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Stantec Consulting Ltd.
607 Torbay Road
St. John's, NL A1A 4Y6
Tel: (709) 576-1458
Fax: (709) 576-2126

Phase II/III Environmental Site Assessment, Human Health and Ecological Risk Assessments and Remedial Action / Risk Management Plan for the Former U.S. Military Site and Residential Subdivision at Hopedale, Labrador

Prepared for

Newfoundland and Labrador
Department of Environment and Conservation

Final Report

File No. 121410103

Date: May 17, 2010

LIST OF ACRONYMS

ACOE	Army Corps of Engineers
ADD	Average Daily Dose
AENV	Alberta Environment
AF	Absorption Factor
ASTM	American Society for Testing Materials
BA	Biotransfer Factors
BAF	Bioaccumulation Factor
BCF	Bioconcentration factor
BMEWS	Ballistic Missile Early Warning System
BS	Bulk Sample
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
BW	Body Weight
CCME	Canadian Council of Ministers of the Environment
CDI	Chronic Daily Intake
CDWQG	Canadian Drinking Water Quality Guideline
CEPA	*Canadian Environmental Protection Act*
COC	Chemical or Contaminant of Concern
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EC50	Effective Concentration, 50%
Eco-SSLs	Ecological Soil Screening Levels
ED50	Effective Dose, 50%
EDI	Estimated Daily Intake
EHQ	Ecological Hazard Quotient
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
ESG	Environmental Sciences Group
FOC	Fraction Organic Carbon
GSI	Groundwater Services Inc.
HD5	Hazardous Dose, 5%
HI	Hazard Index
HHERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment

HQ	Hazard Quotient
HMW	High Molecular Weight
ICE	Interspecies Correlation Estimation
ILCR	Incremental Lifetime Cancer Risk
IRIS	Integrated Risk Information System
ISQG	Interim Sediment Quality Guidelines.
Kd	Partition coefficient of chemicals in bottom sediment
LADD	Lifetime Average Daily Dose
LC50	Lethal Concentration, 50%
LD50	Lethal Dose, 50%
LOAEL	Lowest Observed Adverse Effect Level
LOAEC	Lowest Observed Adverse Effect Concentration
LMW	Low Molecular Weight
mbgs	Meters Below Ground Surface
MW	Monitor Well
NLDEC	Newfoundland and Labrador Department of Environment and Conservation
NOAEC	No Observed Adverse Effects Concentration
NOAEL	No Observed Adverse Effect Level
OMOE	Ontario Ministry of the Environment
ORNL	Oakridge National Laboratory
PAHs	Polycyclic Aromatic Hydrocarbons
PCBs	Polychlorinated Biphenyls
PEL	Probable Effects Level
PIRI	Partnership in RBCA (Risk-Based Corrective Action) Implementation
POL	Petroleum, Oil and Lubricants.
PQRA	Preliminary Quantitative Risk Assessment
PSSL	Pathway Specific Screening Level
QA/QC	Quality Assurance/Quality Control
RBCA	Risk-Based Corrective Action
RBSL	Risk-Based Screening Level
RDL	Reportable Detection Limit
RfC, RfD	Reference Concentration, Reference Dose
RMC	Royal Military College
SAF	Soil Allocation Factor
SARA	*Species at Risk Act*
SF	Slope Factor

SM	Small Mammal
SSTL	Site Specific Target Level
SQG	Soil Quality Guideline
TDI	Tolerable Daily Intake
TP	Test Pit
TPH	Total Petroleum Hydrocarbons.
TR	Target Risk
TRV	Toxicity Reference Value
UCL	Upper Confidence Limit
UP	Uptake Factor
VECs	Valued Ecosystem Components
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

At the request of the Newfoundland and Labrador Department of Environment and Conservation (NLDEC), a Phase II/III Environmental Site Assessment (ESA) and a Human Health and Ecological Risk Assessment (HHERA) have been carried out, and a Remedial Action Plan/Risk Management Plan (RAP/RMP) has been prepared for the Former U.S. Military Site and the Residential Subdivision in Hopedale, Labrador (see Drawing No. 121410103-EE-01a in Appendix 1), herein referred to as “the overall site”. The environmental site investigations and risk assessments were carried out to address data gaps and/or actions recommended in the Plan Forward prepared for the overall site in March, 2008 (Sikumiut Project No. P-037) to enable the development of an overall RAP/RMP.

Based on previous environmental reports, and field work completed as part of the current investigation, the overall site was divided into 21 smaller study sites for the purpose of the Phase II/III ESA investigation. These sites, along with the two (2) background areas, are summarised in Table A and their locations with respect to the overall site are shown on Drawing No. 121410103-EE-01b in Appendix 1.

Table A Study Sites

Area	Site Name
Former U.S. Military Site	BMEWS
	Old Base 1
	Main Base (includes TACAN, Radome, Old Base 2a, 2b and 2c)
	Mid Canada Line
	POL Compound
	Pit No. 1/ Helipad
	Pit No. 2
	Pit No. 3
	Sewage Outfall
	Wharf Area
	Pallet Line

Area	Site Name
Former U.S. Military Site	Old Dump Pond
	Reservoir
	Second Reservoir
	Small Pond Bog
	Valley Drainage Ponds
	Old Dam
	Roadway
	Pipeline
Residential Subdivision	Residential Subdivision (includes Former Waste Sites)
Background	Big Lake
	Clean Background Area

The overall site is located adjacent to the Town of Hopedale, which is located on the Labrador coast approximately 148 air miles north of Goose Bay, as shown on Drawing 121410103-EE-01a. The Former U.S. Military Site consists of three (3) main hilltop sites (i.e., BMEWS, Main Base and Mid-Canada Line) as well as several other associated sites located west of the town. The Residential Subdivision is also located west of the main town area. There is no outside road access to Hopedale, however coastal boat service is available from mid-summer to late fall. Local access to all sites is via a gravel road network (referred to as the ”main access road”) that is in varying conditions of repair.

Construction of the military base and radar site in Hopedale, NL commenced in 1952 and was completed in 1957. The Hopedale site was a station on the United States Air Force Pinetree

Line and was also the most easterly site on the Mid-Canada Line of antennae stations which had extended across the country. The Hopedale site was one of a series of sites that functioned as a Ballistic Missile Early Warning System (BMEWS) where enemy aircraft penetrating the northeastern approaches to the continent were identified and information was communicated to the United States. It has been reported that during peak operations, the site housed 300 personnel.

Hopedale was operated as a radar site from 1957 until 1969 by the United States government. The base was closed down in 1969 and the radome and radar antennae were removed. Portions of the remaining site were operated by Canadian Marconi as a telecommunications site until 1972 and by ITT as a telecommunications site until 1975. The complex was finally closed in 1975. Most of the remaining aboveground structures were demolished and buried in several locations around the site in the mid 1980s. At that time, limited clean-up efforts were carried out, but did include the removal and disposal of PCB containing transformers. Only the foundations and floor slabs of buildings and the foundations and bases of antennae currently remain on the site. Two antennae and an associated operations building are currently being operated by Bell Aliant at the Mid-Canada Line site.

