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SOLICITATION AMENDMENT
MODIFICATION DE L'INVITATION

The referenced document is hereby revised; unless otherwise indicated, all other terms and conditions of the Solicitation remain the same.

Ce document est par la présente révisé; sauf indication contraire, les modalités de l'invitation demeurent les mêmes.

Comments - Commentaires

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Title - Sujet Dartmouth - CCC Bldg Pad Prep & UXO	
Solicitation No. - N° de l'invitation EC016-150964/A	**Amendment No. - N° modif.** 005
Client Reference No. - N° de référence du client EC016-150964	**Date** 2014-09-26
GETS Reference No. - N° de référence de SEAG PW-$PWB-007-3469	
File No. - N° de dossier PWB-4-37058 (007)	**CCC No./N° CCC - FMS No./N° VME**
Solicitation Closes - L'invitation prend fin **at - à 02:00 PM** **on - le 2014-09-30**	**Time Zone** **Fuseau horaire** Atlantic Daylight Saving Time ADT
F.O.B. - F.A.B. **Plant-Usine:** ☐ **Destination:** ☐ **Other-Autre:** ☐	
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Cette modification de l'invitation numéro cinq (5) est soumise et comprend la modification numéro cinq (5) suivante.

La modification qui suit apportée aux documents de soumission entre en vigueur dès maintenant. L'addenda fera partie des document de contrat.

Toutes autres conditions ne changent pas.

Addenda no. 5

RENSEIGNEMENTS ADDITIONELS

See attached draft document: "Quantitative Human Health and Ecological Risk Assessment, Correctional Service Canada Proposed Facility, Parcel 2013-1 of PID 4011 4084, Dartmouth, Nova Scotia - DRAFT REPORT"

This is for information purposes only.

QUANTITATIVE HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT CORRECTIONAL SERVICE CANADA PROPOSED FACILITY PARCEL 2013-1 OF PID 40114084 DARTMOUTH, NOVA SCOTIA

DRAFT REPORT

Prepared for:
Public Works & Government Services Canada
1713 Bedford Row
P.O. Box 2247
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Prepared by:
AMEC Environment & Infrastructure,
a division of AMEC Americas Limited
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August 2014

Project No. TV1412091

GLOSSARY OF TERMS

AEC	Area of Environmental Concern
AMEC	AMEC Environment & Infrastructure, a division of AMEC Americas Limited
CCME	Canadian Council of Ministers of the Environment
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CWS	Canada Wide Standard
d/wk	days per week
EDI	Estimated Daily Intake
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
kg	Kilogram
m	Metres
m^2	Square metres
mg/cm^2	milligrams per square centimetre
mg/kg	milligram per kilogram
$mg/kg\text{-}day^{-1}$	milligrams per kilogram bodyweight per day
PCBs	Polychlorinated Biphenyl
PHC	Petroleum Hydrocarbons
PQRA	Preliminary Quantitative Risk Assessment
RAF	Relative Absorption Factor
SQG	Soil Quality Guideline
SSTLs	Site-specific Target Level
TDI	Tolerable Daily Intake
TRV	Toxicity Reference Value
THQ	Target Hazard Quotient
UF	Uncertainty Factor
USEPA	United States Environmental Protection Agency

EXECUTIVE SUMMARY

AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC), was retained by Public Works and Government Services Canada (PWGSC) to conduct a Human Health and Ecological Risk Assessment (HHERA) at a proposed Correctional Service Canada (CSC) facility on Parcel 2013-1 (the Site), which is a portion of PID 40114084, in Dartmouth, Nova Scotia.

The Site is currently undeveloped but CSC plans to build a Community Correctional Center (CCC) on-site, which will consist of a building with an approximate area of 1,700 m^2 and exterior parking for 30 staff/visitors. A Phase II Environmental Site Assessment (ESA) was completed (AMEC, July 2014) to investigate the fill areas within the footprint of the proposed structure and parking areas.

During previous investigations, AMEC identified potential areas of environmental concern. Therefore, PWGSC requested an HHERA to evaluate if risk management was necessary for the Site. The HHERA program relied on surface information and analytical data collected by AMEC (2014) and used the prescribed Health Canada, CCME, and FCSAP methods to assess the risk to potential human and ecological receptors at the Site.

Human Health Risk Assessment

The HHRA identified a variety of potential receptors including an adult inmate, visitor, adult facility worker, and construction worker; however, the proposed development for the Site includes a building, paved parking area, concrete walkways, and landscaped areas (maintained lawn, flowers, shrubs, etc). It does not include areas of bare soil or planned recreationally attractive areas. Therefore, direct contact with impacted soil (the only active exposure pathway identified) is unlikely for the planned site use and identified receptors, with the exception of the construction worker.

Based on the results of the HHRA, substantive health risks to the identified receptor (construction workers) are not expected as a result of remaining trace metal concentrations in soil. It is assumed that the impacted fill material will be reworked, compacted and covered by the Site development (i.e., building, asphalt parking areas, concrete walkways, and landscaped areas).

The calculated Site-specific Target Level (SSTL) for and corresponding Site maximum are presented below.

TABLE ES-1 Human Health Risk Assessment Results

Receptor	Maximum Concentration (mg/kg)	SSTL (mg/kg) Construction Worker	Comment
Aluminum	19,000	190,000	Maximum is less than SSTL. Further assessment is not required for the Site.
Arsenic	61	127	Maximum is less than SSTL. Further assessment is not required for the Site.
Iron	33,000	146,000	Maximum is less than SSTL. Further assessment is not required for the Site.

Ecological Risk Assessment

For ecological receptors, the risk to ecological receptors from arsenic in soil in the area of the proposed building is negligible. The risk to aquatic receptors due to groundwater concentrations of mercury is low based on the distance to the Halifax Harbour and the low concentrations observed in groundwater. The area of the possible former garage exhibited concentrations of F4G greater than the CCME CWS for PHC (CCME 2008) based on soil contact; however, a qualitative assessment of the impacts concluded that risk to ecological receptors is unlikely.

Recommendations

As noted throughout the report, this assessment has been undertaken for the areas sampled within the Site only (the area of the proposed development and the area of the possible former garage), and on the basis of several assumptions regarding future construction, including:

- that the proposed facility will not use more of the PID than that identified as the Site (i.e., the currently cleared area of the Site),
- that the building will be constructed on the current area of infilling,
- that the assumptions regarding land use and potential receptors are valid, and
- that any areas not covered by the building footprint, asphalt parking, or concrete walkways will be landscaped (i.e., covered with clean topsoil and grass/flowers/shrubs, etc.) and that this cover will be maintained and not allowed to deteriorate.

Should these assumptions cease to be valid or should the anticipated land use change, the HHERA will need to be revisited.

No further environmental investigation is recommended for the Site at this time. Should off-site disposal of the fill be required, further assessment related to the NS CSR may be required and off-site disposal costs will be incurred.

It is noted that this risk assessment does not address any potential risks related to possible UXO on the Site and any further site work needs to be completed under UXO supervision.

A risk management plan has been prepared under separate cover.

The statements made in this Executive Summary are subject to the same limitations included in Section 5.0 (Closure), and are to be read in conjunction with the remainder of this report.

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APPENDICES

1.0 INTRODUCTION

AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC), was retained by Public Works and Government Services Canada (PWGSC) to conduct a Human Health and Ecological Risk Assessment (HHERA) at a proposed Correctional Service Canada (CSC) facility on Parcel 2013-1 (the Site) which is a portion of PID 40114084, in Dartmouth, Nova Scotia. The Site location is shown in Figures 1 and 2.

The Site is currently undeveloped but CSC plans to build a Community Correctional Center (CCC) on-site, which will consist of a building with an approximate area of 1,700 m^2 and exterior parking for 30 staff/visitors. A Phase II Environmental Site Assessment (ESA) was completed (AMEC, July 2014) to investigate the fill areas within the footprint of the proposed structure and parking areas. As most of the fill will have to be removed and/or reworked for geotechnical purposes, the purpose of the Phase II ESA was to characterize soil and groundwater concentrations of contaminants of potential concern (COPC) within the fill.

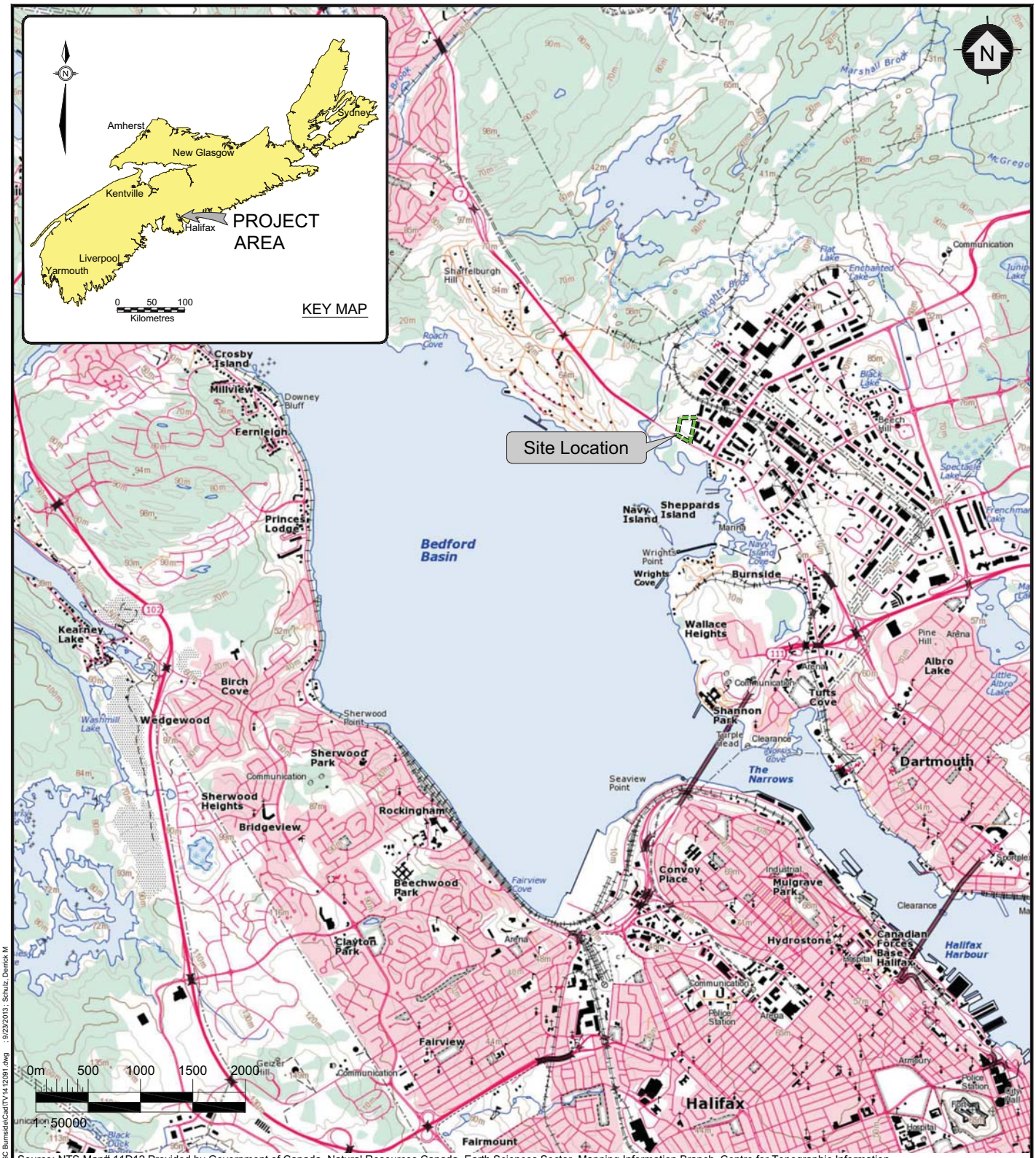
The purpose of this HHERA is to determine whether or not ecological or human health risks exist associated with residual chemical contamination identified on-Site and determine if risk management is required. This HHERA is based on accepted risk assessment standards including those published by Health Canada (HC 2010a, HC 2010b, and HC 2010c) and Environment Canada (EC, 2012a).

1.1 SITE DESCRIPTION AND HISTORY

The subject property is a 5.42 acre parcel (Parcel 2013-1), which is part of PID 40114084. Previous reports (with the exception of Gemtec [2013a, b] discussed in Section 1.3) have investigated all of PID 40114084. According to previous environmental investigations the property has been mainly undeveloped since at least 1931. There were two clearings along the south side of the property adjacent to Windmill Road and an area of infilling on the east side of the Site.

The Site is currently undeveloped and mostly wooded. The area of infilling on the east side of the Site is where the proposed building will be located. Trees and brush in the infilled area were removed as part of the Gemtec investigations in 2013. Access to the Site is via Morris Drive. There are currently two groundwater monitoring wells within the proposed area of development.

Overview of Site facing West



Source: NTS Map# 11D12 Provided by Government of Canada, Natural Resources Canada, Earth Sciences Sector, Mapping Information Branch, Centre for Topographic Information.

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CLIENT
PWGSC Environmental Services
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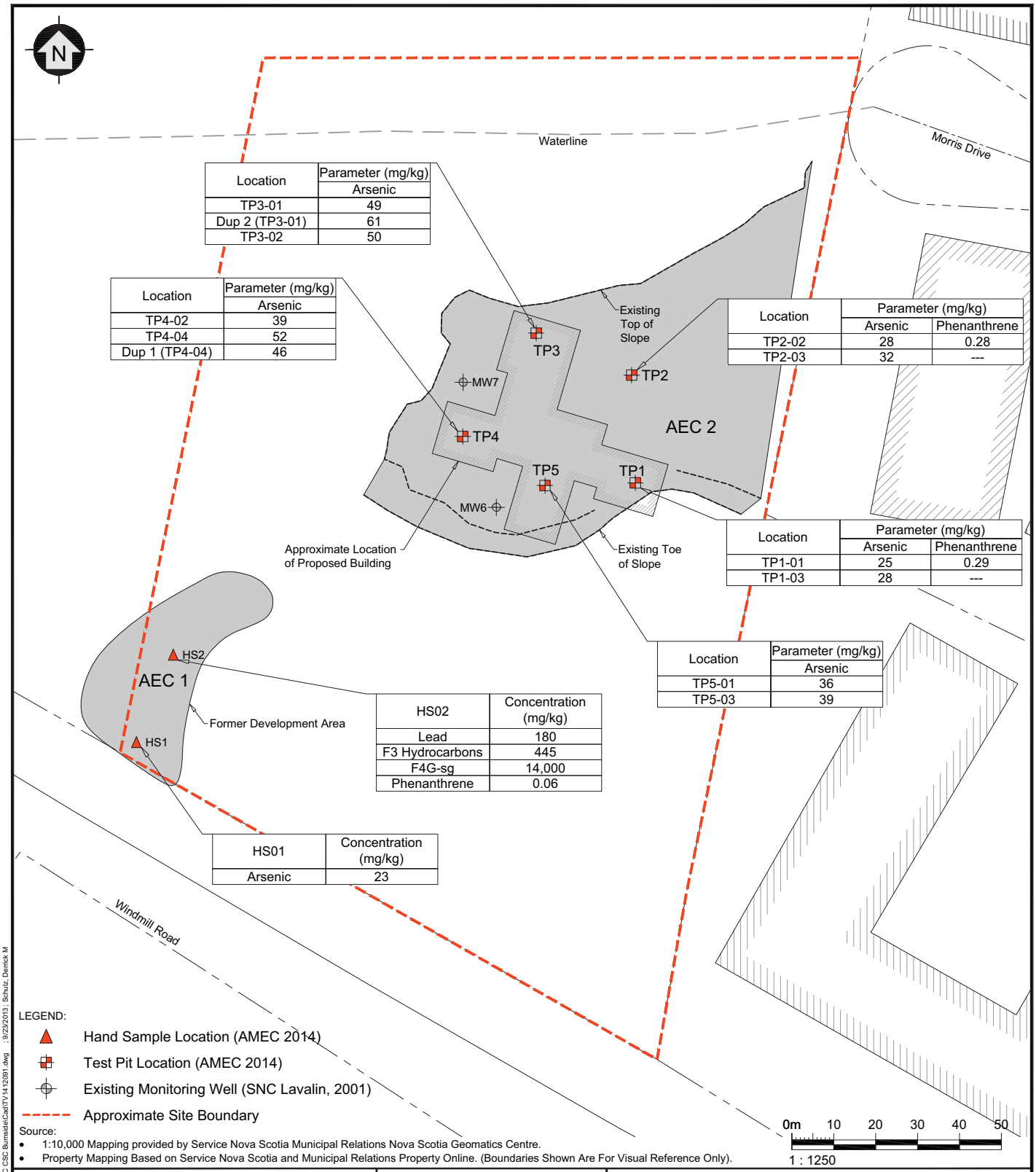
PROJECT
Human Health and Ecological Risk Assessment of Development Area

