Remediation Levels Protocol

Adopted by the Minister of Environment

Pursuant to the Contaminated Sites Regulations

Adopted by the Minister of Environment,
Hon. Sterling Belliveau, on July 3, 2013, effective as of July 6, 2013

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1 OBJECTIVES

The *Remediation Levels Protocol* provides the basis for determining the appropriate numerical remediation levels, or long-term exposure management measures, applicable to a contaminated site under the *Contaminated Sites Regulations*.

The objectives of the protocol are to show the different types of acceptable remediation levels and other applicable measures, and the implications of these choices. The protocol provides information related to the use of the following during remediation:

a) Tier 1 Environmental Quality Standards (EQS) – Tables
b) Tier 2 Pathway Specific Standards (PSS) – Tables
c) Tier 2 Site Specific Risk Assessment (SSRA) - computer modelling (e.g. Atlantic RBCA -Atlantic Risk Based Corrective Action – petroleum hydrocarbon model), or other calculated methodologies (e.g., CCME – Canadian Council of Ministers of the Environment)
d) receptor exposure management by implementing long-term monitoring, engineering controls, administrative controls, or physical restrictions
e) conditional and unconditional closure implications of remedial choices

The *Remediation Levels Protocol* is intended for use by a site professional, the qualifications for which are as defined in Section 5 of the *Contaminated Sites Regulations*.

2 DEFINITIONS

Atlantic RBCA: means the current versions of Atlantic Risk Based Corrective Action guidance documents including the Petroleum Hydrocarbon Impacted Sites User Guidance and software modelling tool, Guidance for Soil Vapour and Indoor Air Monitoring Assessments from Atlantic RBCA and Guidelines for Laboratories as published by the Atlantic Partnership in RBCA Implementation committee.

Remediation Pathway: means the process of either Limited Remediation or Full Property Remediation as provided in the *Contaminated Sites Regulations*

Tier 1 Environmental Quality Standards (EQS): means the comprehensive tables in protocol PRO-100, *Notification of Contamination Protocol* which provide substance generic environmental quality standards that may be used as both notification and remediation levels. These standards represent, based on available information, a standardized level of risk for contributing exposure pathways, using land use and other factors.

Tier 2 Pathway Specific Standards (PSS): means the comprehensive tables in the *Remediation Levels Protocol* with individual standards identified for assessing all

contributions to substance risk in all applicable exposure pathways, based on land use and other factors. The Tier 2 PSS may be used as remediation levels for applicable pathways. The Tier 1 EQS are produced from the Tier 2 PSS. The Atlantic RBCA PSSL (Pathway Specific Screening Level) information for petroleum hydrocarbons is included in the Tier 2 PSS tables.

Tier 2 Site Specific Risk Assessment (SSRA): means a site specific environmental and human health risk assessment that is based on conditions at a particular site. The Tier 2 SSRA evaluates actual site risks and develops remediation levels that may be used as remediation criteria. For petroleum hydrocarbons, the Tier 2 SSRA is modelled using Atlantic RBCA methodologies and software. For other substances, additional computer models or calculation methodologies can be used.

3 REMEDIATION GOALS

The overall regulatory goals for remediation are to manage contamination to reduce related risks to acceptable levels in the environment, considering both humans and ecology.

These goals may be met by a variety of means acceptable to the Minister. These means range from clean-up at the conservative generic Tier 1 level, to Tier 2 clean-up justified based on site specific conditions, to long-term exposure management of site contamination through monitoring, engineered, physical, or administrative controls.

The means to achieve these goals are provided by establishing acceptable remediation levels, Section 4, or alternate, but acceptable, long-term exposure management measures, Section 6.

4 REMEDIATION LEVELS

Final remediation levels or measures determined for a site, including Tier 1 EQS, Tier 2 SSTLs, or exposure management conditions, must all be documented as described in protocol PRO-600, *Remedial Action Plan Protocol* (RAP). These final levels/measures form the basis for determining remediation completion in the confirmation of remediation report for the site.

Sections 4 and 5 describe allowable remediation levels and alternatives. Section 6 presents the implications of remediation choices in more detail with respect to unconditional or conditional closure, and to which remediation pathway (Limited Remediation or Full Property Remediation) these may be applied.