Several environmental assessment reports have been produced (mainly since 1996) relating to potential and actual contamination in the vicinity of the Former U.S. Military Site and the Residential Subdivision in Hopedale. Previous site investigations have confirmed the presence of polychlorinated biphenyls (PCBs), metals and petroleum hydrocarbons in soil and sediment and tar-like debris at the Former U.S. Military Site, and PCBs and petroleum hydrocarbons in soil and sediments and tar-like debris at the Residential Subdivision at concentrations that exceeded current regulatory guidelines. Most of the identified environmental issues at the Former U.S. Military Site and the Residential Subdivision site were not sufficiently defined in previous environmental assessment reports to enable the completion of an overall remedial options review or the development of an overall remedial action plan.

In 2007, the NLDEC commissioned a comprehensive Plan Forward for the Former U.S. Military Site and the Residential Subdivision area in Hopedale. The plan forward was developed following a desktop review of 14 available environmental assessment reports that were previously completed for the overall site. The Plan Forward served as a framework for development and implementation of remedial action plans/risk management plans for the Former U.S. Military Site and the Residential Subdivision. During the review of existing reports, various data gaps and outstanding actions were identified for the Former U.S. Military Site and the Residential Subdivision. The Plan Forward suggested the completion of various studies and investigations at the Former U.S. Military Site and the Residential Subdivision prior to the development of overall remedial action/risk management plans for the areas. The information contained in the Plan Forward was used extensively to develop the scope of work for the current investigation.

The field component of this project consisted of the identification of debris and physical hazards, the excavation of test pits, borehole drilling and monitor well installation, the collection of soil, sediment, surface water, groundwater, benthic invertebrate, vegetation, berry, small mammal, larger mammal (e.g., rabbits) and fish samples, the remediation of PCB impacted tar and the removal of debris from the stream near the Residential Subdivision. Following an initial site visit completed during the period of October 26 – October 29, 2008, field work was performed during the period of July 14 – August 5, 2009 (Stage 1), August 29 – September 10, 2009 (Stage 2) and September 26 to October 3, 2009 (Stage 3). Table B provides a summary of fieldwork completed for this site, subdivided by individual sites.

Table B Summary Table of Phase II/III Scope of Work

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
BMEWS	Debris and physical hazards. PCB CEPA area (i.e., area of soil with concentrations of PCBs detected above guidelines stated in the *Canadian Environmental Protection Act*) - delineation needed. Possible PCBs in rabbits. Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons, metals and PCBs in groundwater. Seven (7) possible waste sites. Possible petroleum hydrocarbons, PCBs, volatile organic compounds (VOCs) and metals in soil and groundwater if waste sites are confirmed.	67	8	Test pit – soil (113) Monitor well - soil (15) Surface soil (38) Groundwater (8) Vegetation (6) Berries (5) Small mammals (10) PCB Swab (1)
Old Base 1	Debris and physical hazards. PCB CEPA area. Possible PCBs in rabbits. Possible waste site under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (12) Rabbit (1)
Main Base	**<u>Main Base Site (overall site)</u>** Possible metals in soils. Possible metals in vegetation, berries, small mammals and rabbits. 10 possible waste sites – possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites are confirmed. **<u>Old Base 2a</u>** PCB CEPA area. Possible PCBs in rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Old Base 2b</u>** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Radome</u>** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Near foundations</u>** Possible PCBs and metals in soil. **<u>TACAN East</u>** Possible petroleum hydrocarbons in soil. **<u>Near POL tanks</u>** Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater **<u>Area north and east of Main Base</u>** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in soil.	79	10	Test pit – soil (136) Monitor well - soil (15) Surface soil (74) Septic tank soil (1) Groundwater (10) Vegetation (27) Berries (10) Small mammals (22) Tar (1)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Roadway	Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	6	1	Test pit – soil (6) Monitor well – soil (1) Groundwater (1)
Sewage Outfall	Debris and physical hazards. Possible petroleum hydrocarbon, PCBs, VOCs or metals impacts in soil.	-	-	Surface soil (4)
Valley Drainage Ponds	Potential for contaminants migrating from the BMEWS, Old Base 1, Main Base, Sewage Outfall, Roadway and Pallet Line sites.	-	-	Sediment (7) Vegetation (7) Berries (7) Small mammals (8)
Mid Canada Line	Debris and physical hazards. Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (18) Vegetation (5) Berries (5) Small mammals (10)
Pallet Line	No previous investigation conducted. Transformer oil odour. Potential for petroleum hydrocarbons, PCBs or metals in soil. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (26)
Pit No. 1/Helipad	Debris and physical hazards. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/drum storage areas under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	18	3	Test pit – soil (25) Monitor well – soil (9) Surface soil (12)
Pit No. 2	Debris and physical hazards. Potential for contaminants migrating from the Pallet Line site. Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	36	3	Test pit – soil (59) Monitor well - soil (10) Surface soil (17) Groundwater (3)
Pit No. 3	Debris and physical hazards. Possible free phase petroleum product. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	16	6	Test pit – soil (23) Monitor well - soil (16) Surface soil (10) Groundwater (6)
Small Pond Bog	**<u>Small Pond Bog</u>** Debris and physical hazards. Delineate TPH, PCBs and metals in sediment. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (5) Benthic (1)
	<u>Drainage Stream Northeast of Small Pond Bog</u> No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Surface soil (4) Sediment (3)
	<u>Drainage Stream from Pit No. 3</u> No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (3)
POL Compound	Debris and physical hazards. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste site in gully. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	3	4	Test pit – soil (4) Monitor well – soil (2) Surface soil (4) Groundwater (4)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Old Dump Pond	**Old Dump Pond** Debris and physical hazards. Delineate PCBs, metals, VOCs in sediment and VOCs and metals in water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (10) Surface water (3) Fish (4) Benthic (1)
	Drainage Streams (2) from Old Dump Pond No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (3)
	Area between subdivision and Old Dump Pond Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed.	9	6 + 5 auger bore-holes	Test pit – soil (13) Monitor well - soil (17) Auger – soil (11) Surface soil (5) Groundwater (6)
Pipeline	Debris and physical hazards. No previous investigation conducted in the wharf and construction camp areas. Potential for petroleum hydrocarbons in soil near existing sections of pipeline and former pipeline location.	-	10	Monitor well - soil (32) Groundwater (10) Surface soil (8)
Wharf Area	**Marine area near wharf and drainage outlets** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (17)
Old Dam	**Drainage Stream at Old Dam area** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (5)
Reservoir	Debris and physical hazards. Delineate PCBs and metals in sediment and PCBs, metals and general chemistry in water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (8) Surface water (3) Fish (1) Benthic (1)
Second Reservoir	No previous investigation conducted. Possible PCBs and metals in sediment and surface water. Test benthic invertebrates, grain size analysis for risk assessment.	-	-	Sediment (5) Surface water (3) Benthic (1)
Residential Subdivision	**Residential Subdivision** Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed. Two former waste disposal areas and on additional possible waste site – further investigations needed. Possible petroleum hydrocarbons in the vicinity of the remediated area.	15	18	Test pit – soil (22) Monitor well - soil (41) Surface soil (36) Groundwater (17) PCB Swab (5) Tar (1)
	Stream that passes through Residential Subdivision Possible petroleum hydrocarbons, PCBs, metals, PAHs and VOCs in sediment and surface water.	-	-	Sediment (4) Surface water (6)
Big Lake	Background PCBs, metals concentrations in sediment, surface water, fish and benthic invertebrates for use in risk assessments.	-	-	Sediment (3) Surface water (3) Fish (5) Benthic (1)
Clean Background Area	Background metals concentrations in soil, vegetation, berries, small mammals, rabbits and fish for use in risk assessments.	-	-	Surface soil (7) Sediment (3) Vegetation (7) Berries (7) Small mammals (2) Fish (1)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Total		**249**	**69 + 5 auger bore-holes**	**Test pit – soil (401) Monitor well – soil (158) Auger – soil (11) Surface soil (271) Sept tank soil (1) Sediment (77) Surface water (18) Groundwater (64) Vegetation (53) Berries (37) Small mammals (56) Benthic (5) Fish (11) Tar (2) Drum product (1) PCB Swab (6)**

A total of 16 barrels of PCB-impacted materials were removed from the overall site during the Stage 1 field event in the three (3) areas (i.e., Old Base 1, Old Base 2a and Old Base 2b) identified during pervious environmental investigations. PCB-impacted tar was manually removed using hand scrapers and powered chippers from the surface of the bedrock, manually picked up and placed into open-top drums and shipped to the Newalta facility in Foxtrap, NL. Bedrock chipping and tar removal continued until no visible evidence of staining remained at the site.

