effects between the exposed and control groups, (i.e., the highest level at which a chemical causes no observable changes in the species under investigation). It is a dose level, expressed in mg/kg body weight/day, at which no effects are noted in exposed populations.

Olefin: Synonymous with alkene.

"Other" Sediment: Are those sites where the sediment is not classified as "typical" such as ditches, industrial-influenced receiving areas such as working harbours etc.; “other” sediment sites may receive a lower level of ecological protection than "typical" sediment sites.

Polycyclic aromatic hydrocarbons (PAHs): PAHs consist of a suite of compounds comprised of two or more aromatic rings. PAHs are found in many petroleum mixtures, and they are predominantly introduced to the environment through natural and anthropogenic combustion processes.

Paraffin (alkanes): One of a series of saturated aliphatic hydrocarbons, the lowest numbers of which are methane, ethane, and propane. The higher homologues are solid waxes.

Pathway: Any specific route by which a potential receptor or individual may be exposed to an environmental hazard, such as the release of a chemical material.

Permanent Water Body: A water body where the water column normally persists through all seasons

Permissible exposure limit (PEL): A maximum (legally enforceable) allowable level for a chemical in workplace air, expressed as ppm or mg/m^3 of substance in air.

Photoionization detector (PID): A gas chromatographic detection system that utilizes an ultraviolet lamp as an ionization source for analyte detection. It is usually used as a selective detector by changing the photon energy of the ionization source.

Pica: The behavior in children and toddlers (usually under age 6 years) involving the intentional eating/mouthing of large quantities of dirt and other objects.

Potency: A measure of the relative toxicity of a chemical.

ppb (parts per billion): An amount of substance in a billion parts of another material.

ppm (parts per million): An amount of substance in a million parts of another material; also expressed by mg/kg or ml/L.

Preferential Flow Pathways: Means by which contaminants may migrate faster or easier than through soil leaching or bulk transport processes (e.g., culverts, trenches, ditches, sewer lines, pipelines, swales, cabling etc.)

Probability: The likelihood of an event occurring.

Protection Goals: A narrative statement that defines the desirable level of protection for a receptor or receptor group.

Purge and trap: A chromatographic sample introduction technique in volatile components that are "purged" from a liquid medium by bubbling gas through it. The components are then concentrated by "trapping" them on a short intermediate column, which is subsequently heated to drive the components on to the analytical column for separation.

Qualitative: Referring to the occurrence of a situation without numerical specifications.

Quantitative: Describing the amounts in exact numerical terms.

Receptor: Refers to members of a potentially exposed population, e.g., persons or organisms that are potentially exposed to concentrations of a particular chemical compound.

Reference dose (RfD): The maximum amount of a chemical that the human body can absorb without experiencing chronic health effects; it is expressed in mg of chemical per kg body weight per day. It is the estimate of lifetime daily exposure of a non-carcinogenic substance for the general human population that appears to be without an appreciable risk of deleterious effects; used interchangeably with acceptable daily dose and Tolerable Daily Intake (TDI).

Residual Saturation Limit (RES): the soil concentration, at which the limits for aqueous solubility, soil sorption and air vapour saturation have been reached. Pure phase product (or Non-Aqueous Phase Liquid – NAPL) is expected in the soil pores in samples with concentrations above the residual saturation limit.

Response: The reaction of the body to a chemical substance or other physical, chemical, or biological agent.

Risk assessment: The determination of the potential adverse effects due to hazardous exposure in a particular situation; it is the total process of qualifying or quantifying risks and finding acceptable levels of the risks for an individual, group, or society. It may involve the characterization of the types of health and environmental effects expected from exposure to a chemical substance, estimation of the probability (risk) of occurrence of adverse effects, estimation of the number of cases, and a recommendation for corrective actions.

Risk management: The steps and processes taken to reduce, abate, or eliminate the risk that has been revealed by a risk assessment. It is an activity concerned with decisions about whether an assessed risk is sufficiently high to present a public health concern and about the appropriate means for controlling the risks judged to be significant.

Risk: The probability or likelihood of an adverse consequence from a hazardous situation or hazard, or the potential for the realization of undesirable adverse consequences from impending events.

Risk perception: The magnitude of the risk as it is perceived by an individual or society consisting of the measured risk and the preconceptions of the observer.

Risk reduction: The action of lowering the probability of occurrence and/or the value of a risk consequence, thereby reducing the magnitude of the risk.

Risk Specific Concentration (RSC): An allowable indoor air (vapour) concentration for carcinogenic parameters calculated using Unit Risk Factors (URFs) and target risk (1 in 100,000 (10^{-5}) in Atlantic Canada).