DWN BY:	PROJECTION:	DATE:
DS	UTM Zone 20	July 2014
CHK'D BY:	DATUM:	PROJECT NO:
BA	NAD83	TV1412091

TITLE
General Site Location

REV. NO.:	SCALE:	FIGURE No.
N/A	1:50,000	1

\\hfx1-fs1\projects\65300 PROJECTS\2014\TV1412091 PWGSC CSC Burnside\Cad\TV1412091.dwg : 9/23/2013 : Schultz, Derrick M



Location	Parameter (mg/kg)
	Arsenic
TP3-01	49
Dup 2 (TP3-01)	61
TP3-02	50

Location	Parameter (mg/kg)
	Arsenic
TP4-02	39
TP4-04	52
Dup 1 (TP4-04)	46

Location	Parameter (mg/kg)	
	Arsenic	Phenanthrene
TP2-02	28	0.28
TP2-03	32	---

Location	Parameter (mg/kg)	
	Arsenic	Phenanthrene
TP1-01	25	0.29
TP1-03	28	---

Location	Parameter (mg/kg)
	Arsenic
TP5-01	36
TP5-03	39

HS02	Concentration (mg/kg)
Lead	180
F3 Hydrocarbons	445
F4G-sg	14,000
Phenanthrene	0.06

HS01	Concentration (mg/kg)
Arsenic	23

LEGEND:

- Hand Sample Location (AMEC 2014)
- Test Pit Location (AMEC 2014)
- Existing Monitoring Well (SNC Lavalin, 2001)
- Approximate Site Boundary

Source:

- 1:10,000 Mapping provided by Service Nova Scotia Municipal Relations Nova Scotia Geomatics Centre.
- Property Mapping Based on Service Nova Scotia and Municipal Relations Property Online. (Boundaries Shown Are For Visual Reference Only).

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PROJECT

Human Health and Ecological Risk Assessment of Development Area

DWN BY:	PROJECTION:	DATE:
DS	UTM Zone 20	July 2014
CHK'D BY:	DATUM:	PROJECT NO:
BA	NAD83	TV1412091

TITLE

Metals, PHC, and PAH Exceedances in Soil (CCME)

REV. NO.:	SCALE:	FIGURE No.
N/A	1:1,250	2

1.1.1 Current and Future Land Use

Parcel 2013-1 was previously owned by the Department of National Defence (DND), as part of the lands of Canadian Forces Ammunition Depot (CFAD) Bedford and was acquired by CSC in 2013. The Site is currently undeveloped and the surrounding portions of the PID are treed. An underground water line is located to the north of the Site (shown on Figure 2). Access to the new CCC will be from Morris Drive. The proposed development will be constructed on the current area of infilling and is understood to consist of a building with paved parking, concrete walkways, and possibly some landscaped areas.

1.1.2 Adjoining Properties

The eastern portion of the Site has access to Burnside Industrial Park via Morris Drive. To the north, and west of the Site a mature forest (mainly 40 years old) with fairly dense underbrush exists. To the south of the Site a provincial highway (No. 7) and associated lands are present. The Bedford Basin is located approximately 250 m downgradient of the Site.

1.1.3 Water Supply/Groundwater Usage

There are no potable wells in use at Site (AMEC 2014, AMEC 2011). Potable water and sewage disposal for the CCC will be supplied by Halifax Regional Municipality. Two groundwater monitoring wells (MW6 and MW7) are currently installed at the Site and were sampled during the Phase II ESA (AMEC, 2014).

1.2 ASSESSMENT STANDARDS

The subject property is on federal land; therefore, the appropriate guidelines for soil and groundwater are the Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines (SQG) for the Protection of Environmental and Human Health (accessed on-line, August 2014) and Federal Interim Groundwater Quality Guidelines (FIGQG) for Federal Contaminated Sites (EC, 2012b). Where these were not available, the Ontario Ministry of the Environment's (OMOE) *Rationale for the Development of Soil and Ground Water Standards for use at Contaminated Sites in Ontario* were consulted.

The *Nova Scotia Contaminated Sites Regulations (NS CSR), Tier I Environmental Quality Standards* for non-potable, coarse grained soil sites were referenced, for off-site soil disposal considerations.

While the property is commercial in nature and located within an industrial park, it will house people on a fulltime (24/7) basis. Therefore, residential standards were selected as most appropriate for human health screening, while commercial guidelines were adopted for ecological health screening.

The *PAH and Metals Baseline Study of Soil and Bedrock in Metro Halifax and Surrounding Area* (Neill and Gunter, 2001) and the *Review of Environment Canada's Background Soil Database (2004-2009), Version No. 1* (Dillon, 2011) were also consulted for average background concentrations of polycyclic aromatic hydrocarbon (PAH) and metals in the Halifax area and in Atlantic Canada, respectively.

1.3 PREVIOUS INVESTIGATIONS

A review of previous investigations at the Site is discussed in the following reports:

- *Desktop Historical Review, Proposed Correctional Service Canada Facility, Dartmouth, Nova Scotia, Final Report*, prepared for PWGSC by AMEC, March, 2011 and
- *DRAFT Phase II Environmental Site Assessment, Correctional Service Canada Proposed Facility, Portion of PID 40114048, Dartmouth, Nova Scotia*, prepared for PWGSC by AMEC, July 2014.

Concerns identified in the historical review consisted of:

- Potential for unexploded ordnance (UXO) at the Site;
- Potential environmental concern associated with a possible garage located at the south side of the property (adjacent to Highway 7);
- Potential environmental concern associated with past dumpsite on the eastern edge of the property; and
- Potential environmental concern associated with debris noted throughout the area in past reports.

As discussed above, Gemtec undertook the following investigations on the property in 2013:

- *Geotechnical Investigation, Proposed Dartmouth CCC Facility, Dartmouth, NS.* Prepared for Defence Construction Canada by Gemtec, November 2013.
- *MEC (Munition or Explosive of Concern) Site Survey, Technical Support, and Specification Development, Dartmouth, NS*. Prepared for Defence Construction Canada by Gemtec, November 2013.

The Gemtec Geotechnical Investigation and MEC Site Survey reports assessed only the area of proposed development (the Site). The MEC report indicated that the Site could have been a dump area for boulders and surface soils from the local area, which would account for the type of fill present. The geotechnical report indicated that the fill material at the Site consisted of "miscellaneous construction material with boulders, metal, concrete with debris and organics". Fill material was noted to range from 1.9 to 3.5 meters thick.

A summary of the results of the findings of the Phase II ESA (AMEC, 2014) is provided below:

- No munitions or munitions scrap was identified during the field work by the UXO supervision team.
- Arsenic soil concentrations exceeded the CCME SQG across the site with concentrations ranging from 23 to 61 mg/kg. These values are greater than the average Halifax area background concentration (18 mg/kg).
- Lead in one hand sample exceeded the CCME SQG as well as the average Halifax area background concentration for lead (97 mg/kg)
- Hand sample location HS02 had concentrations of lead, F3 hydrocarbon, F4G, and phenanthrene exceeding CCME guidelines. The Petroleum Hydrocarbon (PHC) exceedances were noted to be in the lube oil range. HS02 was collected in the area of the possible former garage noted in the Historical Review (AMEC 2011). The identified impacts may be due to the historical use of the area as a garage.
- Phenanthrene was also present at concentrations greater than CCME guidelines at two test pit locations (TP1 and TP2). There were no other PAH exceedances in soil in the samples analyzed from the Site.
- There were no exceedances of applicable guidelines for VOCs in the soil samples analyzed from the Site.
- Groundwater concentrations of mercury at MW6 exceeded the FIGQG.

- There were no groundwater exceedances of the FIGQG for PHCs, PAHs, or VOCs in the samples analyzed from the Site.

It is noted that the data were also compared to the NS CSR Tier I Standards, for reference only, in the event off-site disposal (at a provincial facility) is required. Aluminum, arsenic, and iron concentrations in soil at several locations as well as lead and vanadium at single locations also exceeded the NS CSR standards. Additional treatment/disposal costs would be incurred, should this soil be moved off-site. There were no exceedances of the NS CSR for measured analytes in groundwater (noting that there are no CSR for trace metal parameters).

1.4 CONTAMINANT DISTRIBUTION

Based on the analytical data obtained to date (Tables 1 through 8, Appendix A), several parameters, including arsenic, lead, PHCs (F3 and F4G) and PAHs (phenanthrene) in soil exceeded the generic CCME CSG for human and ecological exposure. The distribution of soil exceedances within the areas assessed is presented on Figure 2.

1.5 OBJECTIVES

The purpose of this study is to evaluate potential human health and ecological risks associated with residual chemical contamination in soil and to identify if risk management for the Site is required. This will require analysis of exposure pathways and possible interactions with human and wildlife receptors to assess how the Site may affect humans and wildlife populations. To meet this objective, AMEC:

- Conducted a quantitative HHERA using the existing data (AMEC 2014); and
- Completed a report summarizing the findings.

This report does not evaluate potential risks that may have been present in the past; rather it is designed only to evaluate current and potential future exposures to chemical contaminants in soil. The risk assessment approach used to assess the data is discussed in the following sections.

2.0 HUMAN HEALTH RISK ASSESSMENT

This HHRA is conducted in accordance with current regulatory guidance documents, including:

- Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment, Version 2.0 (Health Canada, 2010a, revised 2012).
- Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values and Chemical Specific Factors, Version 2.0 (Health Canada, 2010b).
- Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment (Health Canada, 2010c).
- CCME Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006).

2.1 PROBLEM FORMULATION

The Problem Formulation step is an information gathering and interpretation stage that focuses the assessment on the primary areas of concern for the Site. The Problem Formulation step defines the nature and scope of the risk assessment, permits practical boundaries to be placed on the overall scope of work, and ensures that the HHRA is directed at the key areas and issues of concern related to Site activities.

2.1.1 Exposure Pathway Assessment

The exposure assessment evaluates the likelihood that potential hazards may come into contact with potential human receptors. The likelihood of exposure is determined through consideration of the properties of individual hazards that control chemical mobility, and the various pathways through which the hazard could move to contact the receptor, or through which the receptor could move to contact the hazard. The exposure analysis also considers the possible mechanisms through which a hazard can be introduced to a human receptor.

Exposure pathways are used to describe how a substance could move from the impacted media (soil, water, *etc*.) to a point where it can come in contact with the body. Only those pathways for which there is a reasonable potential for exposure were considered quantitatively in this risk assessment. The likelihood of exposure includes consideration of the duration and frequency of exposure to chemicals of potential concern. The exposure scenarios that have been considered for human receptors at the Site include:

- Ingestion/dermal contact with soil;
- Inhalation/ingestion/dermal contact with dust;
- Ingestion of vegetation or garden produce grown in impacted soil;
- Ingestion/dermal contact with surface water;
- Ingestion/dermal contact with groundwater; and
- Inhalation of vapours.

AMEC identified the likelihood that the on-Site receptors may be exposed to the identified hazards through the various exposure scenarios using a qualitative method. The likelihood of exposure is considered and evaluated in terms of the series of definitions presented in Table 1.

TABLE 1 Exposure Definitions

Likelihood of Exposure	Definition
Very Unlikely	Level of exposure that could result in adverse effects is not expected.
Unlikely	Level of exposure that could result in adverse effects would probably not occur.
Possible	Level of exposure that could result in adverse effects might be expected.
Likely	Level of exposure that could result in adverse effects is expected. Exceedance of this exposure level might be expected.

The relevant exposure pathways are summarized in Table 2, which includes the qualitative evaluation of each pathway and a justification for the likelihood of exposure assigned based on Site-specific conditions. The likelihood of exposure includes consideration of the duration and frequency of exposure to each potential hazard and to the relative concentrations to which the receptor is likely to be exposed. Those hazard-exposure-receptor combinations considered to have the highest likelihood to contribute a health risk are carried forward for further quantitative analysis.

TABLE 2 Potential Exposure Scenarios – Human Receptors

Exposure Pathway Description	Likelihood of Exposure	Carried Forward?	Justification
Ingestion of soil	Possible	**Yes**	Trace metal, hydrocarbon, and PAH impacts were identified in the soil. On-Site receptors may be exposed directly to the impacted soil.
Dermal contact with soil			
Inhalation of re-suspended dust	Possible	**Yes**	Trace metal, hydrocarbon, and PAH impacts were identified in the soil. On-Site receptors may inhale re-suspended dust. This pathway is typically included in the calculation of ingestion/dermal contact guidelines.
Ingestion of vegetation/garden produce grown in impacted soil	Very Unlikely	No	It is very unlikely that edible produce would be grown at this Site based on its current and foreseeable future use.
Dermal contact with/Ingestion of surface water	Very Unlikely	No	There are no surface water bodies on Site.
Ingestion of groundwater	Very Unlikely	No	There are no water supply wells on the Site. There is no current or anticipated future use of groundwater on the subject property for drinking water purposes.
Inhalation of vapours (indoors)	Very Unlikely	No	Trace metals are not considered volatile. In addition, the identified hydrocarbons and PAHs on-Site (F3, F4G, and phenanthrene) are not considered volatile.
Inhalation of vapours (outdoors)	Very Unlikely	No	

Therefore, ingestion of/dermal contact with contaminated soil and inhalation of re-suspended dust are carried forward as possible exposure pathways in the HHRA.

2.1.2 Receptor Identification

Existing and intended land use is an important factor in evaluating the potential exposures and estimating risk. It is important that the most protective assumptions are made about the potential receptors. Taking into account current Federal regulatory guidance on risk assessments and information on the planned use of the site, the following receptors are considered:

- Adult Inmates – the duration of stay for inmates at the facility ranges from 6 months to 10 years. Inmates are able to leave the facility during the day. The minimum age for residents of the facility is eighteen.

- Visitors – family members and friends may visit inmates daily for a maximum of four hours per day. Visitors from all age groups are possible (i.e., infant, toddler, child, teen and adults).
- Adult Worker (i.e., commissionaires and facility staff) – for the purposes of this risk assessment, it is assumed that the same adult worker may be present at the Site five days a week, 48 weeks per year.
- An adult construction worker could be exposed to impacted soil during the construction activities. It is assumed that the same construction worker may be present 5 days a week for 52 weeks per year for duration of 1 year.

While a variety of potential receptors are identified above (adult inmate, visitor, adult facility worker), the proposed development for the Site includes a building, paved parking area, concrete walkway(s), and likely some landscaped areas (maintained lawn, flowers, shrubs, etc.). It does not include areas of bare soil or planned recreationally attractive areas. Therefore, direct contact with impacted soil (the only active exposure pathway identified in Table 2) is unlikely for the planned site use and identified receptors, with the exception of the construction worker. It is assumed that following site re-working and development, clean topsoil will be placed on remaining areas of bare soil to create landscaped areas, which, along with any vegetation/plants will prevent incidental contact with the underlying fill.