A total of three (3) tandem dump truck loads of debris were removed from the stream northeast of the Residential Subdivision and a transformer carcass was removed from the BMEWS site during the Stage 1 field event. The debris was transported to a lay-down area at the Pit No. 1/Helipad site. During the Stage 2 field event, the debris and transformer carcass were transported to the Hopedale Landfill.

Results of the Phase II/III ESA are summarized in Table C, which highlights chemicals of concern (COCs) with concentrations exceeding the applicable criteria, where such criteria exist. The maximum concentrations in soil, sediment, surface water and groundwater for each COC and the criteria applied for each site are provided in Table C.

Table C Summary of Impacts Identified in the Phase II/III ESA

Site	Impacted Media	Impacted Test Locations	COCs Exceeding Criteria	Maximum Conc's	Applicable Guideline	Applicable Criteria
BMEWS	Soil	BS1, BS3, BS5, BS6, BS7, BS9, BS12, BS13, BS14, BS15, BS19, BS20, BS22, BS29, BS32, TP75, TP79, TP82, TP101, TP102, TP103, TP107, TP111, TP117, TP118, TP123, TP139, MW10, MW11, MW63, MW64 and MW65	TPH Xylenes PCBs Cadmium Zinc	94,000 mg/kg 12 mg/kg 100 mg/kg 15 mg/kg 4,800 mg/kg	140 mg/kg 11 mg/kg 1.3 mg/kg 10 mg/kg 200 mg/kg	Tier I RBSLs, residential site with potable groundwater, fuel oil impacts; CCME SQGs for a residential/ parkland site
	Ground-water	MW12, MW63 and MW65	Aluminum Manganese	250 µg/L 312 µg/L	200 µg/L 50 µg/L	Health Canada CDWQGs
Old Base 1	Soil	BS121, BS122, BS123, BS124, BS126, BS127, BS128, BS129, BS130, BS131, BS132	TPH PCBs Cadmium Copper Lead Zinc	220 mg/kg 230 mg/kg 29 mg/kg 200 mg/kg 3,000 mg/kg 1,800 mg/kg	140 mg/kg 1.3 mg/kg 10 mg/kg 63 mg/kg 140 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts; CCME SQGs for a residential/ parkland site
Main Base	Soil	TP3, TP6, TP7, TP10, TP13, TP15, TP16, TP18, TP20, TP21, TP20, TP24, TP30,TP33, TP37, TP41, TP42, TP43, TP53, TP54, TP58, TP62, TP221, TP222, TP224, TP225, BS43, BS44,BS48, BS53, BS81, BS91, BS95, BS97, BS100, BS104, BS110, BS112, BS113, MW1, MW2, MW3, MW4, MW5, MW6, MW14 and Septic Tank	TPH PCBs B[a]P TPE Tetrachloro-ethylene Toluene Arsenic Antimony Barium Chromium Copper Lead Tin Zinc	71,000 mg/kg 72 mg/kg 28.2 500 µg/kg 25,000 µg/kg 25 mg/kg 76 mg/kg 2,700 mg/kg 65 mg/kg 2,200 mg/kg 840 mg/kg 250 mg/kg 820 mg/kg	140 mg/kg 1.3 mg/kg 5.3 200 µg/kg 370 µg/kg 20 mg/kg 12 mg/kg 500 mg/kg 64 mg/kg 63 mg/kg 140 mg/kg 50 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts; CCME SQGs for a residential/ parkland site
	Ground-water	MW2	Copper	76.2 µg/L	23 µg/L	OMOE Groundwater Standards
Sewage Outfall	Soil	BS152, BS153 and BS154	TPH PCBs Copper Tin Zinc	1,000 mg/kg 3 mg/kg 100 mg/kg 64 mg/kg 1,500 mg/kg	140 mg/kg 1.3 mg/kg 63 mg/kg 50 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts; CCME SQGs for a residential/ parkland site

Site	Impacted Media	Impacted Test Locations	COCs Exceeding Criteria	Maximum Conc's	Applicable Guideline	Applicable Criteria
Roadway	Soil	TP216 and MW7	TPH	16,000 mg/kg	140 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts
Mid-Canada Line	Soil	BS135, BS140 and BS142	Cadmium Chromium Copper Lead Molybdenum Zinc	13 mg/kg 1,200 mg/kg 210 mg/kg 3,200 mg/kg 81 mg/kg 22,000 mg/kg	10 mg/kg 64 mg/kg 63 mg/kg 140 mg/kg 10 mg/kg 200 mg/kg	CCME SQGs for a residential/ parkland site
Pallet Line	Soil	BS116, BS146 and BS147	TPH PCBs	2,600 mg/kg 2.1 mg/kg	690 mg/kg 1.3 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, lube oil impacts; CCME SQGs for a residential/ parkland site
Pit No. 1	Soil	TP143, TP147, TP152, BS169 and MW18	TPH PCBs	2,800 mg/kg 20 mg/kg	690 mg/kg 1.3 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, lube oil impacts; CCME SQGs for a residential/ parkland site
Pit No. 3	Soil	TP161, TP162, TP164, TP165 to TP167, TP169, TP171, TP172, TP176, BS237, BS238, BS239, BS240, BS241, BS267, BS268, BS269, BS270, BS271, MW25 and MW27 to MW30	TPH Zinc	77,000 mg/kg 420 mg/kg	140 mg/kg 200 mg/kg	Tier I RBSLs, residential non-potable site, fuel oil impacts; CCME SQGs for a residential/ parkland site
	Ground-water	MW26	TPH	20 mg/L	20 mg/L	Tier I RBSLs, residential site with non-potable groundwater fuel oil impacts
Small Pond Bog	Ground-water	BS244 and BS256	TPH	7,500 mg/kg	140 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts
	Sediment	SED-20, SED-21, SED-24, SED-59, SED-60 and SED-64	TPH PCBs Copper Lead Mercury	16,000 mg/kg 0.68 mg/kg 57 mg/kg 42 mg/kg 0.2 mg/kg	1,500 mg/kg 0.0341mg/kg 35.7 mg/kg 35.0 mg/kg 0.17 mg/kg	OMOE Guidelines for total oil and grease in freshwater sediment CCME ISQGs