Sensitivity analysis: A method used to examine the operation of a system by measuring the deviation of its nominal behavior due to perturbations in the performance of its components from their nominal values.

Site Media: Environmental media that exists on a site (e.g., soil, vegetation, groundwater, surface water, sediments).

Soil Horizons: Defined layers within a soil profile indicating differences in particle size distribution, mineralogy and/or organic carbon content.

Soil Invertebrates: Invertebrate organisms that spend all or part of their life cycle in soil (e.g., earthworms, arthropods).

Slope factor (SF): A plausible upper-bound probability estimate of a response per unit intake of a chemical over a lifetime. It is used to estimate an upper bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

SOL is the groundwater concentration representing the solubility limit for the compound. Beyond this point, a separate, non-aqueous phase liquid (NAPL) layer will begin to form. Above SOL concentrations, NAPL will form and will initially be non-mobile, but at higher concentrations will be subject to gravitational forces, be measurable and become mobile.

Stressed Vegetation: Vegetation that displays evidence of chemical, physical or biological stressor impacts (e.g., stunted growth, chlorosis, foliage discoloration or changes to foliage shape and size).

Subchronic exposure: The short-term, high-level exposure to chemicals, i.e., the maximum exposure or doses to a chemical over a portion of a lifetime.

Subchronic: Relates to intermediate duration, usually used to describe studies or exposure levels spanning 5 to 90 days duration.

Sub-Surface Soil: For the purposes of the ecological screening protocol, a soil depth of >1.5 m represents subsurface soil. This depth cut-off is consistent with current CCME Canadian Soil Quality Guidelines for the Protection of Human and Environmental Health.

Suitable Habitat: Habitat that is capable of supporting the continuous presence of valued ecological receptors of interest by providing sufficient food/nutrient resources, shelter, and preferred breeding areas.

Surface Soil: for the purposes of the ecological screening protocol a soil depth of ≤1.5 m represents surface soil. This depth cut-off is consistent with current CCME Canadian Soil Quality Guidelines for the Protection of Human and Environmental Health.

Temporary Water Body: A water body where the water column does not routinely persist through all seasons, but may occur seasonally or intermittently, depending on flow conditions and precipitation rates

Threshold: The lowest dose or exposure of a chemical at which a specified measurable effect is observed and below which such effect is not observed.

Threshold limit value (TLV): The maximal allowable workplace ambient air concentration level for a chemical.

Tolerable Daily Intake (TDI): The maximum amount of a chemical that the human body can absorb without experiencing chronic health effects; it is expressed in mg of chemical per kg body weight per day. It is the estimate of lifetime daily exposure of a non-carcinogenic substance for the general human population that appears to be without an appreciable risk of deleterious effects; used interchangeably with acceptable daily dose and Reference Dose (RfD).

Toxicity assessment: Evaluation of the toxicity of a chemical based on available human and animal data. It is the characterization of the toxicological properties and effects of a chemical substance, with special emphasis on the establishment of dose-response characteristics.

Toxicity: The harmful effects produced by a chemical substance. It is the quality or degree of being poisonous or harmful to human or ecological receptors.

"Typical" Sediment: Those where the sediment is used as habitat for sensitive components of freshwater, marine or estuarine aquatic ecosystems. Refer to Appendix B to determine what is included.

Uncertainty: The lack of confidence in the estimate of a variable's magnitude or probability of occurrence.

Uncertainly factor (UF): Also called safety factor, refers to a factor that is used to provide a margin of error when extrapolating from experimental animals to estimate human health risks.

Urban Green Spaces: Isolated natural areas or wildlife corridors located within densely populated areas that are maintained in part for human use, e.g., lawns, playgrounds, school yards, fairgrounds, sports fields, zoos, biking and walking trails, picnic areas, and vegetable gardens.

Vernal Pools: Perched wetlands which are seasonally to semi-permanently flooded depressions typically occurring on sites with poor drainage; often utilized by amphibians for breeding and early life stage development.

Wetland Habitat: Consult individual Provincial guidance for definitions.

Wildlife Corridors: Segments of undeveloped land connecting to additional undeveloped lands on- or off-site, and may consist of rights-of-way, easements, biking and walking trails or other closely spaced small areas that connect two or more areas of potential habitat.

Working Harbour: a harbour that experiences ongoing use for recreational, commercial, residential and/or industrial purposes and that may receive or may have received inputs from current or past internal activities and/or discharges from surrounding upland or upstream land uses. Working harbours encompass all sizes, from small harbours with moorage for recreational or commercial fishing boats to large urban harbours with commercial shipping (FCSAP, 2018)