2.1.3 Human Health Screening

The identified affected environmental medium is soil. For the human health screening, soil analytical data are compared to applicable human-health-specific guidelines. Typically, only surface soils are included in human health screenings, as this is what people would come into contact with. However, it is understood that the existing fill in the proposed area of construction is not geotechnically suitable for the proposed building and that re-working of this fill will likely be required. As it is possible that re-working will bring subsurface soils to the surface and that the existing fill may be placed anywhere on the site during and after construction, all existing soil data has been included in the screening.

The soil data selected for use in this risk assessment were compiled from the Phase II ESA (AMEC, 2014).

As presented in Tables 1 through 4, Appendix A, COPCs with concentrations in soil in excess of CCME SQGs include arsenic, lead, PHCs (F3 and F4G), and PAHs (phenanthrene). COPCs with concentrations in excess of NS CSR standards include aluminum, arsenic, iron, lead, and vanadium.

The maximum concentration and human health screening guideline for COPCs are displayed in Table 3a. The human health screening guideline for direct contact (soil ingestion and dermal contact) is presented, where available, based on the exposure pathway screening presented in Section 2.1.1. The HRM regional background soil concentration (BSC) and Atlantic region BSC (Dillon, 2011) are also provided, for reference.

TABLE 3a Human Health Screening of Soil for Direct Contact

Parameter	Maximum Concentration (mg/kg)	Background Soil (mg/kg)	Human Health Screening Guidelines (mg/kg)	Comment
Aluminum	19,000	NA[1]/14,606[2]	15,400[3]	**Maximum exceeds the human health screening guideline. Further**

TABLE 3a Human Health Screening of Soil for Direct Contact

Parameter	Maximum Concentration (mg/kg)	Background Soil (mg/kg)	Human Health Screening Guidelines (mg/kg)	Comment
				assessment required.
Arsenic	61	19[1]/4.27[2]	31[4]	**Maximum exceeds the human health screening guideline. Further assessment required.**
Iron	33,000	NA[1]/22,961[2]	11,000[3]	**Maximum exceeds the human health screening guideline. Further assessment required.**
Lead	180	97[1]/13.7[2]	140[5]	**Maximum exceeds the human health screening guideline. Further assessment required.**
Vanadium	71	31[1]/31[2]	39[3]	**Maximum exceeds the human health screening guideline. Further assessment required.**
F3	445	NA[1]/NA[2]	15,000[6]	Maximum concentration is below the human health screening guideline. No further assessment required.
F4	14,000	NA[1]/NA[2]	21,000[6]	Maximum concentration is below the human health screening guideline. No further assessment required
Phenanthrene	0.29	1.286[1]/0.07[2]	5[7]	Maximum concentration is below the CCME interim screening guideline. No further assessment required.

Notes:

1. Average till (Neil and Gunter, 2001)
2. Recommended Atlantic Region BSC (Dillon, 2011)
3. NS CSR
4. CCME SQG for 10^{-5} Incremental Lifetime Cancer Risk (ILCR).
5. CCME SQG
6. CCME CWS for PHC
7. CCME SQG – Interim, recommended by CCME when impacts to surface water bodies are not a concern.

Bold result indicates Max exceeds screening guidelines.

It is noted that the screening guidelines used in Table 3a are based on residential land use and are; hence, protective of toddlers. As discussed, the Site will consist of a building and paved parking area and it is unlikely that people, other than construction workers during the construction phase, will have direct contact with the remaining impacted soil. Neither CCME nor NS CSR incorporate a construction worker scenario into their commercial or industrial guideline development; however, the Ontario Ministry of the Environment's (OMOE) *Rationale for the Development of Soil and Ground water Standards for use at Contaminated Sites in Ontario* have derived guidelines specifically for construction workers:

> *"…a low-frequency, high-intensity, human health exposure scenario without children present that is protective of a worker digging in the soil. It is used for sub-surface soils at commercial/industrial/community sites. The soil value is calculated using TRVs and a soil ingestion, dermal exposure and particulate inhalation exposure model."*

The maximum measured soil concentrations are screened against OMOE construction worker guidelines in Table 3b.

TABLE 3b Human Health Screening of Soil (Construction Worker)

Parameter	Maximum Concentration (mg/kg)	Human Health Screening Guidelines[1] (mg/kg)	Comment
Aluminum	19,000	NG	No guideline available. Further assessment required.
Arsenic	61	47	**Maximum exceeds the human health screening guideline. Further assessment required.**
Iron	33,000	NG	No guideline available. Further assessment required.
Lead	180	1,000	Maximum meets the human health screening guideline. Further assessment not required.
Vanadium	71	160	Maximum meets the human health screening guideline. Further assessment not required.

Notes:
[1] OMOE Table 3 Full Depth, Non-potable Water Scenario, Commercial/Industrial land use, coarse-grained soil, S3 (construction worker) component value
Bold result indicates Max exceeds screening guidelines

As shown in Table 3b, arsenic exceeds its respective OMOE guideline, while there are no guidelines protective of construction workers for aluminum and iron. Therefore, these parameters are carried forward in the HHRA.

2.1.4 Human Health Conceptual Site Model

Based on the qualitative risk evaluation, the Conceptual Site model (CSM) developed for evaluating the quantitative exposure of the human receptor includes:

- Arsenic is present in the surface soil on the Site in concentrations exceeding human health soil contact guidelines for construction workers, who may be exposed to the impacted soil via ingestion, dermal contact, and dust inhalation throughout the construction period. There are no available guidelines protective of construction workers for aluminum and iron.

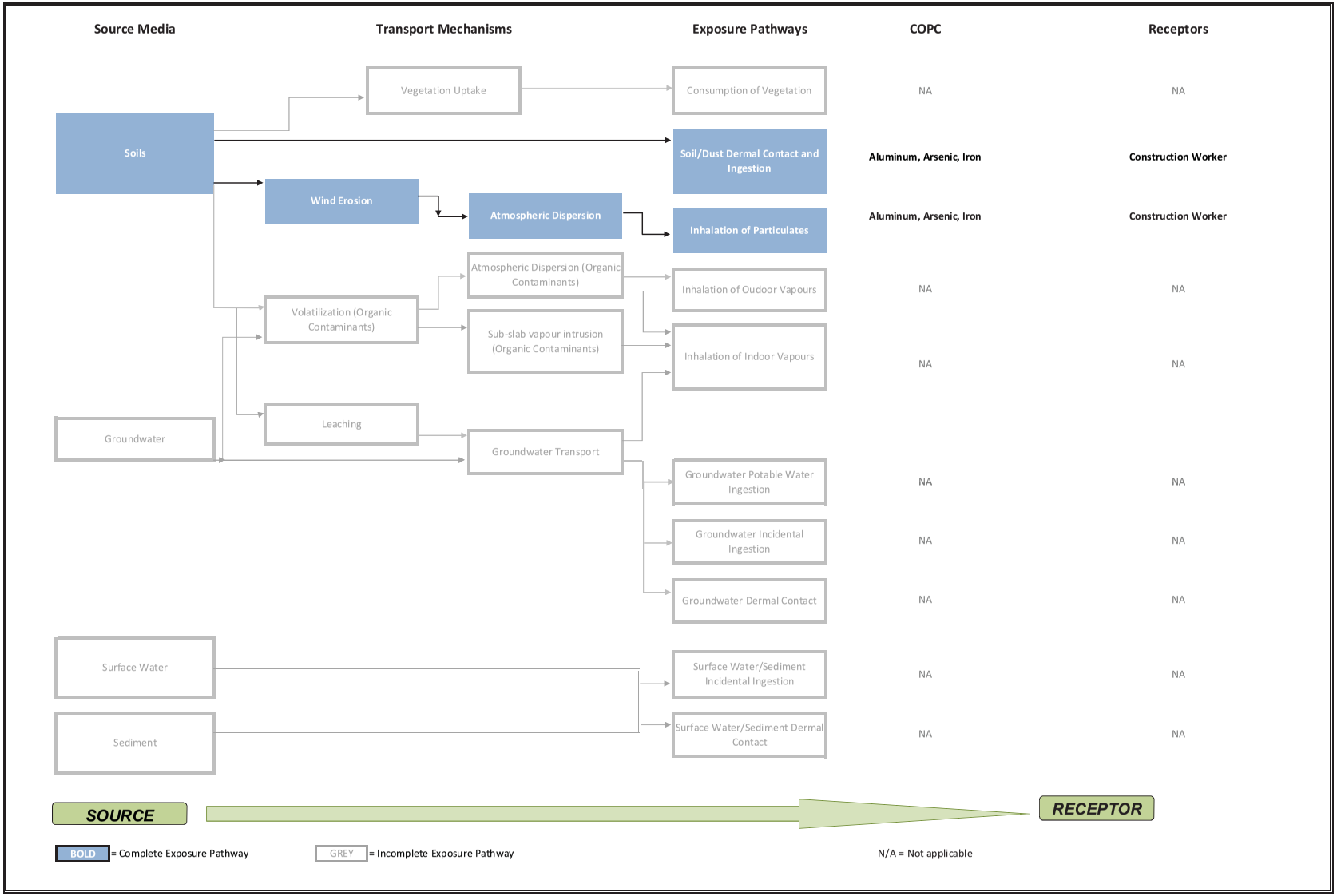
The CSM constructed for this HHRA is presented as Figure 3. The CSM provides a simplified representation of potential exposure pathways, linking COPC to each identified receptor.

2.2 EXPOSURE ASSESSMENT

2.2.1 Modelling Tools

AMEC used a risk assessment model based on Health Canada (2010a) to calculate the human health risk associated with aluminum, arsenic, and iron impacts identified in soil. The specific methods employed to develop the site-specific target levels (SSTLs) are consistent with CCME and Health Canada protocols and with standard HHRA methodologies. The equations used in the modelling of trace metal impacts are shown in the model input/output found in Appendix B.

Figure 3 Human Health Conceptual Site Model



2.2.2 Receptor Characteristics

Receptor characteristics are presented in Table 4. The important characteristics of the receptors (including body weight (BW), exposure duration, *etc*.) considered in the risk analysis are also presented in the input and output tables in Appendix B.

TABLE 4 Receptor Characteristics

Characteristic		Construction Worker
Exposure	D1 (hours per day exposed per 24 h/d)	10/24[1]
	D2 (days per week exposed per 7 d/wk)	5/7[1]
	D3 (weeks exposed per year)	52/52[1]
	D4 (years exposed to Site)	1[1]
BW	Body weight (kg)	70.7[2]
SIR	Soil ingestion rate (kg/d)	0.0001[2]
IR_{air}	Air inhalation rate (m^3/d)	14[2]
SR	Soil dermal contact rate (kg/d)	0.00114[2,3]
PM_{10}	Respirable Particulate Matter (ug/m^3)	250[2]
IR_{soil}	Soil inhalation rate (kg/d) (PM_{10} x IR_{air})/(1E9 ug/kg)	0.0000035[2,3]
SA_H	Skin surface area – Hands (cm^2)	890[2]
SA_O	Skin surface area – Other (arms) (cm^2)	2,500[2]
SL_H	Soil loading factor – Hands (kg/cm^2/event)	0.000001[2]
SL_O	Soil loading factor – Other (kg/cm^2/event)	0.0000001[2]
SR	Soil dermal contact rate (kg/d) [(SA_H x SL_H)+ (SAo x SL_O)]	0.00114[2,3]

[1] Assumed.
[2] Health Canada, PQRA Guidance, Part I (2010)
[3] Calculated

2.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is to identify the types of adverse health effects a chemical may potentially cause as well as the relationship between the magnitude of exposure (dose) and the likelihood of an adverse effect (response). This is called the dose-response relationship. In addition, toxicity assessment involves the classification of the potential toxicological effects of chemicals as carcinogenic or non-carcinogenic, and the subsequent estimation of the amounts of chemicals that can be received by human receptors without experiencing adverse effects on their health. A toxicity assessment is conducted for all COPCs that are screened into the assessment and considers possible modes of toxicity following different routes and durations of exposure. The toxicity assessment provides an estimate of how much chemical exposure may occur without unacceptable health effects occurring from lifetime exposure (or a significant portion of a lifetime) and provides the basis to interpret exposure rates.

Chemical compounds may exhibit different toxicological mechanisms of action depending on the route (i.e., ingestion, inhalation, dermal) of exposure. Different toxicological reference values (TRVs) are often provided for oral and inhalation exposure routes, depending on whether toxicity studies have been conducted and assessed for that route. In general, very few studies are available for dermal TRVs. For all compounds, the oral TRV value was adopted to represent the dermal TRV. The dermal exposure estimates were modified through the use of a Relative Absorption Factor (RAF) following guidance provided by Health Canada (2010b).

The characterization of potential hazards associated with carcinogenic and non-carcinogenic exposures is assessed separately, based on the differences in the way these two types of chemicals may produce effects in the body, as described below.

2.3.1 Non-Carcinogens

For non-carcinogenic COPC, it is assumed that there is a threshold dose or concentration below which there will not be an adverse effect. TRVs for non-carcinogenic COPC are based on point estimates from a range of quantitative dose-response data (e.g., no-observed-adverse-effect level [NOAEL], lowest-observed-adverse-effect level [LOAEL]). These point estimates are often divided by uncertainty factors to derive the final TRV or Reference Dose (RfD). Uncertainty factors can account for intra-species variability (e.g., individual sensitivity and variability), inter-species variability (if animal data are used), extrapolation from sub-chronic to chronic exposure durations, and use of LOAELs. In addition, modifying factors can be applied to reflect the quality of the toxicological database. The final non-carcinogenic TRV represents a dose or air concentration for a COPC at which adverse effects are not expected to occur in populations of humans for the duration of exposure specified. For the purposes of this risk assessment, aluminum and iron are considered non-carcinogenic.

2.3.2 Carcinogens

The underlying assumption of regulatory risk assessment for compounds with known or assumed potential carcinogenic effects is that no threshold dose exists. In other words, it is assumed that a finite level of risk is associated with any dose above zero. Theoretically, even a single molecule could cause some level of risk. For carcinogenic effects, a two-step evaluation is used, in which the compound is assigned a weight-of-evidence classification, and then a cancer slope factor (CSF) is calculated. The weight-of-evidence classification is based on the likelihood of a compound being a human carcinogen. For the purposes of this risk assessment, arsenic is considered a carcinogen.

2.3.3 Toxicity Reference Values (TRVs)

An essential part of the risk assessment is the identification of appropriate toxicity values. This is typically done by a literature review of published toxicological assessments. Toxicity values have been established by several agencies including Health Canada, the USEPA, and the World Health Organization (WHO). Preference has been given to Health Canada values and where these are not established, values from the USEPA's Integrated Risk Information System (IRIS) have been employed as the best basis upon which to evaluate health risks. Summaries of the toxicity values selected for inclusion in the risk assessment are provided in Table 5.

TABLE 5 Selected Toxicity Values

Chemical	TRV		Route of Exposure	Source Agency
Aluminum	1.00 mg/kg-day	RfD	Ingestion	US EPA Region III (2014) [1]
Arsenic	1.80 $(mg/kg\text{-}day)^{-1}$	CSF	Ingestion	Health Canada (2010b)
	27 $(mg/kg\text{-}day)^{-1}$	CSF	Inhalation	Health Canada (2010b)
Iron	0.70 mg/kg-day	RfD	Ingestion	US EPA Region III (2014) [1]

[1] Regional Screening Level (RSL) Resident Soil Table, May 2014. Original source = PPRTV Screen

2.3.4 Bioavailability

Bioavailability refers to "the fraction of the total amount of material in contact with a body portal-of-entry (lung, gut, skin) that enters the blood". For example, not all COPC present in soil may be absorbed through the gut. Relative bioavailability is the amount of a substance entering the blood via a particular route of exposure (*e.g.*, gastrointestinal) relative to the study used to derive the toxicity values. These factors are then applied in the risk assessment to more realistically represent the portion of contaminants held in soil that are available. For instance, a relative bioavailability factor of 0.5 indicates that 50% of the administered (*e.g.*, ingested) toxicant is absorbed into the bloodstream compared to the absorption in the toxicity study.