Site	Impacted Media	Impacted Test Locations	COCs Exceeding Criteria	Maximum Conc's	Applicable Guideline	Applicable Criteria
POL Compound	Soil	TP140, TP141, TP142, BS42, MW21 and MW24	TPH PCBs Antimony Arsenic Chromium Copper Lead Molybdenum Nickel Tin Zinc	25,000 mg/kg 2.4 mg/kg 120 mg/kg 15 mg/kg 350 mg/kg 790 mg/kg 2,100 mg/kg 12 mg/kg 110 mg/kg 550 mg/kg 1,700 mg/kg	690 mg/kg 1.3 mg/kg 20 mg/kg 12 mg/kg 64 mg/kg 63 mg/kg 140 mg/kg 10 mg/kg 50 mg/kg 50 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, lube oil impacts; CCME SQGs for a residential/ parkland site
	Ground-water	MW22	TPH PCBs	59 mg/L 0.5 µg/L	20 mg/L 0.2 µg/L	Tier I RBSLs, residential site with non-potable groundwater, lube oil impacts; OMOE Groundwater Standards
Old Dump Pond	Soil	TP229, TP230, TP231, TP233, MW32, MW33, BS226, BS228, MW61 and AG5	TPH PCBs Antimony Cadmium Chromium Copper Lead Mercury Molybdenum Nickel Selenium Tin Zinc	3,400 mg/kg 29 mg/kg 99 mg/kg 15 mg/kg 100 mg/kg 2,500 mg/kg 8,100 mg/kg 67 mg/kg 23 mg/kg 110 mg/kg 7 mg/kg 420 mg/kg 3,400 mg/kg	690 mg/kg 1.3 mg/kg 20 mg/kg 10 mg/kg 64 mg/kg 63 mg/kg 140 mg/kg 6.6 mg/kg 10 mg/kg 50 mg/kg 1 mg/kg 50 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, lube oil impacts; CCME SQGs for a residential/ parkland site
	Sediment	SED-25, SED-26, SED-27, SED-28, SED-29, SED-30, SED-31, SED-32, SED-33, SED-34	PCBs Cadmium Copper Lead Mercury Zinc	32 mg/kg 10 mg/kg 79 mg/kg 160 mg/kg 0.8 mg/kg 790 mg/kg	0.0341mg/kg 0.06 mg/kg 35.7 mg/kg 35.0 mg/kg 0.17 mg/kg 200 mg/kg	CCME freshwater ISQGs
	Ground-water	MW32, MW33 and MW34	PCBs	4.1 µg/L	0.2 µg/L	OMOE Groundwater Standards
	Surface water	SW-1, SW-2 and SW-3	Aluminum Cadmium Copper Iron Lead	176 µg/L 0.027 µg/L 3.0 µg/L 804 µg/L 1.38 µg/L	100 µg/L 0.0072 µg/L 2 µg/L 300 µg/L 1 µg/L	CCME Freshwater Aquatic Life Guidelines
Pipeline	Soil	MW53, MW54, MW68, MW69 BS230, BS232 and BS234	TPH PCBs Chromium Copper Zinc	52,000 mg/kg 13 mg/kg 110 mg/kg 70 mg/kg 510 mg/kg	140 mg/kg 1.3 mg/kg 64 mg/kg 63 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil; CCME SQGs for a residential/ parkland site
	Ground-water	MW53	TPH	370 mg/L	20 mg/L	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts

Site	Impacted Media	Impacted Test Locations	COCs Exceeding Criteria	Maximum Conc's	Applicable Guideline	Applicable Criteria
Wharf Area	Sediment	SED-1, SED-7, SED-72, SED-73, SED-74, SED-75, SED-76 and SED-77	PCBs Copper Lead	0.46mg/kg 52mg/kg 40 mg/kg	0.0215mg/kg 18.7 mg/kg 30.2 mg/kg	CCME marine ISQGs
Old Dam	Sediment	SED-53	Lead	77 mg/kg	35.0 mg/kg	CCME freshwater ISQGs
Reservoir	Sediment	SED-38, SED-39, SED-41 and SED-43	Cadmium Chromium Copper Mercury Zinc	0.6 mg/kg 58 mg/kg 38 mg/kg 0.2 mg/kg 140 mg/kg	0.6 mg/kg 37.3 mg/kg 35.7 mg/kg 0.17 mg/kg 123 mg/kg	CCME freshwater ISQGs
	Surface water	SW-4, SW-5 and SW-6	pH Turbidity	6.26 1.1 NTU	6.5 – 8.5 1.0 NTU	Health Canada CDWQGs
Second Reservoir	Sediment	SED-55 and SED-57	Cadmium Copper Zinc	1.3 mg/kg 38 mg/kg 160 mg/kg	0.6 mg/kg 35.7 mg/kg 123 mg/kg	CCME freshwater ISQGs
	Surface water	SW-7, SW-8 and SW-9	pH	6.36	6.5 – 8.5	Health Canada CDWQGs
Residential Subdivision	Soil	TP235, TP236, TP238, TP241, TP243, TP244, TP247, TP248, TP249, BS203, BS211, BS218, MW39,MW40, MW37, MW46, MW48 and MW52	TPH PCBs Lead Tin Zinc	5,400 mg/kg 2.6 mg/kg 170 mg/kg 80 mg/kg 300 mg/kg	140 mg/kg 1.3 mg/kg 140 mg/kg 50 mg/kg 200 mg/kg	Tier I RBSLs, residential site with non-potable groundwater, fuel oil impacts; CCME SQGs for a residential/ parkland site
	Sediment	SED-67 and SED-68	PCBs	0.48 mg/kg	0.0341mg/kg	CCME ISQGs
	Ground-water	MW47	PCBs	0.32 µg/L	0.2 µg/L	OMOE Groundwater Standards
	Surface water	SW-13, SW-15, SW-16, SW-17 and SW-18	Cadmium Copper Iron Zinc	0.039 µg/L 6.2 µg/L 469 µg/L 35.8 µg/L	0.0017 µg/L 2-4 µg/L 300 µg/L 30 µg/L	CCME Freshwater Aquatic Life Guidelines
Big Lake	Sediment	SED-71	Chromium	39 mg/kg	37.3 mg/kg	CCME freshwater ISQGs
	Surface water	SW-10, SW-11 and SW-12	Aluminum Lead	123 µg/L 1.19 µg/L	100 µg/L 1 µg/L	CCME Freshwater Aquatic Life Guidelines
Clean Back-ground Area	Soil	BS253 and BS255	Copper Uranium	85 mg/kg 26 mg/kg	63 mg/kg 23 mg/kg	CCME SQGs for a residential/ parkland site

Notes:
MW = Monitor well
TP = Test pit
BS = Bulk soil sample
SED = Sediment sample
SW = Surface water sample
B[a]P TPE = Benzo(a)pyrene Total Potency Equivalents

Human Health Risk Assessment

For the purposes of the human health risk assessment, the Residential Area and the Former Radar Site were assessed separately based on the expected human exposure time (*i.e.*, human receptors would be expected to spend less time on the Former Radar Site than in the Residential Area) and activities (*e.g.*, hunting is expected to be limited to the Former Radar Site).

Based on the screening of chemicals in soil, the following chemicals were carried forward in the human health risk assessment:

Former Radar Site

- TPH (fuel oil);
- TPH (lube oil);
- PCBs; and,
- Lead.

Residential Area

- TPH (fuel oil)
- PCBs;
- Antimony; and,
- Lead.