4.1 Tier 1 Environmental Quality Standards Tables

The Tier 1 Environmental Quality Standards (EQS) tables that are used for notification of contamination may also be used to determine Tier 1 remediation levels. Use of the Tier 1 EQS for remediation is a conservative and typical application of clean-up standards. The Tier 1 EQS incorporates both human health and ecological considerations (where applicable), as described within the land uses presented in the *Notification of Contamination Protocol*. The following points relate specifically to use of the Tier 1 EQS:

- The Tier 1 EQS can be used for all substances listed, which include the petroleum hydrocarbons as adopted from the applicable version of Atlantic RBCA.
- For remediation purposes, and the acceptable use of the Tier 1 EQS, there is a requirement to meet all default and use assumptions identified in Section 5.1.
- When Tier 1 EQS criteria are met, site closure is considered unconditional.

4.2 Tier 2 Pathway Specific Standards Tables

Tier 2 Pathway Specific Standards (PSS) tables for soil and groundwater are provided in Appendix 2 of this document. There are no Tier 2 PSS tables for sediment and surface water, as direct contact is considered the only operable exposure pathway in these media. The Tier 2 PSS tables present the applicable criteria for each operable exposure pathway. They include the detailed exposure pathway criteria used in selecting the Tier 1 EQS. Additional information about the Tier 2 PSS tables includes the following:

a) The Tier 2 PSS tables can be used in determining remediation levels or measures for all substances listed, based on specific exposure pathways. However, the following human health exposure pathways for a site must always be addressed for each applicable contaminant for a site to be considered for unconditional closure:

   i. direct soil contact
   ii. indoor air inhalation

   Removal of these exposure pathways is allowable, but only in the context of creating conditional closure with a long-term exposure management requirement, and is only allowable under Limited Remediation.

b) When using the Tier 2 PSS tables for agricultural land uses, all ecological exposure pathways are to be evaluated, with no exclusions, for the site to be potentially considered for unconditional closure. This is also the case for some other undeveloped, wild or natural lands that will use agricultural land use criteria, as described in protocol PRO-100, *Notification of Contamination Protocol*.

Removal of ecological pathways for agricultural land use is allowable, but only in the context of creating conditional closure with an ongoing exposure management requirement under protocol PRO-200, *Environmental Site Assessment for Limited Remediation Protocol*.

c) Section 5.2 provides a summary of the effects of Tier 2 options as related to the type of file closure. Details of the specific use of the PSS tables are shown in Appendix 1, Table 1.

4.3 Tier 2 Site Specific Risk Assessment

Any risk assessment methodology to determine the level of risk and appropriate remediation level for any substance is considered a Tier 2 Site Specific Risk Assessment (SSRA). A Tier 2 SSRA can be used to develop site specific target levels (SSTLs), which provide alternate risk-based site specific remediation levels for a site. These SSTLs are protective of environmental risks found at a site, based on site specific information.

These alternate remediation levels are usually specific to individual sites and require the collection of detailed site information to justify their development. The alternate criteria are developed by substituting actual site data for defaults used in the analytical models or formulas to calculate risks to environmental receptors and cleanup levels. The defaults that are changed will determine whether sites are eligible for unconditional or conditional closure. Table 2 in Appendix 1 provides additional detailed information related to the effects of changing model defaults.

4.3.1 Atlantic RBCA for Petroleum Hydrocarbons

The Minister requires the use of the current Atlantic RBCA user guidance and modelling software tool for conducting Tier 2 SSRA and producing Tier 2 SSTLs for petroleum hydrocarbons. The SSTLs developed for a particular site are considered equally as protective of human health risks as the use of Tier 1 EQS, when modeling default changes result in unconditional closure (see Section 5.2)

The use of Atlantic RBCA in the context of the *Contaminated Sites Regulations* requires adherence to the current Atlantic RBCA user guidance, including the collection of necessary additional data, documentation, and reporting.

4.3.1.1 Tier 2 Site Specific Target Levels (SSTLs) Using Atlantic RBCA

The following default parameters may be adjusted in a petroleum hydrocarbon Tier 2 SSRA using the Atlantic RBCA software model to produce SSTLs, which, if met, can result in unconditional closure:

- documented physical properties of site soil data as used in the Atlantic RBCA model
- documented physical properties of site groundwater data as used in the Atlantic RBCA model
- some other documented parameters as described in Table 2, Appendix 1

Changes to other default parameters can signify that the site requires closure conditions and ongoing exposure management. Such conditional closure is allowable only under protocol PRO-200, *Environmental Site Assessment for Limited Remediation Protocol*. In particular, the default parameters include:

- some documented human exposure parameters
- some documented building parameters

Table 2, Appendix 1 provides a full description of the effects of changes to default parameters, used in determining SSTLs, on file closure and remediation pathway options.