Soil ingestion can be a significant exposure pathway, especially for young children. Subsequent to ingestion, a portion of the COPC in soil is released and absorbed during the digestive process. This fraction that is released into the gastrointestinal tract is termed the "bioaccessible" fraction. The "bioavailable" fraction is the fraction of the COPC absorbed from the gastrointestinal tract and into the bloodstream.

COPC bioavailability from soil can be significantly lower than bioavailability from diet. Toxicity studies used to derive Toxicity Reference Values (TRVs) are typically based on administered doses in diet. The relative bioavailability via oral and inhalation routes of exposure is conservatively assumed to be equal to 1. The bioavailability factors used in this assessment are provided in Table 6 and were sourced from Health Canada (2010b). Relative dermal absorption factors were not available from health Canada (2010b), nor were values recommended in the US EPA RBC tables from which the screening guidelines and TRVs for aluminum and iron were sourced. Following Health Canada guidance (2010b), a dermal relative absorption factor of 1% was applied for aluminum and iron.

> *For several inorganics, the quantitative data were considered insufficient to estimate chemical-specific dermal absorption fractions. The value of 1% was assigned to these inorganics, based on an analysis of other inorganics deemed to have sufficient data.* .

TABLE 6 Bioavailability Factors

Chemical	Bioavailability Factor (or Relative Absorption Factor)		
	Oral	Dermal	Inhalation
Aluminum	1 [a]	0.01 [b]	1 [a]
Arsenic	1 [a]	0.03 [b]	1 [a]
Iron	1 [a]	0.01 [b]	1 [a]

[a] Assumed
[b] Health Canada (2010b).

2.4 RISK CHARACTERIZATION

Risk characterization compares the estimated exposures with the identified toxicity values for each substance to determine the potential for an adverse effect.

In determining the risk associated with soil-related exposures to total arsenic, the estimated dose multiplied by slope factors are compared to the established risk factors (i.e. 10^{-5}). Details of the equations and input parameter values used in the risk assessment are provided in Appendix B, including a sample calculation. The model results indicate that the risk to the potential human receptors were all below the 10^{-5} risk factor.

2.4.1 Human Health Risk Assessment Results

The calculated SSTLs and corresponding maximum concentrations are presented in Table 7. The risk assessment spreadsheets are provided in Appendix B.

TABLE 7 Human Health Risk Assessment Results

Receptor	Maximum Concentration (mg/kg)	SSTL (mg/kg) Construction Worker	Comment
Aluminum	19,000	190,000	Maximum is less than SSTL. Further assessment is not required for the Site.
Arsenic	61	127	Maximum is less than SSTL. Further assessment is not required for the Site.
Iron	33,000	146,000	Maximum is less than SSTL. Further assessment is not required for the Site.

As shown, maximum measured concentrations of COPC met their respective SSTLs for the identified human health receptors (construction worker). No further assessment is warranted with respect to human health at this time.

Note that soil with concentrations exceeding NS CSR guidelines has been identified at the site, which may require further assessment and disposal costs in the event off-site disposal is required.

2.5 UNCERTAINTY ANALYSIS

As a result of the scientific investigations, literature reviews, and risk assessment guidance that have been undertaken or followed in the preparation of this HHRA, it is believed that the risk assessment results present a reasonable, yet conservative, evaluation of the risk to human receptors present at the Site. Where uncertainty or lack of knowledge were encountered in the development of the risk estimates, reasonable, yet conservative, assumptions were made, or data were selected, in order to ensure that risks were not underestimated. A summary of the uncertainty analysis is provided in Appendix B.

3.0 ECOLOGICAL RISK ASSESSMENT

The purpose of this ERA is to evaluate the potential for ecological receptors to be harmed as a result of exposure to concentrations of COPCs found at the site. As with the HHRA, the ERA process follows a recognized framework that progresses from a qualitative initial phase (*i.e.*, problem formulation), through exposure and toxicity (effects) analysis, and culminates in a quantitative risk characterization. Following this framework, the limitations and uncertainties inherent in the ERA process, and the relevance of these limitations and uncertainties to the conclusions stemming from the assessment, are discussed. This ERA has been conducted in a manner consistent with accepted ERA methodologies and guidance published by regulatory agencies, including the CCME (1996; 1997), the USEPA (1998), and (FCSAP, 2010a, b and FCSAP 2012a,b).

3.1 PROBLEM FORMULATION

Problem formulation is the first step of risk assessment process and provides the framework upon which the ERA is developed. The problem formulation identifies the nature of issues associated with contamination at the site and the potential interaction between contaminants and ecological receptors (summarized by the ecological conceptual site model). The framework used for this ERA considered a qualitative evaluation of plant and soil invertebrate communities and effects at the population level for common mammals and birds, and at the individual level for species identified as endangered, threatened, or extirpated under the *Species at Risk Act* (SARA) or similar provincial legislation.

As there is no single set of ecological values or resources to be protected that can be generally applied to every site, the initial conceptual site model constructed for this site, which was based on a desktop review of the site and similar sites, was re-evaluated based on habitat and wildlife observed during site visits, as well as professional judgment.

3.1.1 Exposure Pathway Assessment

In order for chemicals to have deleterious effects, they need to gain access to the organism or receptor. The route by which this occurs is referred to as an exposure pathway, and is dependent on the nature of both the chemical and receptor. A complete exposure pathway is one that meets the following four criteria (USEPA, 1989):

- A source of COPC must be present;
- Transport mechanisms and media must be available to move the chemicals from the source to the ecological receptors;
- An opportunity must exist for the ecological receptors to contact the affected media; and
- A means must exist by which the chemical is taken up by ecological receptors, such as direct contact, ingestion or inhalation.

The relevant exposure pathways are summarized in Table 8 which includes a qualitative evaluation of each pathway and a discussion about whether the pathways are complete. Those complete hazard-exposure-receptor combinations considered to have the highest likelihood to contribute to an ecological health risk were carried forward in the ERA.

TABLE 8 Potential Exposure Pathways for Ecological Receptors

Exposure Pathway Description	Complete Pathway?	Carried Forward for Analysis?	Justification
Ingestion of soil	**Yes**	**Yes**	COPCs are present in surface and subsurface soils at the site. Although terrestrial receptors may come into contact with chemicals identified in surface soil, direct dermal contact is considered unlikely due to the presence of fur or feathers. However, ecological receptors may ingest soil through grooming or other related behaviors. As such, the ingestion of soil containing COPCs was considered further within this ERA.
Dermal contact with soil			
Ingestion of terrestrial invertebrates, vegetation, or small animal prey living at the site and exposed to contaminated soil	**Yes**	**Yes**	Terrestrial receptors on the site may ingest terrestrial invertebrates and terrestrial vegetation that are living at the site and have been exposed to the impacts in surface soil. Some receptors prey on small animals.
Contamination in soil leaching to aquatic environments	**Yes**	**Yes**	The Halifax Harbour is downgradient of the Site. Therefore, the soil leaching to marine aquatic receptors pathway was carried forward in the ERA.
Ingestion of surface water, freshwater, sediments, aquatic plants, invertebrates or fish	No	No	There are no surface water bodies on the Site.
Dermal contact with surface water or freshwater sediments			
Dermal contact with marine water or sediments	No	No	There are no surface water bodies on the Site.

3.1.2 Ecological screening

Ecological screening was conducted to identify potential chemical hazards to ecological health by comparing concentrations of COPCs to the CCME media specific criteria. The identified potentially affected environmental media are surface soil and groundwater. For the ERA screening, soil and groundwater analytical data are compared to applicable environmental guidelines. The soil and groundwater data selected for use in this risk assessment were compiled from the Phase II ESA (AMEC, 2014).

3.1.2.1 Soil

As presented in Tables 1 through 4, Appendix A, COPCs with concentrations in soil in excess of CCME SQGs include arsenic, lead, PHCs (F3 and F4G), and PAHs (phenanthrene). Note that a comparison to the NS CSR, completed for off-site disposal considerations has been discussed within the HHRA and only those COPC that exceed CCME SQGs are carried forward into the ERA screening.

The maximum soil concentration and ecological health screening guideline for COPCs are displayed in Table 9. The ecological health screening guideline for direct contact is presented, where available, based on the exposure pathway screening presented in Table 8.

TABLE 9 Ecological Health Screening of Soil

Parameter	Maximum Concentration (mg/kg)	Ecological Health Screening Guidelines (mg/kg)	Comment
Arsenic	61	26[1]	**Maximum exceeds the ecological health screening guideline. Further assessment required.**
Lead	180	600[1]	Maximum concentration is below the ecological health screening guideline. No further assessment required.
F3	445	1,700[2]	Maximum concentration is below the ecological health screening guideline. No further assessment required.
F4G	14,000	3,300[2]	**Maximum exceeds the ecological health screening guideline. Further assessment required.**
Phenanthrene	0.29	12[3]	Maximum concentration is below the ecological health screening guideline. No further assessment required.

Notes:
1. CCME SQG
2. CCME CWS for PHC, ecological soil contact
3. OMOE Table 3, Full Depth, Non-potable Water Scenario, coarse-grained soil, commercial/industrial land use, ecological soil contact

Bold result indicates Max exceeds screening guidelines.

In summary, arsenic in soil at the building site and PHC F4G in soil at the location of the possible former garage remain at concentrations above ecological screening guidelines and further assessment is required.

3.1.2.2 Groundwater

As presented in Tables 5 through 8, Appendix A, mercury concentrations in water exceed the FIGWQG. No exceedances of the NS CSR groundwater standards were noted. The maximum groundwater concentration and ecological health screening guideline for mercury are displayed in Table 10. The ecological health screening guideline for marine aquatic life is presented, based on the exposure pathway screening presented in Section 3.1.1

TABLE 10 Ecological Screening of Groundwater

Parameter	Maximum Concentration (µg/L)	Aquatic Life Criteria [1] (µg/L)	Comment
Mercury	0.08	0.016	The maximum measured concentration exceeds the guideline for MAL.

Notes:
1. FIGWQG, Environment Canada, 2012

Bold result indicates maximum exceeds screening guidelines.

The FIGWQG for mercury is the CCME surface water quality guideline for the protection of marine aquatic life (meant to be applied directly to surface water analyses or groundwater within 10m of the receiving body).

However, the FIGWQG states that:

"*For inorganic substances, the Canadian Water Quality guidelines for the Protection of Aquatic Life are applied directly to groundwater, due to the high level of variability in the behaviour of inorganic substances in groundwater and the lack of biodegradation of these substances ... For most contaminants, including petroleum hydrocarbons and metals, if there are no surface water bodies within 500 m then the contaminants are unlikely to reach surface water*"

As the harbour is located over 200 metres from the Site, it is likely that some attenuation and dilution of the COPC will take place prior to discharge into the receiving environment (the harbour) and that applying a surface water guideline directly to a groundwater source located over 200 m away is overly conservative. The OMOE publishes guidelines for non-potable groundwater, protective of aquatic receptors, based on a separation distance of 30 metres (site to surface water body). The OMOE groundwater guideline for mercury protective of aquatic life is $1.3x10^{13}$ µg/L (which is well above the solubility limit of 60 µg/L). The maximum measured mercury concentration at the Site (0.08 µg/L) is below this groundwater guideline and also below the Ontario background value of 0.1 µg/L. Additionally, the CCME MAL criterion for mercury (which was adopted as the FIGWQG) is based on a lowest observed adverse effect level (LOAEL) of 0.16 µg/L. The highest concentration of mercury observed in Site groundwater was 0.08 µg/L. Therefore, the risk to aquatic organisms in Halifax Harbour from existing mercury concentrations in Site groundwater is negligible. No further assessment of mercury in groundwater is required at this time.

3.1.3 Habitat Description

3.1.3.1 Proposed Building Area

As previously discussed, the area of the Site where the building will be constructed is highly disturbed, consisting of dumped fill that has been extensively test-pitted for the purposes of geotechnical, environmental, and UXO investigations. Following construction, this area will consist of a building, asphalt parking areas, and concrete walkway(s). While there will likely be landscaped areas (grass, flowers, shrubs) present, these areas will be man-made (using imported, clean top-soil) and maintained (or mowed) and as such, are not considered to represent functional ecological habitat. Therefore, for contact with contaminants in soil, there will be no plausible ecological exposure pathways present and no valuable ecological components (VECs) would be identified. Since there will be no functional habitat in this area of the Site, there are no complete exposure pathways and risk to VECs is negligible. Based on the future site development plans (i.e., building and asphalt parking over an in-filled area), no further evaluation of direct soil contact and assessment of terrestrial receptors is required. As such, exposure to remaining arsenic-impacted soil in this area is unlikely and is not considered further in this ERA.

3.1.3.2 Former Garage Area

The area of the site located at the south side of the property (adjacent to Highway 7), which is the location of the possible former garage, is wooded. Based on observations and a review of available land-based and aerial photographs taken of the site, the vegetative communities in this area of the Site appeared to be generally healthy. Soil invertebrates were observed

during soil sampling in this area. Therefore, significant adverse effects to plant and soil invertebrate communities in this area of the Site are not anticipated and plant and soil invertebrate communities appear functionally intact.

The only COPC that exceeded ecological screening guidelines in this area was F4G in one sample (HS02). Only low levels of PHC F1, F2, and F3 (i.e., all <CCME SQGs) were detected in the soil samples taken from this area. Ecological risks due to the reported F4G concentration in HS02 are considered unlikely for the following main reasons:

- The elevated concentration represents a small area of the contiguous habitat available on the remaining (undisturbed) portions of the Site and of the larger PID (i.e., the area beyond the Site). The primary focus of ERA is on risk at the population level. The F4G concentration in soil would affect the habitat of only a few individual birds or mammals, and would be unlikely to result in an adverse effect at the population level.

- The existing CCME CWS F4 guideline was calculated based on extrapolating the toxicity of whole crude oil (which contains lighter, more toxic components). CCME CWS (2008) states that "*Since the whole product contained appreciable portions of CWS fractions F1, F2 and F3 in addition to the heavier hydrocarbon fraction (including asphaltenes) found in F4, there is a strong likelihood that the actual observed toxicity thresholds would occur at higher soil concentrations had the test organisms been exposed to F4 alone"*. F4 is largely insoluble with low bioavailability and is unlikely to be substantially toxic to plants and soil invertebrates.

- The F4G laboratory method is a gravimetric determination (i.e., by weight) of all extractable organic material in the soil sample and is not specific to F4 nor to petroleum hydrocarbons. Sample HS02 was a highly organic sample from the forest floor; hence, the reported F4G concentration likely includes a significant portion of non-petrogenic hydrocarbons.

Therefore, potential risks to ecological receptors from the reported F4G concentration in HS02 are considered unlikely.

3.2 UNCERTAINTY ANALYSIS

As a result of the scientific investigations, literature reviews, and risk assessment guidance followed in the preparation of this ERA, it is believed that the risk assessment results present a reasonable yet conservative evaluation of the risk to ecological receptors present at the site. Where uncertainty or lack of knowledge were encountered in the development of the risk estimates, reasonable yet conservative assumptions were made, or data were selected, in order to ensure that risks were not underestimated. Uncertainties are inherent in every aspect of the ERA process. The most effective way to decrease uncertainty is to collect site-specific data. Application of site-specific information assists in reduction of uncertainty by allowing removal of generic data.

Despite incorporation of a considerable amount of site-specific data, the ERA incorporates assumptions that lead to uncertainty. Significant aspects of uncertainty inherent in this risk assessment are discussed qualitatively in Appendix C.

4.0 CONCLUSIONS AND RECOMMENDATIONS

AMEC completed a HHERA for two areas of potential environmental concern at the Site. The conclusions are summarized below.