The following receptor categories were considered in this human health risk assessment:

- *Former Radar Site*: recreational site user (toddler for non-carcinogenic compounds and composite receptor for all life stages for carcinogenic compounds).
- *Residential Area*: resident (toddler for non-carcinogenic compounds and composite receptor for all life stages for carcinogenic compounds).

Based on the qualitative risk evaluation, the conceptual model developed for evaluating the quantitative exposure of the human receptor identified the following possible exposure pathways.

Former Radar Site:

- Recreational visitors to the Former Radar Site may be exposed to the impacted soil through ingestion, dermal contact, and dust inhalation at the property.
- Residents of Hopedale living near the Former Radar Site may be exposed to impacts in fish and small game that may be hunted at the site.
- Residents of Hopedale living near the Former Radar Site may be exposed to impacts in berries that may be picked form the site for human consumption.

Residential Area:

- Residents at the Residential Area may be exposed to the impacted soil through ingestion, dermal contact, and dust inhalation.
- Residents at the Residential Area may be exposed to the impacted sediment through ingestion and dermal contact with impacted sediment in Small Pond Bog, Old Dump Pond and the stream.

Outdoor air pathway specific criteria are not calculated because the criteria (Atlantic PIRI, 2003) are greater than the residual saturation limit of TPH in soil (*i.e.*, ">Res") and greater than the solubility in groundwater (*i.e.*, ">Sol") thus requiring only free product remediation. The inhalation of indoor air was considered an operable exposure pathway for residential receptors living in the Residential Area of Hopedale where petroleum hydrocarbons were identified in soil and groundwater. Most houses in the Residential Area are constructed with an earthen floor in the basement or crawl space. The Tier I RBSL and Tier II PSSL Tables do not apply to buildings without a concrete floor due to the increased vapour infiltration in the absence of a concrete barrier. The Atlantic RBCA Version 2.1 software is not applicable for homes with earthen floors (Atlantic PIRI, 2003). Therefore, the outdoor air and indoor air exposure pathways are not considered further in this human health risk assessment. Recommendations will be provided for additional work to assess the indoor air inhalation exposure pathway.

The ingestion of fish from Big Lake was identified as a potential exposure pathway for the Hopedale Radar Site. Concentrations of PCBs were non-detectable and 0.06 mg/kg in two brook trout collected from Big Lake. Additional samples would be required to determine if PCBs are present in the fish from Big Lake.

<u>HHRA Results - Baseline Risks</u>

The cumulative hazard indices and carcinogenic risks for the exposure scenarios assessed are shown in Table D. The hazard index values for the soil ingestion, inhalation, and dermal contact pathway for PCBs at the Former Radar Site and for PCBs and antimony at the Residential Area exceed the target maximum hazard index value of 0.2. The calculated total carcinogenic risks for the wild game exposure pathway for PCBs exceed the target risk of 1 x 10^{-5}. The hazard index and carcinogenic risk values for all other chemicals for all other pathways were below their targets.

Table D Cumulative Pathway Hazard Indices and Target Risks – Metals and PAHs

COC	Exposure Pathway	Hazard Index	Target Hazard Index	Total Carcinogenic Risk	Target Risk (Carcinogens)
Antimony	Residential Area – Soil Exposure	**0.28**	0.2	NA	NA
	Residential Area – Sediment Exposure	0.018	0.2	NA	NA
Lead	Residential Area – Soil Exposure	0.13	0.2	NA	NA
	Residential Area – Sediment Exposure	0.014	0.2	NA	NA
	Former Radar Site – Soil Exposure	0.13	0.2	NA	NA

COC	Exposure Pathway	Hazard Index	Target Hazard Index	Total Carcinogenic Risk	Target Risk (Carcinogens)
	Former Radar Site – Game Ingestion	0.05	0.2	NA	NA
	Former Radar Site – Berry Ingestion	0.03	0.2	NA	NA
PCBs	Residential Area – Soil Exposure	**0.47**	0.2	**2.0E-05**	1.0E-05
	Residential Area – Sediment Exposure	0.13	0.2	5.5E-06	1.0E-05
	Former Radar Site – Soil Exposure	**0.26**	0.2	**1.1E-05**	1.0E-05
	Former Radar Site – Game Ingestion	0.15	0.2	**2.9E-05**	1.0E-05
	Former Radar Site – Berry Ingestion	0.094	0.2	**1.3E-05**	1.0E-05
TPH (Fuel Oil)	Residential Area – Soil Exposure	0.55	1	NA	NA
	Residential Area – Sediment Exposure	0.25	1	NA	NA
	Former Radar Site – Soil Exposure	0.64	1	NA	NA
TPH (Lube Oil)	Former Radar Site – Soil Exposure	0.27	1	NA	NA
Note: BOLD indicates risk estimate is higher than target.					

Aquatic Ecological Risk Assessment

Eight potential freshwater habitats and one marine habitat have been identified for assessment in this ecological risk assessment. The freshwater habitats include: 1) Subdivision Stream, 2) Old Dump Pond, 3) Small Pond Bog, 4) Old Dam, 5) Valley Drainage Ponds, 6) Reservoir, 7) Second Reservoir, and 8) Big Lake.

The one marine aquatic habitat, the Wharf Area, includes the coastline and Hopedale Harbour.

The following marine and freshwater organisms were identified as ecological receptors for quantitative risk evaluation in the ERA:

- fish; and,
- benthic invertebrates.

Aquatic ERA Results

Chemicals of concern in sediment and surface water that exceed their applicable benchmark for each site are shown in Table E. Only COCs in sediment (PCBs, TPH and tin) were identified as potential chemicals of concern (*i.e.*, PCBs: CCME sediment quality guidelines; TPH: Toxicity value for benthic invertebrates; tin: no guidelines available).

Table E Magnitude of Impacts for Chemicals in Aquatic Habitats at Hopedale Radar Site

Site	Sediment	Surface Water	Magnitude of Impacts
Subdivision Stream	PCBs	None	PCBs: Localised; two samples exceeded the PEL. No toxicity value could be calculated due to lack of organic carbon data
Old Dump Pond	Tin	None	Tin: widely distributed in sediment
Small Pond Bog	TPH	Not Tested	TPH: widely distributed in sediment
Old Dam	TPH	Not Tested	TPH: Localised; site is not considered significant habitat and may dry up seasonally
Valley Drainage Ponds	None	Not Tested	Not applicable
Reservoir	None	None	Not applicable
Second Reservoir	None	None	Not applicable
Big Lake	None	None	Not applicable
Wharf Area	TPH, PCBs	Not tested	PCBs: Localised; mainly near where stream enters ocean and near the wharf TPH: localised; exceeds value in one sample near where stream enters ocean

Aquatic ERA Results Summary

Subdivision Stream

- Only two sediment samples had concentrations that exceeded the PEL.
- It was not possible to calculate a toxicity value for the Subdivision Stream because the amount of organic carbon was unknown. A conservative assumption is 1% organic carbon which equals a toxicity value for the Subdivision Stream of 38 mg/kg. The maximum concentration of PCBs in the Subdivision Stream is 0.48 mg/kg. Therefore, it is unlikely that PCBs are causing adverse effects to benthic invertebrates at the Subdivision Stream.