4.3.1.2 Soil Vapour and Indoor Air Monitoring Using Atlantic RBCA

Atlantic RBCA provides methodology and guidance regarding soil vapour and indoor air samples for petroleum hydrocarbons. The following are key points relevant to the application of the guidance:

- The use of the Atlantic RBCA Guidance for Soil Vapour and Indoor Air Monitoring Assessments methodology for determining the need for remediation at a particular site is acceptable for confirming, through measurement, either Tier 2 PSS or Tier 2 SSTLs (see Section 5.2 for effects on file closure).
- If used, soil vapour or indoor air monitoring results that follow the Atlantic RBCA methodology are considered as actual measurements that take precedence over Tier 2 soil or groundwater volatilization to indoor air pathway values.
- The use of air samples for determining the need for remediation does not preclude the need for soil and groundwater assessment, including sampling and comparison of sample results to Tier 1 EQS, in accordance with environmental site assessment and notification requirements.

4.3.2 Risk Assessment Methods for Substances Other Than Petroleum Hydrocarbons

For many of the other substances included in the Tier 1 EQS tables there are models or formula calculation methods that can be used for conducting Tier 2 SSRA. The Minister will consider the use of properly conducted Tier 2 SSRA for other substances that follow methodologies as outlined in Section 4.3.2.3 and document the following information.

4.3.2.1 Evaluation

Prior to conducting risk assessment for other substances, steps that are necessary include:

- evaluations of the substances against protocol PRO-100, *Notification of Contamination Protocol* Tier 1 EQS, if available for the substance
- in the absence of protocol PRO-100, *Notification of Contamination Protocol* Tier 1 EQS, the site professional must research screening levels from other jurisdictions and present and/or discuss the findings (i.e. Health Canada, Canadian Council of Ministers of the Environment [CCME], other Canadian provincial jurisdictions and the United States Environmental Protection Agency [USEPA])
- providing a detailed written and tabulated hazard, exposure, and receptor assessment

4.3.2.2 Toxicological Data

Written documentation must be provided in the risk assessment that includes the toxicological database dose response relationship for the substances carried forward in the risk assessment. This will include chemical, physical, and toxicological data in the following hierarchy:

- Health Canada
- CCME
- Canadian provincial jurisdictions
- USEPA

Written documentation and references must be provided for the substance toxicological values used (in tabular format) for the following data:

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

4.3.2.3 Model and Calculation Methods

The model or calculation method used for the risk assessment input calculations must be specified. All of the following items must be addressed:

- Preference is given to an appropriately modified, current Atlantic RBCA model (for assessing any volatile substances for vapour intrusion), Johnson and Ettinger vapour intrusion model, or use of CCME published methodology. The calculation equations must be shown for the use of any Tier 2 contaminant transport models. Assumptions such as bio-degradation rates must be documented, supported, and shown to be appropriate for the study.
- The volatility of substances must be quantitatively considered. If considered as volatile, substances must be assessed for any applicable vapour intrusion and air exposure pathways.
- For certain groups of substances, such as polycyclic aromatic hydrocarbons (PAHs) and dioxins, a potency equivalency approach is preferred. For PAHs, Health Canada's benzo(a)pyrene potency equivalency scheme should be used.
- Chlorinated solvent substances, parent compounds, and all theoretical degradation compounds of concern must have SSTLs calculated, in addition to any forward calculated risk levels. This must be done even if the degradation products are not currently present, or do not exceed protocol PRO-100, *Notification of Contamination Protocol* Tier 1 EQS or alternate researched screening levels. Consideration should also be given to the use of groundwater chemical transformation models for sites involving long term site exposure management or to calculate the predicted future concentration of accumulated degradation compounds.
- Site-specific conditions should be evaluated (relative to defaults shown in Section 5.1) and documented in the Remedial Action Plan report, prepared under protocol PRO-600, *Remedial Action Plan Protocol* (RAP).

- In the case of groundwater assessments, realistic upper solubility limits must be used. For example, site-specific target levels should not exceed theoretical groundwater solubility limits for parameters.
- A comprehensive summary of the approach used (multiple exposure scenarios) and the results obtained for modelling or direct measurements must be provided. For example, if the vapour intrusion equations from the Atlantic RBCA Tool Kit are used, the summary should reference the separate Atlantic RBCA Tool Kit runs in the Appendices that are individually numbered or labelled, or otherwise clearly identified.
- For substances other than petroleum hydrocarbons, Tier 2 SSTLs must be developed that meet health targets of ILCR of 1x10-5 for carcinogens and a hazard quotient (HQ) <0.2 for non-carcinogens in each medium evaluated (e.g., soil, water). The use of other HQs (between 0.2 and 1.0) will only be considered if research and documentation of suitable, alternate site specific estimated daily intake rates are provided. In these cases, consultation with Nova Scotia Environment is required prior to acceptance of values used.
- Once developed, the Tier 2 SSTLs may be used as remediation criteria and are to be included in the remedial action plan for the site. See protocol PRO-600, *Remedial Action Plan Protocol*.