4.1 CONCLUSIONS

The HHRA identified a variety of potential receptors including an adult inmate, visitor, adult facility worker, and construction worker; however, the proposed development for the Site includes a building, paved parking area(s), and concrete walkway(s), and landscaped areas (maintained lawn, flowers, shrubs, etc). It does not include areas of bare soil or planned recreationally attractive areas. Therefore, direct contact with impacted soil (the only active exposure pathway identified) is unlikely for the planned site use and identified receptors, with the exception of the construction worker. Based on the results of the HHRA, substantive health risks to the identified receptor (construction workers) are not expected as a result of remaining trace metal concentrations in soil. It is assumed that the impacted fill material will be reworked, compacted and covered by the Site development (i.e., building, asphalt parking area(s), concrete walkway(s), and landscaped areas).

For ecological receptors, the risk to ecological receptors from arsenic in soil in the area of the proposed building is negligible. The risk to aquatic receptors due to groundwater concentrations of mercury is low based on the distance to the Halifax Harbour and the low concentrations observed in groundwater. The area of the possible former garage exhibited concentrations of F4G greater than the CCME CWS for PHC (CCME 2008) based on soil contact; however, a qualitative assessment of the impacts concluded that risk to ecological receptors is unlikely.

4.2 RECOMMENDATIONS

As noted throughout the report, this assessment has been undertaken for the areas sampled within the Site only (the area of the proposed development and the area of the possible former garage), and on the basis of several assumptions regarding future construction, including:

- that the proposed facility will not use more of the PID than that identified as the Site (i.e., the currently cleared area of the Site),
- that the building will be constructed on the current area of infilling,
- that the assumptions regarding land use and potential receptors are valid, and
- that any areas not covered by the building footprint, asphalt parking, or concrete walkways will be landscaped (i.e., covered with clean topsoil and grass/flowers/shrubs, etc.) and that this cover will be maintained and not allowed to deteriorate.

Should these assumptions cease to be valid or should the anticipated land use change, the HHERA will need to be revisited.

No further environmental investigation is recommended for the Site at this time. Should off-site disposal of the fill be required, further assessment related to the NS CSR may be required and off-site disposal costs will be incurred.

It is noted that this risk assessment does not address any potential risks related to possible UXO on the Site and any further site work needs to be completed under UXO supervision.

A risk management plan has been prepared under separate cover.

5.0 CLOSURE

This report was prepared for the exclusive use of Public Works and Government Services Canada and Correctional Service Canada, and is intended to provide a human health and ecological risk assessment for the Site. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of the third party. Should additional parties require reliance on this report, written authorization from AMEC will be required. With respect to third parties, AMEC has no liability or responsibility for losses of any kind whatsoever, including direct or consequential financial effects on transactions or property values, or requirements for follow-up actions and costs.

The report is based on data and information collected during the investigations (AMEC 2011, AMEC 2014, Gemtec 2013a and Gemtec 2013b) of the property. It is based solely on a review of historical information and data obtained by AMEC as described in this report, and discussion with a representative of the owner/occupant, as reported herein. Except as otherwise maybe specified, AMEC disclaims any obligation to update this report for events taking place, or with respect to information that becomes available to AMEC after the time during which AMEC completes the HHERA.

In evaluating the property, AMEC has relied in good faith on information provided by other individuals noted in this report. AMEC has assumed that the information provided is factual and accurate. In addition, the findings in this report are based, to a large degree, upon information provided by the current owner/occupant. AMEC accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations or fraudulent acts of persons interviewed or contacted.

AMEC makes no other representations whatsoever, including those concerning the legal significance of its findings, or as to other legal matters touched on in this report, including, but not limited to, ownership of any property, or the application of any law to the facts set forth herein. With respect to regulatory compliance issues, regulatory statutes are subject to interpretation and change. Such interpretations and regulatory changes should be reviewed with legal counsel. This Report is also subject to the further Standard Limitations contained in Appendix D.

We trust that the information presented in this report meets your current requirements. Should you have any questions, or concerns, please do not hesitate to contact the undersigned.

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APPENDIX A

ANALYTICAL DATA AND LABORATORY CERTIFICATES OF ANALYSIS

TABLE 1 METALS IN SOIL
(All units in mg/kg)

		Sample ID	TP1-01	TP1-03	TP2-02	TP2-03	TP3-01	DUP2 (Duplicate of TP3-01)	TP3-02	TP4-02
		Sample Depth	0.3	2	1.0	2	0.3		1.0	1
		Date Sampled	9-Jun-14	9-Jun-14	9-Jun-14	9-Jun-14	9-Jun-14	9-Jun-14	9-Jun-14	9-Jun-14
Parameters	**CCME SQG[a] Residential / Parkland**	**NS CSR[b]**								
Acid Extractable Aluminum (Al)	NGA	15,400	**17,000**	**19,000**	**18,000**	12,000	15,000	**16,000**	**17,000**	15,000
Acid Extractable Antimony (Sb)	20	7.5	<2	<2	<2	<2	<2	<2	<2	<2
Acid Extractable Arsenic (As)	12	31	25	28	28	**32**	**49**	**39**	**50**	**39**
Acid Extractable Barium (Ba)	500	10,000	43	50	38	26	25	28	26	20
Acid Extractable Beryllium (Be)	4	38	<2	<2	<2	<2	<2	<2	<2	<2
Acid Extractable Bismuth (Bi)	NGA	NGA	<2	<2	<2	<2	<2	<2	<2	<2
Acid Extractable Boron (B)	NGA	4,300	<50	<50	<50	<50	<50	<50	<50	<50
Acid Extractable Cadmium (Cd)	10	14	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Acid Extractable Chromium (Cr)	64	220	23	24	23	18	20	21	21	20
Acid Extractable Cobalt (Co)	50	22	12	12	13	10	11	12	12	11
Acid Extractable Copper (Cu)	63	1,100	35	33	35	27	24	27	24	25
Acid Extractable Iron (Fe)	NGA	11,000	**31,000**	**33,000**	**32,000**	**25,000**	**27,000**	**28,000**	**28,000**	**27,000**
Acid Extractable Lead (Pb)	140	140	88	110	78	55	34	38	35	30
Acid Extractable Lithium (Li)	NGA	NGA	26	26	26	21	22	24	23	23
Acid Extractable Manganese (Mn)	NGA	NGA	590	550	650	500	600	620	590	630
Acid Extractable Mercury (Hg)	6.6	6.6	0.1	0.2	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Acid Extractable Molybdenum (Mo)	10	110	<2	<2	<2	<2	<2	<2	<2	<2
Acid Extractable Rubidium (Rb)	NGA	NGA	28	27	27	24	25	26	26	25
Acid Extractable Nickel (Ni)	50	330	11	10	9	8	8	9	10	8
Acid Extractable Selenium (Se)	1	80	<1	<1	<1	<1	<1	<1	<1	<1
Acid Extractable Silver (Ag)	20	77	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Acid Extractable Strontium (Sr)	NGA	9,400	11	12	10	11	11	11	12	8
Acid Extractable Thallium (Tl)	1	1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Acid Extractable Tin (Sn)	50	9,400	9	12	6	9	<2	<2	<2	<2
Acid Extractable Uranium (U)	23	23	0.7	0.7	0.8	0.6	0.6	0.6	0.6	0.6
Acid Extractable Vanadium (V)	130	39	24	22	21	16	19	20	20	17
Acid Extractable Zinc (Zn)	200	5,600	140	110	110	77	87	94	92	82

General Notes:
(a) CCME Soil Quality Guidelines (SQG), Residential Land Use (Updated to 2012)
(b) Nova Scotia Contaminated Sites Regulations - Residential/Parkland land use, Coarse grained soil. July 6, 2013.
NC = Not Calculated, NGA = No Guideline Available
Shaded = Exceedance of CCME SQG
Bold Underlined = Exceedance of NS CSR

TABLE 1 METALS IN SOIL
(All units in mg/kg)

		Sample ID	TP4-04	DUP1 (Duplicate of TP4-04)	TP5-01	TP5-03	HS01	HS02
		Sample Depth	3.0	3.0	0.3	2.0	0.3	0.3
		Date Sampled	10-Jun-14	10-Jun-14	9-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14
Parameters	**CCME SQG[a] Residential / Parkland**	**NS CSR[b]**						
Acid Extractable Aluminum (Al)	NGA	15,400	**18,000**	**17,000**	**16,000**	15,000	11,000	2,600
Acid Extractable Antimony (Sb)	20	7.5	<2	<2	<2	<2	<2	<2
Acid Extractable Arsenic (As)	12	31	**52**	**46**	**36**	**61**	23	4
Acid Extractable Barium (Ba)	500	10,000	30	23	30	22	7	47
Acid Extractable Beryllium (Be)	4	38	<2	<2	<2	<2	<2	<2
Acid Extractable Bismuth (Bi)	NGA	NGA	<2	<2	<2	<2	<2	<2
Acid Extractable Boron (B)	NGA	4,300	<50	<50	<50	<50	<50	<50
Acid Extractable Cadmium (Cd)	10	14	<0.3	<0.3	<0.3	<0.3	<0.3	0.4
Acid Extractable Chromium (Cr)	64	220	23	22	21	19	6	5
Acid Extractable Cobalt (Co)	50	22	14	14	12	12	<1	<1
Acid Extractable Copper (Cu)	63	1,100	32	30	38	26	2	29
Acid Extractable Iron (Fe)	NGA	11,000	**30,000**	**29,000**	**31,000**	**26,000**	11,000	4,500
Acid Extractable Lead (Pb)	140	140	39	33	62	25	4.2	**180**
Acid Extractable Lithium (Li)	NGA	NGA	26	25	25	23	<2	<2
Acid Extractable Manganese (Mn)	NGA	NGA	920	730	630	550	24	48
Acid Extractable Mercury (Hg)	6.6	6.6	<0.1	<0.1	0.1	<0.1	<0.1	0.2
Acid Extractable Molybdenum (Mo)	10	110	<2	<2	<2	<2	<2	<2
Acid Extractable Rubidium (Rb)	NGA	NGA	30	28	28	25	<2	10
Acid Extractable Nickel (Ni)	50	330	9	8	9	7	2	4
Acid Extractable Selenium (Se)	1	80	<1	<1	<1	<1	<1	<1
Acid Extractable Silver (Ag)	20	77	<0.5	<0.5	<0.5	<0.5	<0.5	0.6
Acid Extractable Strontium (Sr)	NGA	9,400	10	10	12	8	<5	10
Acid Extractable Thallium (Tl)	1	1	0.1	<0.1	0.1	<0.1	<0.1	0.1
Acid Extractable Tin (Sn)	50	9,400	<2	<2	3	<2	<2	3
Acid Extractable Uranium (U)	23	23	0.7	0.7	0.6	0.5	0.3	0.2
Acid Extractable Vanadium (V)	130	39	19	18	18	15	**71**	26
Acid Extractable Zinc (Zn)	200	5,600	95	90	110	76	7	23

General Notes:
(a) CCME Soil Quality Guidelines (SQG), Residential Land Use (Updated to
(b) Nova Scotia Contaminated Sites Regulations - Residential/Parkland lanc
NC = Not Calculated, NGA = No Guideline Available
Shaded = Exceedance of CCME SQG
Bold Underlined = Exceedance of NS CSR

TABLE 2: PETROLEUM HYDROCARBONS IN SOIL
(All units in mg/kg)

			Sample ID	TP1-01	TP2-02	TP3-02	TP4-04	DUP1 (Duplicate of TP4-04)	TP5-03	HS01	HS02
			Depth (m)	0.3	1.0	1.0	3.0	3.0	2.0	0.3	0.3
			Date Sampled	9-Jun-14	9-Jun-14	9-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14
Parameters	**CCME SQG[a]**	**CWS[b]**	**NS CSR[c]**								
Benzene	0.03	---	0.099	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Toluene	0.37	---	77	0.08	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Ethylbenzene	0.082	---	30	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Xylene (Total)	11	---	8.8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
C6 - C10 (less BTEX)	NGA	30 (F1)	NGA	<3	<3	<3	<3	<3	<3	<3	<3
>C10-C16 Hydrocarbons	NGA	150 (F2)	NGA	<10	<10	<10	<10	<10	<10	<10	<10
>C16-C21 Hydrocarbons	NGA	300 (F3)	NGA	<10	<10	<10	<10	<10	<10	<10	65
>C21-<C32 Hydrocarbons	NGA		NGA	56	26	27	<20	<20	<20	35	380
Modified TPH (Tier1)	NGA	---	1,100	56	26	27	<20	<20	<20	35	440
Reached Baseline at C32	N/A	N/A	N/A	Yes	Yes	Yes	NA	NA	NA	Yes	No
F4G-sg (Grav. Heavy Hydrocarbons)	---	2800	---	---	---	---	---	---	---	---	14,000
Hydrocarbon Resemblance	N/A	N/A	N/A	Lube oil fraction	Lube oil fraction	Lube oil fraction	NA	NA	NA	Lube oil fraction	Lube oil fraction

General Notes:

(a) CCME Canadian Soil Quality Guidelines (CCME, 2013), Residential/Parkland, Surface Soil, Coarse Grained Soil. The CCME human health based guidelines shown for benzene are based on a target cancer risk of 10^{-5}, consistent with Health Canada and Atlantic Canada Regulators recommendations. To be conservative surface soil criteria have been applied to both surface and subsurface soil samples, in the event that the soil at the site becomes reworked (ie. test pitting, excavation etc.).

(b) CCME Canada Wide Standards for Petroleum Hydrocarbons in Soil, User Guidance (CCME, 2008)Coarse-Grained Surface Soils, Residential/Parkland Land Use To be conservative surface soil criteria have been applied to both surface and subsurface soil samples, in the event that the soil at the site becomes reworked (ie. test pitting, excavation etc.).

(c) Nova Scotia Contaminated Sites Regulations - Residential/Parkland land use, Coarse grained soil. July 6, 2013.

NGA = No Guideline Available
N/A = Not Applicable
Shaded = Exceedance of CCME
Bold Underlined = Exceedance of NS CSR

TABLE 3: PAHs IN SOIL
(All units in mg/kg)

			Sample ID	TP1-01	TP2-02	TP3-02	TP4-04	DUP1 (Duplicate of TP4-04)	TP5-03	HS01	HS02
			Depth (m)	0.3	1.0	1.0	3.0	3.0	2.0	0.3	0.3
			Date Sampled	9-Jun-14	9-Jun-14	9-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14
	CCME PEFs (for B(a)P TPE	**CCME SQG[a] Environmental Health**	**NS CSR [b]**								
1-Methylnaphthalene	N/A	NGA	72	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methylnaphthalene	N/A	NGA	72	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthene	N/A	NGA	3,900	0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	N/A	NGA	4.5	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	N/A	2.5	24,000	0.08	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benz(a)anthracene	0.1	1	NGA	0.21	0.18	0.01	<0.01	<0.01	<0.01	<0.01	0.03
Benzo(a)pyrene	1	20	NGA	0.24	0.21	0.01	<0.01	<0.01	<0.01	<0.01	<0.08
Benzo(b)fluoranthene	0.1	1	NGA	0.19	0.17	0.01	<0.01	0.01	<0.01	<0.01	<0.04
Benzo(g,h,i)perylene	0.01	NGA	NGA	0.14	0.13	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(j)fluoranthene	0.1	NGA	NGA	0.13	0.11	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	0.1	1	NGA	0.12	0.10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.01	NGA	NGA	0.20	0.18	0.02	<0.01	0.01	<0.01	<0.01	0.04
Dibenz(a,h)anthracene	1	1	NGA	0.04	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	N/A	50	3,500	0.42	0.39	0.03	<0.01	<0.01	0.01	<0.01	0.07
Fluorene	N/A	NGA	2,700	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	0.1	1	NGA	0.13	0.12	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	N/A	0.013 (0.6)[d]	2.2	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Perylene	N/A	NGA	NGA	0.06	0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	N/A	0.046 (5)[e]	NGA	0.29	0.28	0.02	<0.01	<0.01	<0.01	<0.01	0.06
Pyrene	N/A	10	2,100	0.36	0.32	0.03	<0.01	<0.01	<0.01	<0.01	0.05
B(a)P Total Potency Equivalents (TPE) [c]	N/A	5.3	NGA	0.3614	0.3211	0.0188	0.0126	0.0132	0.0126	0.0126	0.0520

General Notes:

(a) CCME = Canadian Council of Ministers of the Environment (CCME), Canadian Soil Quality Guidelines, Polycyclic Aromatic Hydrocarbons Commercial or Residential land use, 2008, revised 2010. CCME 1991 interim guidelines have been applied to applicable parameters for environmental health, soil contact pathway.