Old Dump Pond

- No guideline or toxicity value exists for tin in sediment, it was identified as being a potential concern in sediment of Old Dump Pond.
- Metals debris was observed to be present in Old Dump Pond and this may be contributing to the elevated levels of tin in sediment.
- There are no guidelines available for tin in sediment, however, most of the aquatic toxicity testing with tin is carried out with soluble tin(II)chloride which is classified as moderately toxic (Howe and Watts, 2005). Speciation under environmental conditions favours tin oxide compounds which have low toxicity mainly due to their low solubility, poor absorption, low accumulation in tissues and rapid excretion (Howe and Watts, 2005). Therefore, adverse effects on aquatic life due to tin in Old Dump Pond are considered unlikely.
- Concentrations of PCBs in sediment of Old Dump Pond were not considered to be a concern because the concentrations were below the toxicity value.
- Concentrations of PCBs in three sticklebacks collected from Old Dump Pond had concentrations of 4.8 mg/kg, 5.6 mg/kg, and 5.9 mg/kg.

- The concentrations of PCBs in stickleback from old Dump Pond are less than the reported LOAECs reported in the literature. Therefore, adverse effects to fish at old Dump Pond are considered unlikely.

Small Pond Bog

- Petroleum hydrocarbon impacts in sediment from Small Pond Bog are widespread and may cause adverse effects to aquatic biota.
- Small Pond Bog does not represent significant fish habitat but benthic invertebrates were observed to be present. Sampling for benthic invertebrates was conducted during the 2009 field work.
- Further conclusions and recommendations may be made for Small Pond Bog with respect to impacts of petroleum hydrocarbons on benthic invertebrates.

Old Dam

- Petroleum hydrocarbon impacts at the Old Dam are considered localised.
- Old Dam is also not expected to represent significant habitat as it additional investigation is required at Old Dam.

Wharf

- The TPH impacts at the Wharf area are considered localised because only one sample had an elevated concentration of 1000 mg/kg.
- PCB impacts are also considered to be confined to the immediate vicinity of the wharf and shoreline.

Terrestrial Ecological Risk Assessment

The home ranges for masked shrew, meadow vole and red fox are potentially smaller than the radar site. It is therefore possible that these VECs could spend their entire life in one particular portion of the radar site. Therefore, the site was separated into three smaller areas (shown on Drawing No. 121410103-EE-16b) for assessment. These areas include:

- Area 1 (0.61 km^2): BMEWS, Valley Drainage Ponds, Reservoir
- Area 2 (0.69 km^2): Main Base, Pit No. 2, Mid Canada Line, Old Base1, Pallet Line
- Area 3 (0.29 km^2): Pit No. 1, Pit No. 3, Small Pond Bog, POL Compound, Old Dump Pond

The following mammalian species were identified as ecological receptors for quantitative risk evaluation in the ERA:

- masked shrew (*Sorex cinereus*);
- meadow vole (Microtus pennsylvanicus);
- Arctic hare (*Lepus arcticus*); and,
- red fox (Vulpes vulpes).

The following avian species were identified as ecological receptors for quantitative risk evaluation in the ERA:

- Herring gull (*Larus argentatus);*
- American robin (*Turdus migratorius*);
- Short-eared owl (*Asio flammeus*); and
- Common merganser (*Mergus merganser*).

<u>Terrestrial ERA Results</u>

Table F summarizes the COCs at each area of the Hopedale Radar Site that were identified as potentially posing adverse risks to VECs based on the terrestrial ERA.

Table F Summary of Chemicals Identified as being of Potential Unacceptable Risk based on Terrestrial Ecological Risk Assessment at Hopedale Radar Site

Area	VEC	Chemicals of Concern
Area 1	Red fox	TPH, PCBs
	Masked shrew	TPH, PCBs, Cadmium
	Meadow vole	TPH, PCBs
Area 2	Red fox	PCBs, Cadmium
	Masked shrew	TPH, PCBs, Cadmium, Chromium, Molybdenum
	Meadow vole	TPH, Cadmium, Chromium
Area 3	Red fox	PCBs
	Masked shrew	TPH, PCBs, Antimony, Chromium, Lead
	Meadow vole	TPH, Antimony
Whole Site	American robin	TPH, PCBs, Cadmium, Chromium, Lead
	Short-eared owl	TPH, PCBs
	Herring gull	None
	Common merganser	None
	Arctic hare	TPH, PCBs, Antimony, Cadmium, Molybdenum

Recommendations

The following actions, remedial activities, and risk management strategies are recommended for the control of hazards related to petroleum hydrocarbons, PCB and metal impacts at the site. Some of these recommendations are intended to be flexible, and will be modified as appropriate, depending upon the results of consultation with regulators and the Town of Hopedale.

<u>Actions</u>

1. Issue an advisory (similar to that issued in 2009) advising of potential risks associated with consuming wild game and berries from the Former Radar Site.
2. Remove metal and other debris from Old Dump Pond as well as from the area of test pit TP229, which is located in the proximity of Old Dump Pond.
3. Remove the septic tank from the Main Base Site.

4. In order to assess the potential risks associated with inhalation of petroleum hydrocarbon vapours in indoor air, soil vapour monitoring should be considered for homes constructed within the footprint of the former landfill.
5. Soil samples should be collected from individual properties located in the footprint of the former landfill at the Residential Subdivision and analysed for petroleum hydrocarbons, PCBs and metals. The results of this additional sampling would require comparison to SSTLs calculated in this human health risk assessment.
6. Further evaluation is required for homes constructed on the former landfill with respect to the long term structural stability of these affected homes.
7. Additional fish samples should be collected from Big Lake to confirm that concentrations are below applicable fish advisory guidelines.
8. If site conditions or land uses change (e.g., residential usage, potable groundwater or if further development takes place on the site), the results of the on-site risk assessment may need to be revisited to ensure that there are no additional or increased risks to potential receptors, on-site or off-site.
9. It is recommended that if vegetable gardens are grown in the future, they are kept away from contaminated areas of the site. Clean imported topsoil should be brought in for this purpose.
10. It is our understanding that there is no current groundwater use for potable drinking water. The assumption is made that prior to any future use of groundwater for potable drinking water or other human use (i.e., showering, washing), the groundwater will be tested to demonstrate that groundwater quality is within the Guidelines for Canadian Drinking Water Quality.

Remedial Activities

1. Perform additional delineation and investigations in areas requiring soil remediation, as identified in the HHERA and listed in Table G, to provide more accurate estimates of soil volumes to be remediated.
2. Carry out active remediation of site soil for those COCs which exceed the SSTLs developed as part of this human health and ecological risk assessment in the areas identified in Table G. PCB, TPH and metals impacts at Old Dump Pond and the Wharf Area should be given priority over other impacted areas identified throughout the site, due to the proximity of the Town of Hopedale.
3. Where possible, implement mitigative measures to reduce the potential for the remobilization of impacts and to enhance natural attenuation.
4. Following remediation, carry out a confirmatory sampling program for soil and groundwater to demonstrate that remedial goals have been attained.
5. Obtain closure for the site remediation from NLDEC.

Site Specific Target Levels for PCBs, TPH and Metals in Soil

Table G presents the SSTLs for the Residential Area and the Former Radar Site and identifies the areas requiring remediation.