5 CONSIDERATIONS REGARDING REMEDIATION MEASURES

5.1 Tier 1 EQS

5.1.1 Default Assumptions

The following list of default assumptions applies to all Tier 1 EQS when used for remediation at a site:

1) Free product in groundwater must not be present.
2) Free product in soil must not be present.
3) Potable water must be free of objectionable taste and odour which has resulted from the site contaminants.
4) Conditions must be met when addressing volatile contaminants at sites. The conditions are:

a) Soil or groundwater with residual contamination must not create human health criteria exceedances, objectionable odours, or explosive conditions in indoor or outdoor air,
b) Buildings on the site where protocol PRO-100, *Notification of Contamination Protocol* Tier 1 EQS are used must have concrete floors with no dirt basement floors, no sumps with dirt or gravel bottoms, etc.
c) The depth to groundwater must be approximately 3 metres or greater.
d) Impacted soil thickness must be less than 3 metres.
e) The building foundation slab thickness must be 11.25 cm or greater.
f) The building foundation slab crack fraction must not exceed 0.067%.
g) Two floors exist if using a residential scenario.
h) Volatile contaminants in soil (including petroleum hydrocarbons) above PRO-100, *Notification of Contamination Protocol* Tier 1 EQS must not be within 0.3 m of foundation walls or floor slab.

5) The determination and applicability of land use and potential groundwater potability must be as described in PRO-100, *Notification of Contamination Protocol*.
6) If soil type – Fine - is selected in determining the soil Tier 1 EQS, then soil sample grain size analytical results must be provided to confirm the presence of fine-grained soils.

5.1.2 Actions When Tier 1 Defaults Are Not Met

If any of the default conditions in Section 5.1.1 are not met, then the use of Tier 1 EQS criteria as remediation levels is not acceptable. In such cases the site professional must:

1) address the limiting condition in Section 5.1.1 to make the Tier 1 EQS criteria applicable; or
2) use the Tier 2 Pathway Specific Standards (PSS) to assess and address individual exposure pathways.

   Table 1 (Tier 2 Pathway Specific Standards – Exposure Pathway Removal Effects) in Appendix 1 summarizes the effects of removing exposure pathways when determining remediation criteria from the Tier 2 PSS tables. Exposure pathway removal has effects on both the type of closure as well as the type of remediation pathway followed; or

3) conduct Tier 2 Site Specific Risk Assessment (SSRA) using appropriate modelling methods with additional site data to update default parameters and determine alternate Tier 2 SSTL remediation levels.

   Table 2 (Tier 2 Site Specific Risk Assessment Modelling: Changes to Typical Default Data Parameters) in Appendix 1 summarizes the effects of changing typical default

parameters used in modelling Tier 2 Site Specific Target Levels. These apply to the Atlantic RBCA User Guidance and software model for petroleum hydrocarbon, as well as any other models that incorporate these parameters; and

4) Use exposure management methods to control exposure pathways, where necessary.

5.2 Remediation Level and Type of File Closure

The following table shows remediation level options and their effect on type of closure and remediation pathway.

Remediation Level or Method	Closure Conditional/ Unconditional	Use in Limited Remediation	Use in Full Property Remediation
Tier 1 EQS	Unconditional	Yes	Yes
Tier 2 (Unconditional)	Unconditional	Yes	Yes
Tier 2 (Conditional)	Conditional	Yes	No
Exposure Management Monitoring or Controls	Conditional	Yes	No

5.2.1 Tier 1

Tier 1 EQS may be used as remediation levels at a site either for the Limited Remediation pathway or the Full Property Remediation pathway in the *Contaminated Sites Regulations*. Clean-up to Tier 1 EQS results in unconditional closure.