(b) Nova Scotia Contaminated Sites Regulations - Residential/Parkland land use, Coarse grained soil. July 6, 2013.

(c) Benzo(a) Pyrene Total Potency (B(a)P TPE) is the sum of estimated cancer potency relative to all B(a)P for all potentially carcinogenic unsubstituted PAHs. The B(a)P TPE for a soil sample is calculated by multiplying the concentration of each PAH in the sample by its B(a)P Potency Equivalent Factor (PEF), as indicated above, and summing the products. Where results are <RDL, 1/2 the RDL was used in the B(a)P TPE calculation.

(d) 1997 provisional SQG_E for use if surface water is not a concern at the Site.

(e) 1991 Interim soil quality guideline for use if surface water is not a concern at the Site.

NGA = No guideline available

Shaded = Exceedance of CCME SQG

Bold Underlined = Exceedance of NS CSR

TABLE 4: VOCs IN SOIL
(All units in µg/kg)

		Sample ID	TP1-01	TP2-02	TP3-02	TP4-04	DUP1 (Duplicate of TP4-04)	TP5-03	HS01	HS02
		Sample Depth (m)	0.3	1.0	1.0	3.0	3.0	2.0	0.3	0.3
		Date Sampled	9-Jun-14	9-Jun-14	9-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14	10-Jun-14
Parameters	**CCME SQG[a]**	**NS CSR [b]**								
1,1,1-Trichloroethane	5,000	380	<30	<30	<30	<30	<30	<30	<30	<30
1,1,2,2-Tetrachloroethane	5,000	NGA	<30	<30	<30	<30	<30	<30	<30	<30
1,1,2-Trichloroethane	5,000	300	<30	<30	<30	<30	<30	<30	<30	<30
1,1-Dichloroethane	5,000	3,500	<30	<30	<30	<30	<30	<30	<30	<30
1,1-Dichloroethylene	5,000	50	<30	<30	<30	<30	<30	<30	<30	<30
1,2-Dichlorobenzene	1,000	10,000	<30	<30	<30	<30	<30	<30	<30	<30
1,2-Dichloroethane	5,000	50	<30	<30	<30	<30	<30	<30	<30	<30
1,2-Dichloropropane	5,000	50	<30	<30	<30	<30	<30	<30	<30	<30
1,3-Dichlorobenzene	1,000	420,000	<30	<30	<30	<30	<30	<30	<30	<30
1,4-Dichlorobenzene	1,000	670	<30	<30	<30	<30	<30	<30	<30	<30
Methyl t-butyl ether (MTBE)	NGA	50	<30	<30	<30	<30	<30	<30	<30	<30
Benzene	30	99	<30	<30	<30	<30	<30	<30	<30	<30
Bromodichloromethane	NGA	NGA	<30	<30	<30	<30	<30	<30	<30	<30
Bromoform	NGA	2,700	<30	<30	<30	<30	<30	<30	<30	<30
Bromomethane	NGA	50	<50	<50	<50	<50	<50	<50	<50	<50
Carbon Tetrachloride	5,000	50	<30	<30	<30	<30	<30	<30	<30	<30
Chlorobenzene	1,000	50	<30	<30	<30	<30	<30	<30	<30	<30
Chloroethane	NGA	NGA	<200	<200	<200	<200	<200	<200	<200	<200
Chloroform	5,000	50	<50	<50	<50	<50	<50	<50	<50	<50
cis-1,2-Dichloroethylene	5,000	3,400	<30	<30	<30	<30	<30	<30	<30	<30
cis-1,3-Dichloropropene	5,000	1,700	<30	<30	<30	<30	<30	<30	<30	<30
Dibromochloromethane	NGA	270	<30	<30	<30	<30	<30	<30	<30	<30
Ethylbenzene	82	30,000	<30	<30	<30	<30	<30	<30	<30	<30
o-Xylene	11,000	8,800	<30	<30	<30	<30	<30	<30	<30	<30
p+m-Xylene			<30	<30	<30	<30	<30	<30	<30	<30
Ethylene Dibromide	NGA	50	<30	<30	<30	<30	<30	<30	<30	<30
Methylene Chloride(Dichloromethane)	5,000	710	<30	<30	<30	<30	<30	<30	<30	<30
Styrene	5,000	16,000	<30	<30	<30	<30	<30	<30	<30	<30
Tetrachloroethylene	200	160	<30	<30	<30	<30	<30	<30	<30	<30
Toluene	370	77,000	<30	<30	<30	<30	<30	<30	<30	<30
Total Xylenes	11,000	8,800	<50	<50	<50	<50	<50	<50	<50	<50
trans-1,2-Dichloroethylene	5,000	84	<30	<30	<30	<30	<30	<30	<30	<30
trans-1,3-Dichloropropene	5,000	1,700	<30	<30	<30	<30	<30	<30	<30	<30
Trichloroethylene	10	360	<10	<10	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane (FREON 11)	NGA	NGA	<30	<30	<30	<30	<30	<30	<30	<30
Vinyl Chloride	NGA	20	<20	<20	<20	<20	<20	<20	<20	<20
1,3-Dichloropropene (cis+trans)	NGA	1,700	<25	<25	<25	<25	<25	<25	<25	<25

General Notes:

(a) CCME Soil Quality Guidelines (SQG), Residential Parkland Land Use (Updated to 2012).

(b) Nova Scotia Contaminated Sites Regulations - Residential/Parkland land use, Coarse grained soil. July 6, 2013.

NC = Not Calculated, NGA = No Guideline Available

Shaded = Exceedance of CCME SQG

Bold Underlined = Exceedance of NS CSR

TABLE 5: METALS IN GROUNDWATER
(All units in µg/L)

	Sample ID	MW6	MW7
	Date Sampled	6-Jun-14	6-Jun-14
Parameters	**FIGWQG[a]**		
Dissolved Aluminum (Al)	NGA	14	53
Dissolved Antimony (Sb)	NGA	<1.0	<1.0
Dissolved Arsenic (As)	12.5	<1.0	<1.0
Dissolved Barium (Ba)	500 [b]	29	30
Dissolved Beryllium (Be)	100 [b]	<1.0	<1.0
Dissolved Bismuth (Bi)	NGA	<2.0	<2.0
Dissolved Boron (B)	5000 [b]	<50	<50
Dissolved Cadmium (Cd)	0.12	0.051	0.12
Dissolved Calcium (Ca)	NGA	32000	30000
Dissolved Chromium (Cr)	56	<1.0	3.0
Dissolved Cobalt (Co)	NGA	<0.40	<0.40
Dissolved Copper (Cu)	2 [b]	<2.0	<2.0
Dissolved Iron (Fe)	NGA	<50	<50
Dissolved Lead (Pb)	2 [b]	<0.50	<0.50
Dissolved Magnesium (Mg)	NGA	3300	3000
Dissolved Manganese (Mn)	NGA	<2.0	44
Total Mercury (Hg)	0.016	0.080	0.023
Dissolved Molybdenum (Mo)	NGA	<2.0	<2.0
Dissolved Nickel (Ni)	83 [b]	<2.0	<2.0
Dissolved Phosphorus (P)	NGA	<100	<100
Dissolved Potassium (K)	NGA	2600	2100
Dissolved Selenium (Se)	54 [b]	<1.0	<1.0
Dissolved Silver (Ag)	1.5 [b]	<0.10	<0.10
Dissolved Sodium (Na)	NGA	230000	160000
Dissolved Strontium (Sr)	NGA	110	97
Dissolved Thallium (Tl)	NGA	<0.10	<0.10
Dissolved Tin (Sn)	NGA	<2.0	<2.0
Dissolved Titanium (Ti)	NGA	<2.0	<2.0
Dissolved Uranium (U)	NGA	<0.10	<0.10
Dissolved Vanadium (V)	NGA	<2.0	<2.0
Dissolved Zinc (Zn)	10 [b]	<5.0	5.6

General Notes:

(a) Federal Interim Groundwater Quality Guidelines, protection of marine aquatic life (Updated 2012) adopted from CCME (surface water guidelines protective of marine aquatic life), unless otherwise noted [see (b)]

(b) adopted from BC Contaminated Sites Regulation, 10x factor for dilution in surface water was removed

NGA = No Guideline Available for marine aquatic life

NC = Not Calculated

Shaded = exceedance of FIGWQG

TABLE 6: PHCs IN GROUNDWATER
(All units in mg/L)

		Sample ID	MW6	MW7
		Date Sampled	6-Jun-14	6-Jun-14
Parameters	**FIGWQG [a]**	**NS CSR [b]**		
Benzene	0.2	2.6	<0.001	<0.001
Toluene	8.9	20	<0.001	<0.001
Ethylbenzene	11	20	<0.001	<0.001
Xylene (Total)	NGA	20	<0.002	<0.002
C6 - C10 (less BTEX)	NGA	NGA	<0.01	<0.01
>C10-C16 Hydrocarbons	NGA	NGA	<0.05	<0.05
>C16-C21 Hydrocarbons	NGA	NGA	<0.05	<0.05
>C21-<C32 Hydrocarbons	NGA	NGA	<0.1	<0.1
Modified TPH (Tier1)	NGA	20	<0.1	<0.1
Reached Baseline at C32	N/A	N/A	N/A	N/A
Hydrocarbon Resemblance	N/A	N/A	N/A	N/A

General Notes:

(a) Federal Interim Groundwater Quality Guidelines, protection of marine aquatic life (Updated 2012)

(b) Nova Scotia Contaminated Sites Regulations - Agricultural/Residential land use, non-potable groundwater, coarse grained soil. July 6, 2013.

NGA = No Guideline Available

NC = Not Calculated

Shaded = exceedance of CCME CWQG

Bold Underlined = exceedance of NS CSR

TABLE 7: PAHs IN GROUNDWATER
(All units in µg/L)

		Sample ID	MW6	MW7
		Date Sampled	6-Jun-14	6-Jun-14
Parameters	**FIGWQG [a]**	**NS CSR [b]**		
1-Methylnaphthalene	NGA	6,200	<0.050	<0.050
2-Methylnaphthalene	NGA	6,200	<0.050	<0.050
Acenaphthene	NGA	NGA	<0.010	<0.010
Acenaphthylene	NGA	36	<0.010	<0.010
Anthracene	NGA	NGA	<0.010	<0.010
Benzo(a)anthracene	NGA	NGA	<0.010	<0.010
Benzo(a)pyrene	NGA	NGA	<0.010	<0.010
Benzo(b)fluoranthene	NGA	NGA	<0.010	<0.010
Benzo(g,h,i)perylene	NGA	NGA	<0.010	<0.010
Benzo(j)fluoranthene	NGA	NGA	<0.010	<0.010
Benzo(k)fluoranthene	NGA	NGA	<0.010	<0.010
Chrysene	NGA	NGA	<0.010	<0.010
Dibenz(a,h)anthracene	NGA	NGA	<0.010	<0.010
Fluoranthene	NGA	NGA	<0.010	<0.010
Fluorene	NGA	NGA	<0.010	<0.010
Indeno(1,2,3-cd)pyrene	NGA	NGA	<0.010	<0.010
Naphthalene	1.4	600	<0.20	<0.20
Perylene	NGA	NGA	<0.010	<0.010
Phenanthrene	NGA	NGA	0.014	<0.010
Pyrene	NGA	NGA	<0.010	<0.010

General Notes:

(a) Federal Interim Groundwater Quality Guidelines, protection of marine aquatic life (Updated 2012)

(b) Nova Scotia Contaminated Sites Regulations - Agricultural/Residential land use, non-potable groundwater, coarse grained soil. July 6, 2013.

NGA = No Guideline Available

NC = Not Calculated

Shaded = exceedance of CCME CWQG

Bold Underlined = exceedance of NS CSR

TABLE 8: VOCs IN GROUNDWATER
(All units in µg/L)

		Sample ID	**MW6**	**MW7**
		Date Sampled	6-Jun-14	6-Jun-14
Parameters	**FIGWQG [a]**	**NS CSR [b]**		
1,2-Dichlorobenzene	42	5,400	<0.5	<0.5
1,3-Dichlorobenzene	42	NGA	<1	<1
1,4-Dichlorobenzene	NGA	220	<1	<1
Chlorobenzene	25	14	<1	<1
1,1,1-Trichloroethane	NGA	640	<1	<1
1,1,2,2-Tetrachloroethane	NGA	32	<0.5	<0.5
1,1,2-Trichloroethane	NGA	47	<1	<1
1,1-Dichloroethane	NGA	320	<2	<2
1,1-Dichloroethylene	NGA	NGA	<0.5	<0.5
1,2-Dichloroethane	NGA	16	<1	<1
1,2-Dichloropropane	NGA	16	<0.5	<0.5
Benzene	NGA	2,600	<1	<1
Bromodichloromethane	NGA	NGA	<1	<1
Bromoform	NGA	3,800	<1	<1
Bromomethane	NGA	5.6	<0.5	<0.5
Carbon Tetrachloride	NGA	0.56	<0.5	<0.5
Chloroethane	NGA	NGA	<8	<8
Chloroform	NGA	3	<1	<1
Chloromethane	NGA	NGA	<8	<8
cis-1,2-Dichloroethylene	NGA	NGA	<0.5	<0.5
cis-1,3-Dichloropropene	NGA	NGA	<0.5	<0.5
Dibromochloromethane	NGA	1,100	<1	<1
Ethylbenzene	NGA	20,000	<1	<1
Ethylene Dibromide	NGA	5.2	<0.2	<0.2
Methylene Chloride(Dichloromethane)	NGA	3,400	<3	<3
o-Xylene	NGA	20,000	<1	<1
p+m-Xylene	NGA	20,000	<2	<2
Styrene	NGA	1,300	<1	<1
Tetrachloroethylene	NGA	110	<1	<1
Toluene	NGA	20,000	<1	<1
trans-1,2-Dichloroethylene	NGA	NGA	<0.5	<0.5
trans-1,3-Dichloropropene	NGA	NGA	<0.5	<0.5
Trichloroethylene	NGA	20	<1	<1
Trichlorofluoromethane (FREON 11)	NGA	NGA	<8	<8
Vinyl Chloride	NGA	1.1	<0.5	<0.5

General Notes:
(a) Federal Interim Groundwater Quality Guidelines, protection of marine aquatic life (Updated 2012)
(b) Nova Scotia Contaminated Sites Regulations - Agricultural/Residential land use, non-potable groundwater, coarse grained soil. July 6, 2013.