Table G Summary of SSTLs to be applied to the Former Radar Site and Residential Area

Chemical	SSTL (mg/kg)	Source	Areas Requiring Remediation
Residential Area			
PCBs	9	HHRA	Old Dump Pond (Drawing No. 121410103-EE-28b) and the Wharf Area (Drawing No. 121410103-EE-28a)
Antimony	30	HHRA	Old Dump Pond (Drawing No. 121410103-EE-28b)
Former Radar Site			
PCBs	22	HHRA	BMEWS (Drawing No. 121410103-EE-28c) and Old Base1 and Main Base (Drawing No. 121410103-EE-28d)
TPH	1700	ERA	BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Pit No. 3 and POL Compound (Drawing No. 121410103-EE-28f)
Metals	Lead: 75 Antimony: 5 Chromium: 20 Cadmium: 1.3	ERA	Old Dump Pond (Drawing No. 121410103-EE-28b), BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Mid Canada Line (Drawing No. 121410103-EE-28e), and POL Compound (Drawing No. 121410103-EE-28f)

Based on the remedial options evaluation, the preferred options for soil remediation at the Former U.S. Military Site and Residential Subdivision in Hopedale are as follows:

- PCB-Impacted Soil: Stock-pile soil and transport to an existing out-of-province hazardous waste landfill.
- TPH-Impacted Soil: Pretreat soil in temporary on-site biopile, then place soil in local landfill.
- Metals-Impacted Soil: Prior to selecting a remedial option, perform bioaccessibility testing on metals in soil requiring remediation and re-evaluate the SSTLs for metals within the HHERA.

Prior to remediation or site soils, additional delineation would be conducted to potentially reduce the areas of soil to be remediated. Soil removal operations would be inspected on a continuous basis by an environmental consultant. Confirmatory soil sampling would be carried out in remediated areas to demonstrate that remedial objectives are obtained. A monitoring program would be established to determine the effectiveness of the remedial approach for TPH-impacted soil. Approval is needed from the local landfill and the hazardous waste landfill before soil can be sent there for disposal. It is assumed that approval would be received from the landfills to accept the soil described in the following sections, based on the site characterization information which describes the acceptable levels of contaminants in soil disposed of a the landfill.

The abandoned septic tank at the Main Base site would be emptied of septic sludge by qualified personnel, following standard procedures. The removed septic sludge would be disposed of at a local approved facility.

Metal and other debris from Old Dump Pond, as well as from the area of TP229 would be removed and sampled for PCBs. Based on the results of PCB testing, the debris would be disposed of at the Hopedale landfill or an appropriate approved disposal facility.

Once all soils requiring remediation have been removed from the site and the EPCs for the site are below the SSTLs and the identified human health and ecological risks at the site have been mitigated, a summary report would be prepared and submitted to NLDEC to obtain site closure for the property.

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1.0 INTRODUCTION

At the request of the Newfoundland and Labrador Department of Environment and Conservation (NLDEC), a Phase II/III Environmental Site Assessment (ESA) and a Human Health and Ecological Risk Assessment (HHERA) have been carried out, and a Remedial Action Plan/Risk Management Plan (RAP/RMP) has been prepared for the Former U.S. Military Site and the Residential Subdivision in Hopedale, Labrador (see Drawing No. 121410103-EE-01a in Appendix 1), herein referred to as "the overall site ". The environmental site investigations and risk assessments were carried out to address data gaps and/or actions recommended in the Plan Forward prepared for the overall site in March, 2008 (Sikumiut Project No. P-037) to enable the development of an overall RAP/RMP.

Based on previous environmental reports, and field work completed as part of the current investigation, the overall site was divided into 22 smaller study sites for the purpose of the Phase II/III ESA investigation. These sites are summarised in Table 1.1 and their locations with respect to the overall site are shown on Drawing No. 121410103-EE-01b in Appendix 1. Supporting documentation for the individual study sites was grouped into appendices based on the site location plans and is provided in Appendices 2 to 23, as described in Table 1.1.

Table 1.1 Study Sites

Area	Site Name	Supporting Documentation
Former U.S. Military Site	BMEWS	Appendix 2
	Old Base 1	Appendix 3
	Main Base (includes TACAN, Radome, Old Base 2a, 2b and 2c)	Appendix 4
	Sewage Outfall	Appendix 5
	Roadway	Appendix 6
	Valley Drainage Ponds	Appendix 7
	Mid Canada Line	Appendix 8
	Pallet Line	Appendix 9
	Pit No. 1/ Helipad	Appendix 10
	Pit No. 2	Appendix 11
	Pit No. 3	Appendix 12
	Small Pond Bog	Appendix 13
	POL Compound	Appendix 14
	Old Dump Pond	Appendix 15
	Pipeline	Appendix 16
	Wharf Area	Appendix 17
	Old Dam	Appendix 18
	Reservoir	Appendix 19
	Second Reservoir	Appendix 20
Residential Subdivision	Residential Subdivision (includes Former Waste Sites)	Appendix 21
Background	Big Lake	Appendix 22
	Clean Background Area	Appendix 23

This report is organized into nine (9) sections. Section 1 provides background information about the property, explains the regulatory guidelines and their applicability, and describes the scope of work. Section 2 summarizes the methodology used for the field investigation and for laboratory analyses. Results of the Phase II/III investigations are presented in Section 3 by site; and include the results of field investigations and laboratory analyses, as well as a discussion of results and conclusions. Sections 4 to 8 present the human health risk assessment and ecological risk assessment. Details on various remedial options for the overall site are provided in Section 9. Section 9 also provides recommendations for future work on the property. Section 8 discusses the limitations of the assessment and its findings and Section 11 lists referenced materials. Supporting information is given in appendices.

This report was prepared specifically and solely for the above project. The report presents all of the factual findings and laboratory results of the Phase II/III ESA investigation, and presents our comments on the environmental status of the overall site.

1.1 Property Description

1.1.1 Location and Access

The overall site is located adjacent to the Town of Hopedale, which is located on the Labrador coast approximately 148 air miles north of Goose Bay, as shown on Drawing 121410103-EE-01a. The Former U.S. Military Site consists of three (3) main hilltop sites (i.e., BMEWS, Main Base and Mid-Canada Line) as well as several other associated sites located west of the town. The Residential Subdivision is also located west of the main town area. There is no outside road access to Hopedale, however coastal boat service is available from mid-summer to late fall. Local access to all sites is via a gravel road network (referred to as the "main access road") that is in varying conditions of repair.

1.1.2 Historical Development and Land Use

Construction of the military base and radar site in Hopedale, NL commenced in 1952 and was completed in 1957. The Hopedale site was a station on the United States Air Force Pinetree Line and was also the most easterly site on the Mid-Canada Line of antennae stations which had extended across the country. The Hopedale site was one of a series of sites that functioned as a Ballistic Missile Early Warning System (BMEWS) where enemy aircraft penetrating the northeastern approaches to the continent were identified and information was communicated to the United States. It has been reported that during peak operations, the site housed 300 personnel.

The military base and radar site in Hopedale were operated from 1957 until 1969 by the United States government. The base was closed down in 1969 and the radome and radar antennae were removed. Portions of the remaining site were operated by Canadian Marconi as a telecommunications site until 1972 and by ITT as a telecommunications site until 1975. The complex was finally closed in 1975. Most of the remaining aboveground structures were demolished and buried in several locations around the site in the mid 1980s. At that time, limited clean-up efforts were carried out, including the removal and disposal of PCB containing transformers. With the exception of the Mid-Canada Line site, only the foundations and floor slabs of buildings and the foundations and bases of antennae currently remain on the military base and radar site. Two (2) antennae and an associated operations building are currently being operated by Bell Aliant at the Mid-Canada Line site.