5.2.2 Tier 2

For Tier 2 remediation there are a number of options allowed including the use of the PSS tables in Appendix 2, use of Atlantic RBCA modelling to determine petroleum hydrocarbon SSTLs, and use of other types of site SSRA Tier 2 calculations or modelling. The use of Tier 2 methods may result in either unconditional or conditional closure, as indicated below.

a) Tier 2 Unconditional

The use of Tier 2 remediation levels (PSS tables or SSTLs) results in unconditional closure when no exposure pathways are removed, or no default parameters are

changed, that result in conditional closure as indicated in Appendix 1, Table 1 and Table 2, respectively.

b) Tier 2 Conditional

The use of Tier 2 remediation levels (PSS tables or SSTLs) results in conditional closure when exposure pathways are removed, or when default parameters are changed, that result in conditional closure as indicated in Appendix 1, Table 1 and Table 2, respectively. Conditional closure is only allowable within the context of the Limited Remediation pathway.

c) Use of Atlantic RBCA Guidance for Soil Vapour and Indoor Air Monitoring Assessments

The Guidance for Soil Vapour and Indoor Air Monitoring Assessments from Atlantic RBCA (latest version) can be used to support the development of Tier 2 remediation levels. Since the method is one of direct confirmatory measurement, exposure pathways that show acceptable risk under this method are eligible (if all other conditions and exposure pathway criteria are met) for unconditional closure under either Limited Remediation, or Full Property Remediation. Table 1 in Appendix 1 indicates this concept for the relevant indoor air pathways.

5.3 Requirements Regarding Third-Party Properties

In general, the Minister accepts any remediation levels or measures for third-party properties that were determined following this protocol and are consistent with the requirements of the *Contaminated Sites Regulations* and all other protocols.

6 LONG-TERM EXPOSURE MANAGEMENT MEASURES

Contaminated sites that are not cleaned-up to acceptable Tier 1 EQS or Tier 2 remediation levels in some cases may be managed through the use of long-term exposure controls documented in a risk management plan. Such controls protect all applicable human and ecological receptors from exposure to contaminants. The use of exposure controls for managing contamination results in conditional closure that may only be used in Limited Remediation.

Long-term exposure management measures may include monitoring pathway exposures as well as acceptable controls for reducing or eliminating contaminated site exposures. Monitoring is intended to confirm that receptor exposure does not occur over time despite the existence of contamination on a site. Exposure controls may involve engineering or physical controls as well as administrative receptor access controls.

To ensure information is administratively linked with properties, conditions associated with site monitoring, inspection and maintenance of exposure management controls must be documented in a Risk Management Plan. This must be included as specified in protocol PRO-600, *Remedial Action Plan Protocol*.

6.1 Exposure Management using Monitoring to Confirm No Exposure to Receptors

When monitoring is used as a means to manage exposure from a contaminated site, a detailed long-term monitoring plan is required, in the Risk Management Plan, that includes the following:

a) sufficient initial monitoring to verify that site contaminants in any affected media are not mobile

b) identification of exposure pathways of concern that need to be monitored

c) long-term monitoring plan preparation showing the contaminants to be monitored, the media that are to be sampled, and the frequency of monitoring

d) establishment of monitoring action target levels

e) description of actions to be taken if monitoring results exceed action levels

6.2 Exposure Management with Engineering or Physical Controls

Soil or groundwater contamination exceeding remedial objectives for a site (Tier 1 EQS or Tier 2 levels) may be left in place if appropriate engineering or physical controls ensure that receptors are not exposed to the contaminant hazards. This includes such controls as fencing, caps, covers, barriers, vapour removal systems, indoor ventilation, liners, and groundwater

hydraulic barriers, among others. Requirements by the Minister regarding engineering or physical controls that must be included in the Risk Management Plan are:

a) physical controls that are appropriately designed or otherwise determined by site professionals

b) demonstrated effectiveness of physical controls prior to closure

c) ongoing monitoring and inspection of proper physical control function

d) proper consideration of the physical controls used, since they will affect the type of site closure as well as requiring long-term exposure management requirements.

6.3 Exposure Management Using Administrative Restricted Access Controls

As an alternate to physical controls, exposure to site contaminants may be managed by administrative controls that effectively restrict access to contamination. This includes such controls as building restrictions and covenants, security programs, activity prevention programs, changes to land use through zoning or by-laws, and contingency plans. Requirements by the Minister regarding administrative controls that must be documented in the Risk Management Plan are as follows:

a) administrative controls must be properly determined by a site professional and implemented

b) the effective use of administrative controls must be demonstrated prior to site closure

c) monitoring and inspection measures must be in place to ensure administrative controls remain effective over time.

APPENDICES

Appendix 1

Appendix 2 Pathway Specific Standards (PSS) Tables