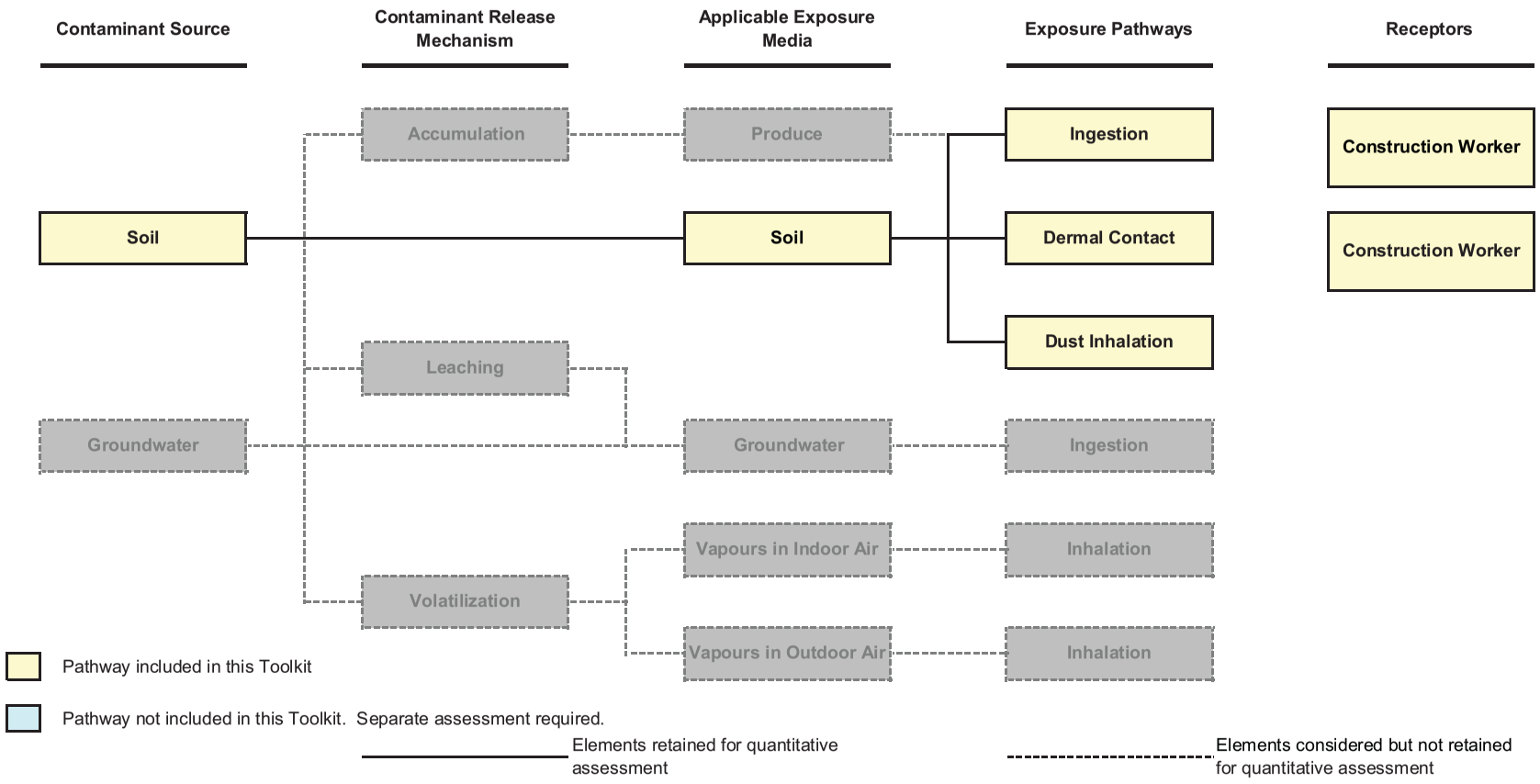
NGA = No Guideline Available
NC = Not Calculated
Shaded = exceedance of CCME CWQG
Bold Underlined = exceedance of NS CSR

APPENDIX B

HHRA SUPPORTING INFORMATION

Conceptual Site Model

Tier II Metals Toolkit **v1.01**



Input Parameters Summary

Tier II Metals Toolkit, v1.01

Site Name: Correctional Facility - Burnside
Project No.: TV1412091

Completed by: Erin Smith
Date: 8-Aug-14

Conceptual Model		
Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Aluminum	
Soil concentration	19000	
# Applicable exposure media	1	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Values used in calculations are highlighted in BOLD

Default Factors

Receptor Characteristics

		Units	Infant	Toddler	Child	Teen	Adult 20+	Adult - Female
ED	Exposure duration	years	0.5	4.5	7	8	61	45
ATn	Averaging time (non-carcinogens)	days	182.5	1642.5	2555	2920	22265	16425
ATc	Averaging time (carcinogens)	days	29200	29200	29200	29200	29200	29200
SIR	Soil ingestion rate	kg soil/day	0.00002	0.00008	0.00002	0.00002	0.00002	0.00002
BW	Body weight	kg bw	8.2	16.5	32.9	59.7	70.7	62.2
SAhands	Skin surface area - hands	cm2	320	430	590	800	890	820
SAbody	Skin surface area - body	cm2	1460	2580	4550	2230	2500	2270
AFhands	Soil adherence factor - hands	kg/cm2/event	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
AFbody	Soil adherence factor - body	kg/cm2/event	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08
InhR	Inhalation rate	m3/day	2.1	9.3	14.5	15.8	15.8	14.9
DWing	Drinking water ingestion rate	L/day	0.3	0.6	0.8	1	1.5	1.5

Exposure Characteristics

		Units	Residential	Commercial	Industrial
ET	Exposure time	hours/day	24	8	8
EF	Exposure frequency	days/year	365	260	240

User Inputs

Receptor Characteristics

		Units	User Defined
ED	Exposure duration	years	**1**
ATn	Averaging time (non-carcinogens)	days	**365**
ATc	Averaging time (carcinogens)	days	**12775**
SIR	Soil ingestion rate	kg soil/day	**0.0001**
BW	Body weight	kg bw	**70.7**
SAhands	Skin surface area - hands	cm2	**890**
SAbody	Skin surface area - body	cm2	**2500**
AFhands	Soil adherence factor - hands	kg/cm2/event	**1.00E-06**
AFbody	Soil adherence factor - body	kg/cm2/event	**1.00E-07**
InhR	Inhalation rate	m3/day	**14**
DWing	Drinking water ingestion rate	L/day	**1.5**

Exposure Characteristics

		Units	User Defined
ET	Exposure time	hours/day	**10**
EF	Exposure frequency	days/year	**260**

Calculated Values

Receptor Characteristics

		Units	User Defined
SR	Soil dermal contact rate	kg soil/day	**1.14E-03**
IRs	Soil inhalation rate	kg soil/day	**3.50E-06**

Age-Adjusted Receptor Characteristics

		Units	Lifetime Composite
SIR	Soil ingestion rate	kg soil - year/kg bw-d	
SR	Soil dermal contact rate	kg soil - year/kg bw-d	
IRs	Soil inhalation rate	kg soil - year/kg bw-d	

Exposure Characteristics

		Units	User Defined
ET1	Exposure term 1	unitless	**7.12E-01**
ET2	Exposure term 2	unitless	**4.17E-01**

Example Calculation Worksheet

Tier II Metals Toolkit, v1.01

Non-Carcinogenic CoPC

Site Name: Correctional Facility - Burnside

Project No.: TV1412091

Conceptual Model		
Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Aluminum	
Soil concentration	19000	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Results Summary		
Soil Concentration (C_{soil})	19000	mg/kg
Chronic Daily Intake	2.16E-02	mg/kg bw-day
SSTL	190494	mg/kg
Hazard Quotient	1.99E-02	

where: $HQ = \frac{C_{soil}}{SSTL} \times SAF$

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{(TDI_{oral} - EDI) \times SAF \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_l \times IR_s) \times ET_2) \times ET_1} + BSC$$

where:		Value	Units	Reference
Tolerable Daily Intake oral	TDI_{oral} =	1.00E+00	mg CoPC/kg bw - day	PPRTV
Tolerable Daily Intake inhaled	TDI_{inh} =		mg CoPC/kg bw - day	
Estimated Daily Intake	EDI =		mg CoPC/kg bw - day	** EDI data incomplete - not used in calculation **
Estimated Daily Intake inhaled	EDI_{inh} =		mg CoPC/kg bw - day	
Soil Allocation Factor	SAF =	2.00E-01	unitless	EDI data incomplete - Soil allocation set at default 20%
Body Weight	BW =	7.07E+01	kg bw	Health Canada (2006)
Absorption Factor - gut	AF_g =	1.00E+00	unitless	Default
Absorption Factor - skin	AF_s =	1.00E-02	unitless	Health Canada (2010)
Absorption Factor - lung	AF_l =	1.00E+00	unitless	Default
Soil Ingestion Rate	SIR =	1.00E-04	kg soil/day	Health Canada (2006)
Soil Dermal Contact Rate	SR =	1.14E-03	kg soil/day	calculated
Soil Inhalation Rate	IR_s =	3.50E-06	kg soil/day	calculated
Exposure Term	ET_1 =	7.12E-01	unitless	calculated
Exposure Term (inhalation only)	ET_2 =	4.17E-01	unitless	calculated
Background Soil Concentration	BSC =	1.46E+04	mg CoPC/kg soil	Dillon, 2011

Example Calculation =

$$\frac{1.00E+00 \times 0.2 \times 70.7}{((1 \times 0.0001) + (0.01 \times 1.14E\text{-}03) + (1 \times 3.50E\text{-}06) \times 4.17E\text{-}01) \times 7.12E\text{-}01} + 14606$$

SSTL (mg/kg) = 190494

If EDI > TDI, calculate SSTL as lowest of 10% EDI or 20% TDI

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{TDI_{oral} \times 0.2 \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_l \times IR_s) \times ET_2) \times ET_1}$$

Example Calculation =

SSTL (mg/kg) = EDI does not exceed TDI, SSTL calculated above

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{0.1 \times EDI \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_l \times IR_s) \times ET_2) \times ET_1} + BSC$$

Example Calculation =

SSTL (mg/kg) = EDI does not exceed TDI, SSTL calculated above

Input Parameters Summary

Tier II Metals Toolkit, v1.01

Site Name: Correctional Facility - Burnside
Project No.: TV1412091

Completed by: Erin Smith
Date: 8-Aug-14

Conceptual Model		
Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Arsenic	
Soil concentration	61	
# Applicable exposure media	1	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Values used in calculations are highlighted in BOLD

Default Factors

Receptor Characteristics

		Units	Infant	Toddler	Child	Teen	Adult 20+	Adult - Female
ED	Exposure duration	years	0.5	4.5	7	8	61	45
ATn	Averaging time (non-carcinogens)	days	182.5	1642.5	2555	2920	22265	16425
ATc	Averaging time (carcinogens)	days	29200	29200	29200	29200	29200	29200
SIR	Soil ingestion rate	kg soil/day	0.00002	0.00008	0.00002	0.00002	0.00002	0.00002
BW	Body weight	kg bw	8.2	16.5	32.9	59.7	70.7	62.2
SAhands	Skin surface area - hands	cm2	320	430	590	800	890	820
SAbody	Skin surface area - body	cm2	1460	2580	4550	2230	2500	2270
AFhands	Soil adherence factor - hands	kg/cm2/event	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
AFbody	Soil adherence factor - body	kg/cm2/event	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08
InhR	Inhalation rate	m3/day	2.1	9.3	14.5	15.8	15.8	14.9
DWing	Drinking water ingestion rate	L/day	0.3	0.6	0.8	1	1.5	1.5

Exposure Characteristics

		Units	Residential	Commercial	Industrial
ET	Exposure time	hours/day	24	8	8
EF	Exposure frequency	days/year	365	260	240

User Inputs

Receptor Characteristics

		Units	User Defined
ED	Exposure duration	years	**1**
ATn	Averaging time (non-carcinogens)	days	**365**
ATc	Averaging time (carcinogens)	days	**12775**
SIR	Soil ingestion rate	kg soil/day	**0.0001**
BW	Body weight	kg bw	**70.7**
SAhands	Skin surface area - hands	cm2	**890**
SAbody	Skin surface area - body	cm2	**2500**
AFhands	Soil adherence factor - hands	kg/cm2/event	**1.00E-06**
AFbody	Soil adherence factor - body	kg/cm2/event	**1.00E-07**
InhR	Inhalation rate	m3/day	**14**
DWing	Drinking water ingestion rate	L/day	**1.5**

Exposure Characteristics

		Units	User Defined
ET	Exposure time	hours/day	**10**
EF	Exposure frequency	days/year	**260**

Calculated Values

Receptor Characteristics

		Units	User Defined
SR	Soil dermal contact rate	kg soil/day	**1.14E-03**
IRs	Soil inhalation rate	kg soil/day	**3.50E-06**

Age-Adjusted Receptor Characteristics

		Units	Lifetime Composite
SIR	Soil ingestion rate	kg soil - year/kg bw-d	
SR	Soil dermal contact rate	kg soil - year/kg bw-d	
IRs	Soil inhalation rate	kg soil - year/kg bw-d	

Exposure Characteristics

		Units	User Defined
ET1	Exposure term 1	unitless	**7.12E-01**
ET2	Exposure term 2	unitless	**4.17E-01**

Example Calculation Worksheet

Carcinogenic CoPC

Site Name: Correctional Facility - Burnside
Project No.: TV1412091

Conceptual Model

Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Arsenic	
Soil concentration	61	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Results Summary

Lifetime Average Daily Dose		2.38E-06	mg/kg bw-day
	SSTL	127	mg/kg
	ILCR	4.97E-06	

where: $ILCR = \frac{C_{soil}}{SSTL - BSC} \times TR$

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{TR \times BW}{((ET1 \times SFo \times AFg \times SIR) + (ET1 \times SFo \times AFs \times SR) + (ET1 \times ET2 \times SFi \times AFl \times IRs)) \times (ATn / ATc)} + BSC$$

		Value	Units	Reference
where:				
Oral Slope Factor	SF_o =	1.80E+00	1/ (mg CoPC/kg bw - day)	Health Canada (2009)
Inhalation Slope Factor	SF_i =	2.80E+01	1/ (mg CoPC/kg bw - day)	Health Canada (2009)
Target Risk	TR =	1.00E-05	unitless	
Body Weight	BW =	7.07E+01	kg bw	Health Canada (2006)
Absorption Factor - gut	AF_g =	1.00E+00	unitless	Default
Absorption Factor - skin	AF_s =	3.00E-02	unitless	Health Canada (2010)
Absorption Factor - lung	AF_l =	1.00E+00	unitless	Default
Soil Ingestion Rate	SIR =	1.00E-04	kg soil/day	Health Canada (2006)
Soil Dermal Contact Rate	SR =	1.14E-03	kg soil/day	calculated
Soil Inhalation Rate	IR_s =	3.50E-06	kg soil/day	calculated
Age-adjusted Soil Ingestion Rate	SIR_{adj} =		kg soil - year/kg bw-d	calculated
Age-adjusted Soil Dermal Contact Rate	SR_{adj} =		kg soil - year/kg bw-d	calculated
Age-adjusted Soil Inhalation Rate	IRs_{adj} =		kg soil - year/kg bw-d	calculated
Exposure Frequency	EF =		days/year	Health Canada (2006)
Exposure Term	ET_1 =	7.12E-01	unitless	calculated
Exposure Term (inhalation only)	ET_2 =	4.17E-01	unitless	calculated
Averaging Time (non-carcinogens)	ATn =	3.65E+02	days	Health Canada (2006)
Averaging Time (carcinogens)	ATc =	1.28E+04	days	Health Canada (2006)
Background Soil Concentration	BSC =	4.27E+00	mg CoPC/kg soil	Dillon, 2011

Example Calculation =

$$\frac{1.00E\text{-}05 \times 70.7}{((7.12E\text{-}01 \times 1.8 \times 1 \times 0.0001) + (7.12E\text{-}01 \times 1.8 \times 0.03 \times 1.14E\text{-}03) + (7.12E\text{-}01 \times 4.17E\text{-}01 \times 28 \times 1 \times 3.50E\text{-}06)) \times (365 / 12775)} + 4.27$$

SSTL (mg/kg) = 127

Input Parameters Summary

Tier II Metals Toolkit, v1.01

Site Name: Correctional Facility - Burnside
Project No.: TV1412091

Completed by: Erin Smith
Date: 8-Aug-14

Conceptual Model		
Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Iron	
Soil concentration	33000	
# Applicable exposure media	1	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Values used in calculations are highlighted in BOLD

Default Factors

Receptor Characteristics

		Units	Infant	Toddler	Child	Teen	Adult 20+	Adult - Female
ED	Exposure duration	years	0.5	4.5	7	8	61	45
ATn	Averaging time (non-carcinogens)	days	182.5	1642.5	2555	2920	22265	16425
ATc	Averaging time (carcinogens)	days	29200	29200	29200	29200	29200	29200
SIR	Soil ingestion rate	kg soil/day	0.00002	0.00008	0.00002	0.00002	0.00002	0.00002
BW	Body weight	kg bw	8.2	16.5	32.9	59.7	70.7	62.2
SAhands	Skin surface area - hands	cm2	320	430	590	800	890	820
SAbody	Skin surface area - body	cm2	1460	2580	4550	2230	2500	2270
AFhands	Soil adherence factor - hands	kg/cm2/event	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
AFbody	Soil adherence factor - body	kg/cm2/event	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08	1.00E-08
InhR	Inhalation rate	m3/day	2.1	9.3	14.5	15.8	15.8	14.9
DWing	Drinking water ingestion rate	L/day	0.3	0.6	0.8	1	1.5	1.5

Exposure Characteristics

		Units	Residential	Commercial	Industrial
ET	Exposure time	hours/day	24	8	8
EF	Exposure frequency	days/year	365	260	240

User Inputs

Receptor Characteristics

		Units	User Defined
ED	Exposure duration	years	**1**
ATn	Averaging time (non-carcinogens)	days	**365**
ATc	Averaging time (carcinogens)	days	**12775**
SIR	Soil ingestion rate	kg soil/day	**0.0001**
BW	Body weight	kg bw	**70.7**
SAhands	Skin surface area - hands	cm2	**890**
SAbody	Skin surface area - body	cm2	**2500**
AFhands	Soil adherence factor - hands	kg/cm2/event	**1.00E-06**
AFbody	Soil adherence factor - body	kg/cm2/event	**1.00E-07**
InhR	Inhalation rate	m3/day	**14**
DWing	Drinking water ingestion rate	L/day	**1.5**

Exposure Characteristics

		Units	User Defined
ET	Exposure time	hours/day	**10**
EF	Exposure frequency	days/year	**260**

Calculated Values

Receptor Characteristics

		Units	User Defined
SR	Soil dermal contact rate	kg soil/day	**1.14E-03**
IRs	Soil inhalation rate	kg soil/day	**3.50E-06**

Age-Adjusted Receptor Characteristics

		Units	Lifetime Composite
SIR	Soil ingestion rate	kg soil - year/kg bw-d	
SR	Soil dermal contact rate	kg soil - year/kg bw-d	
IRs	Soil inhalation rate	kg soil - year/kg bw-d	

Exposure Characteristics

		Units	User Defined
ET1	Exposure term 1	unitless	**7.12E-01**
ET2	Exposure term 2	unitless	**4.17E-01**

Example Calculation Worksheet

Tier II Metals Toolkit, v1.01

Non-Carcinogenic CoPC

Site Name: Correctional Facility - Burnside

Project No.: TV1412091

Conceptual Model		
Exposure Scenario	User Defined	- Construction Worker
Receptor	User Defined	- Construction Worker
CoPC	Iron	
Soil concentration	33000	
Target risk	1.E-05	
Age-adjustment?	FALSE	

Results Summary		
Soil Concentration (C_{soil})	33000	mg/kg
Chronic Daily Intake	3.75E-02	mg/kg bw-day
SSTL	146082	mg/kg
Hazard Quotient	4.52E-02	

where: $HQ = \frac{C_{soil}}{SSTL} \times SAF$

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{(TDI_{oral} - EDI) \times SAF \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_I \times IR_s) \times ET_2) \times ET_1} + BSC$$

where:		**Value**	**Units**	**Reference**
Tolerable Daily Intake oral	TDI_{oral} =	7.00E-01	mg CoPC/kg bw - day	PPRTV
Tolerable Daily Intake inhaled	TDI_{inh} =		mg CoPC/kg bw - day	
Estimated Daily Intake	EDI =		mg CoPC/kg bw - day	** EDI data incomplete - not used in calculation **
Estimated Daily Intake inhaled	EDI_{inh} =		mg CoPC/kg bw - day	
Soil Allocation Factor	SAF =	2.00E-01	unitless	EDI data incomplete - Soil allocation set at default 20%
Body Weight	BW =	7.07E+01	kg bw	Health Canada (2006)
Absorption Factor - gut	AF_g =	1.00E+00	unitless	Default
Absorption Factor - skin	AF_s =	1.00E-02	unitless	Health Canada (2010)
Absorption Factor - lung	AF_I =	1.00E+00	unitless	Default
Soil Ingestion Rate	SIR =	1.00E-04	kg soil/day	Health Canada (2006)
Soil Dermal Contact Rate	SR =	1.14E-03	kg soil/day	calculated
Soil Inhalation Rate	IR_s =	3.50E-06	kg soil/day	calculated
Exposure Term	ET_1 =	7.12E-01	unitless	calculated
Exposure Term (inhalation only)	ET_2 =	4.17E-01	unitless	calculated
Background Soil Concentration	BSC =	2.30E+04	mg CoPC/kg soil	Dillon, 2011

Example Calculation = $\frac{7.00E\text{-}01 \times 0.2 \times 70.7}{((1 \times 0.0001) + (0.01 \times 1.14E\text{-}03) + (1 \times 3.50E\text{-}06) \times 4.17E\text{-}01) \times 7.12E\text{-}01} + 22961$

SSTL (mg/kg) = 146082

If EDI > TDI, calculate SSTL as lowest of 10% EDI or 20% TDI

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{TDI_{oral} \times 0.2 \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_I \times IR_s) \times ET_2) \times ET_1}$$

Example Calculation =

SSTL (mg/kg) = EDI does not exceed TDI, SSTL calculated above

$$SSTL\ (mg_{CoPC}/kg_{soil}) = \frac{0.1 \times EDI \times BW}{((AF_g \times SIR) + (AF_s \times SR) + (AF_I \times IR_s) \times ET_2) \times ET_1} + BSC$$

Example Calculation =

SSTL (mg/kg) = EDI does not exceed TDI, SSTL calculated above

HUMAN HEALTH RISK ESTIMATION UNCERTAINTIES

Risk estimates normally include an element of uncertainty, and generally these uncertainties are addressed by incorporating conservative assumptions in the analysis. As a result, risk assessments tend to overstate the actual risk. Although many factors are considered in preparation of a risk analysis, analysis results are generally only sensitive to very few of these factors. The uncertainty analysis is included to demonstrate that assumptions used are conservative, or that the analysis result is not sensitive to the key assumptions.

A risk assessment containing a high degree of confidence will be based on:

- conditions where the problem is defined with a high level of certainty based on data and physical observations;
- an acceptable and reasonable level of conservatism in assumptions which will ensure that risks are overstated; or,
- an appreciation of the bounds and limitations of the final solution.

The exposure assessment performed as part of this study was based on:

- available data to describe existing surface soil conditions;
- sound conservative assumptions for certain parameters, as required; and
- well-understood and generally accepted methods for risk prediction.

Uncertainties in Toxicological Information

There is a very limited amount of toxicological information on the effects associated with human exposures to low levels of chemicals in the environment. What human information is available is generally based on epidemiological studies of occupationally exposed workers. These studies are generally limited in scope and provide results that may not be applicable to chronic or continuous exposures to low levels of chemicals. Because human toxicological information is limited, reference doses and cancer potency estimates for many compounds are based on the results of dose-response assessment studies using animals. The use of experimental animal data to estimate potential biological effects in humans introduces uncertainties into the evaluation of potential human health effects. These estimations require that a number of assumptions be made:

- The toxicological effect reported in animals is relevant and could occur in humans.
- The assumption that extrapolation from high-dose studies to low-dose environmental exposures
- adequately represents the shape of the dose-response curve in the low-dose exposure range.
- Short-term exposures used in animal studies can be extrapolated to chronic or long-term exposures in humans.
- The uptake of a compound from a test vehicle (drinking water, food, etc.) in animals will be the same as the uptake of the chemical from environmental media (soil, sediment, air-borne particulate matter) in humans.
- The pharmacokinetic processes that occur in the test animals also occur in humans.

There are clearly a number of uncertainties associated with extrapolating from experimental animal data to humans. In order to address these weaknesses, regulatory agencies, such as Health Canada and the USEPA incorporate a large number of conservative assumptions to try and account for the uncertainties associated with this process. The uncertainties are accounted for by the use of Uncertainty Factors that are used to lower the reference dose well below the

level at which adverse health effects have been reported in the test species. Uncertainty factors are generally applied by factors of 10 and are used to account for the following types of uncertainties:

- Variation within the population (protection of sensitive members of the population).
- Differences between humans and the test species.
- Differences in using short or medium-term studies to estimate the health effects associated with long-term or chronic exposures.
- Limitations in the available toxicological information.

The magnitude of the uncertainty factors applied by the various regulatory agencies provides an indication of the level of confidence that should be placed in the reference value. Uncertainty factors typically range between 100 and 10,000, although some can be lower than 10. The latter values are found for a few chemicals where sound and substantial human toxicological information is available to enable the setting of toxicological end-point solely on the basis of human epidemiological information. The application of uncertainty factors are intended to introduce a high degree of conservatism into the risk assessment process and to ensure, as far as possible, that limited exposures that exceed the reference concentrations will not re suit in adverse human health effects. Because risk assessments that use these regulatory limits incorporate the conservatism used in the development of the toxicological information, the results can generally be viewed as being extremely conservative.

Modelling Assumptions

The Table below contains a summary of the assumptions used in the human health risk analysis, providing an evaluation for each assumption and an opinion as to whether the assumption is acceptable.

Evaluation of Assumptions used in the Risk Assessment

Risk analysis study factor/Assumption	Justification	Analysis likely to over/under estimate exposure	Acceptable assumption?
Chemical Screening			
Delineation of arsenic in soil for the facility has not occurred.	Delineation was not accomplished for samples from TP1 to TP5 in the vicinity of the planned facility. Sampling was meant to provide a cross-section of concentrations in the area of fill. It is assumed the range of concentrations was captured and that concentrations in the fill are below the calculated SSTL of 127 mg/kg for a construction worker.	Neutral to under estimate	Yes
Measured concentrations are representative	Laboratory QA/QC and duplicate analysis indicates the chemistry are valid.	Over-estimate to neutral	Yes
Receptor characteristics			
Soil ingestion rate	Used the Health Canada rate for a construction worker.	Over estimate	Yes
Dermal exposure	Used the health Canada Assumption of 1 dermal exposure event per day.	Neutral	Yes
Soil inhalation rate	Assumed the higher Health Canada recommended airborne concentration of respirable particles for dust on unpaved roads.	Over-estimate to neutral	Yes
Toxicity Assessment			
Slope factors were available from health Canada.	Used the Health Canada approved Toxicity Reference Value, as per Health Canada guidance on selection of TRVs.	Over estimate to neutral	Yes

APPENDIX C

ERA SUPPORTING INFORMATION

ERA Uncertainty Analysis

The ERA incorporates assumptions that lead to uncertainty. This section qualitatively discusses some significant aspects of uncertainty inherent in this risk assessment.

Habitat Survey and Receptor Selection. This risk assessment did no conduct an examination of existing habitats and the species that may exist within them through a site. A review of photographs and aerials was completed to evaluate habitat potential.

Utilization of Receptors as Sentinels to Represent Other Organisms. The use of receptors as sentinels is intended to limit the number of ecological receptors evaluated. Specific receptors were not selected for the PQERA as the majority of the Site (fill area) will be paved or covered with a building (not habitat).

Species at Risk. A review of Species at Risk potentially present at the property was not conducted for the PQERA.

Receptor-Specific Toxicity Data. For most COPCs and receptors, toxicity data are available in some form. However, it is important to note that toxicity data are not necessarily available for the particular receptor species under consideration. Toxicity values are not necessarily specific to the receptor species, or to a reproductive or population-level endpoint. As a result, there is uncertainty associated with the extrapolations that may be used to translate toxicity data from one species into a TRV for a second species despite the fact that the toxicity data represent organisms that are expected to be sensitive to the COPC and that the conversion factors are scientifically based, and are applied in a reasonable manner.

Data Limitations. The quality of a risk assessment calculation often hinges on the size, extent and quality of the data. The time available for collection of data precluded consideration of fluctuations in measured concentrations due to daily or seasonal influences. For the site, sufficient site-specific soil data have been collected for both metals and PHCs to complete the PQERA.

Selection of COPCs. The COPCs were selected independently in each of the media and/or areas evaluated in the ecological risk assessment, and the analysis was completed to include all relevant media and/or areas if the substance exceeded screening criteria for any one of these. For each of the media, there are gaps in understanding of the toxicology of constituents of concern, and the physical and chemical properties of these chemicals. The approach for selecting COPCs included comparison of detected chemical concentrations in soil values that are believed to be protective of most North American species, in most ecosystems. However, contaminant concentrations in soil are likely to be stable or decline over time. Because empirical data do not exist for all possible COPCs and media, it is possible that relevant test species and sometimes even the same environmental media have not been evaluated in the proper context for comparison.

Chemical Speciation. The fate, food chain interactions, and toxicity of a number of inorganic contaminants (such as aluminum) depend to a large extent upon their chemical form. Oral reference

doses, however, are typically based on chemical forms that have high bioavailability (*e.g.*, salts). When administered in food or water to laboratory animals, it is expected that the bioavailability of the toxicant is maximal. When trace elements are ingested by wildlife, some portion will be of natural origin, distributed through soil fractions ranging from inorganic soil particles to biological materials, having widely varying bioaccessibility. Another portion may be present in soils as a contaminant, and the speciation and bioaccessibility of the contaminant fraction will also vary, depending upon site conditions and the source of the contaminant. As such, conservative assumptions about chemical form, bioavailability, and absorption over the gut were generally carried forward in the risk assessment, and the potential for toxicity is likely to be overstated. For example, it has been assumed that 100% of each ingested COPC is absorbed from ingested food, and is available to the organism as a potentially toxic substance. This may be reasonable for some COPCs, but will be highly conservative for others. For soil, bioaccessibility was conservatively assumed to be 1.0.

Food Chain Interactions. Food chain modelling was not completed for this PQERA.

Wildlife Exposure Factors. Food chain modelling was not completed for this PQERA.

Measurement Endpoints from the Toxicity Data. Food chain modelling and the calculation of ecological hazard quotients was not completed for this PQERA.

APPENDIX D

LIMITATIONS

LIMITATIONS

1. The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.
2. The report was prepared in accordance with generally accepted environmental study and/or engineering practices for the exclusive use of Defence Construction Canada and the Department of National Defence. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.
3. Third party information reviewed and used to develop the opinions and conclusions contained in this report is assumed to be complete and correct. This information was used in good faith and AMEC does not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.
4. The services performed and outlined in this report were based, in part, upon visual observations of the site and attendant structures. Our opinion cannot be extended to portions of the site which were unavailable for direct observation, reasonably beyond our control.
5. The objective of this report was to assess environmental conditions at the site, within the context of our contract and existing environmental regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations was not included in our contract for services.
6. Our observations relating to the condition of environmental media at the site are described in this report. It should be noted that compounds or materials other than those described could be present in the site environment.
7. The findings and conclusions presented in this report are based exclusively on the field parameters measured and the chemical parameters tested at specific locations. It should be recognized that subsurface conditions between and beyond the sample locations may vary. AMEC cannot expressly guarantee that subsurface conditions between and beyond the sample locations do not vary from the results determined at the sample locations. Notwithstanding these limitations, this report is believed to provide a reasonable representation of site conditions at the date of issue.
8. The contents of this report are based on the information collected during the monitoring and investigation activities, our understanding of the actual site conditions, and our professional opinion according to the information available at the time of preparation of this report. This report gives a professional opinion and, by consequence, no guarantee is attached to the conclusions or expert advice depicted in this report. This report does not provide a legal opinion in regards to Regulations and applicable Laws.
9. Any use of this report by a third party and any decision made based on the information contained in this report by the third party is the sole responsibility of the third party. AMEC will not accept any responsibility for damages resulting from a decision or an action made by a third party based on the information contained in this report.