1.1.3 Topography, Drainage and Soils

The natural environment in Hopedale is typical of Labrador Coastal Barrens. Bedrock is granite and gneiss, and is largely exposed. Soil cover on the hills is relatively thin (generally < 0.5 m), with accumulations of rock, gravel, sand and organic matter in low lying areas. Deeply incised U-shaped valleys occur in conjunction with steep-sided, rounded mountains and fjords that extend well inland. Large bogs can be found in the low-lying areas.

The overall site is dominated by three (3) installations on hilltops elevated between 100 m and 150 m above sea level, including (from west to east): the BMEWS site, the Main Base and the Mid-Canada Line antennae site. The BMEWS site, which has an area of approximately 1 hectare, is located on the top of a hill approximately 2 km northwest of the Town of Hopedale. Drainage from the BMEWS site is in all directions (i.e., to the north, east, south and west), including to the south towards Reservoir Lake (approximately 300 m to the south). The Main Base site, which has an area of approximately 45 hectares, is located on the top of a hill approximately 1.2 km northwest of the Town of Hopedale. The Mid-Canada Line antennae site is located on the top of a hill approximately 700 m northwest of the Town of Hopedale. Drainage from the Main Base and Mid-Canada Line sites is in all directions. Much of the area around the sites is exposed bedrock, with limited soil cover.

Based upon the site topography and site inspections, the majority of contaminants of potential concern released from the Former U.S. Military Site would eventually make their way towards the Small Pond Bog, and from there through the Residential Subdivision to be discharged at the mouth of the small creek located near the wharf. A potential pathway for contaminant of potential concern migration could extend north from Old Base 1 and BMEWS through the Valley Drainage Ponds. This pathway leads through a series of small ponds and wetlands within the Valley Drainange Ponds site. A third possible pathway extends northwest from BMEWS towards Big Lake approximately 650 m northwest of the overall site.

1.2 Previous Environmental Assessments

Several previous environmental assessment reports have been produced (mainly since 1996) relating to potential and actual contamination in the vicinity of the Former U.S. Military Site and the Residential Subdivision site in Hopedale. Previous site investigations have confirmed the presence of polychlorinated biphenyls (PCBs), metals and petroleum hydrocarbons in soil and sediment and tar-like debris at the Former U.S. Military Site, and PCBs and petroleum hydrocarbons in soil and sediments and tar-like debris at the Residential Subdivision at concentrations that exceed current regulatory guidelines. Most of the identified environmental issues at the Former U.S. Military Site and the Residential Subdivision site were not sufficiently defined in previous environmental assessment reports to enable the completion of an overall remedial options review or the development of an overall remedial action plan.

In 2007 the NLDEC commissioned a comprehensive Plan Forward for the Former U.S. Military Site and the Residential Subdivision area in Hopedale. The plan forward was developed following a desktop review of fourteen (14) available environmental assessment reports that were previously completed for the overall site. The Plan Forward served as a framework for development and implementation of remedial action plans/risk management plans for the Former U.S. Military Site and the Residential Subdivision. During the review of existing reports, various data gaps and outstanding actions were identified. The Plan Forward suggested the completion of various studies and investigations at the Former U.S. Military Site and the Residential Subdivision prior to the development of overall remedial action/risk management plans for the areas. The information contained in the Plan Forward was used extensively to develop the scope of work for the current investigation.

1.3 Project Objectives

In general, the project objectives set forth in the Terms of Reference (TOR) prepared by the NLDEC for the Former U.S. Military Site and Residential Subdivision in Hopedale, NL, were as follows:

1. Review existing environmental assessment reports for the sites.
2. Collect additional local information to document the available history of the Former U.S. Military Site as well as the area of the Residential Subdivision, with the intention of identifying areas of the site that may not have been previously investigated.
3. Attend to the concerns of local stakeholders during all aspects of project implementation, including but not limited to the residents of Hopedale, the Inuit Community Government of Hopedale and the Nunatsiavut Government.
4. Complete a Phase II/III ESA at the overall site. Collect additional samples as required to determine the presence/absence of contaminants of concern. Collect additional samples as required to fully delineate the extent of contaminants identified in previous site investigations.
5. Identify areas of potential concern that were not fully investigated. Conduct reconnaissance testing in those areas and make recommendations for further Phase III delineation.
6. Collect additional samples as required to provide data inputs for the HHERA.
7. Review the scope of previous physical hazards and surface debris removal. Evaluate the current extent of on-site physical hazards and surface debris. Make recommendations for further physical hazards mitigation and surface debris removal that may be required.
8. Complete an HHERA for the Former U.S. Military Site and the Residential Subdivision, if necessary.
9. Prepare a RAP/RMP, complete with cost estimates, for the Former U.S. Military Site and the Residential Subdivision. The RAP/RMP will outline alternative approaches and preferred methods to address mitigation of physical hazards, removal of surface debris and remediation of environmental contaminants of concern.

Following the initial site visit in October 2008, the NLDEC requested that the following items be added to the project objectives:

1. Perform a limited remediation of polychlorinated biphenyl (PCB) impacted tar at the former Hopedale military base and radar site.
2. Perform a cleanup of visible and readily removable debris from the stream near the residential subdivision.

1.4 Scope of Work

The scope of work for the Phase II/III ESA, HHERA and RAP/RMP was adapted from the Plan Forward report and revised in March 2009 based on observations made during a preliminary site visit conducted in October 2008. The scope of work for this investigation was limited to a Phase II/III ESA, HHRA, ERA, RAP, RMP, limited PCB-impacted tar remediation and limited debris cleanup. The scope of work for the Former U.S. Military Site and Residential Subdivision was as follows:

- Complete Phase II subsurface test pit and borehole/monitor well investigations for the purposes of investigating potential subsurface soil and groundwater impacts associated with various historical operations and activities, as recommended in the Plan Forward completed for the site.
- Collect representative soil samples from test pits and borehole/monitor wells.
- Collect representative groundwater samples from selected monitor wells.
- Collect representative surface soil samples to assess impacts associated with areas of PCB-impacted tar and known or suspected contaminants to determine the lateral surface extent of contaminant impacts.
- Collect representative sediment and surface water samples from potentially impacted streams, ponds, lakes and the wharf area, as identified in the Plan Forward.
- Carry out headspace vapour screening to select soil and sediment samples for chemical analysis of petroleum hydrocarbons.
- Submit selected soil, sediment, groundwater and surface water samples for laboratory analysis for contaminants of concern (summary of laboratory testing in proceeding sections).
- Collect representative biota samples such as vegetation, berries, small mammals and larger mammals.
- Collect background soil, sediment, groundwater, surface water and biota samples for use in the risk assessments.
- Conduct a limited remediation of PCB-impacted tar from the surface of the bedrock at the three (3) areas identified in the Plan Forward (i.e., Old Base 1, Old Base 2a and Old Base 2b).
- Conduct surface debris cleanup in the stream located northeast of the Residential Subdivision.
- Prepare a report detailing all observations, conclusions and recommendations made during the investigation.
- Carry out a human health risk assessment for the overall site to evaluate the risks to human receptors associated with petroleum hydrocarbons, PCBs, metals and other impacts identified in media; and,

- Carry out an ecological risk assessment for the overall site to evaluate the risks to ecological receptors associated with petroleum hydrocarbon and other impacts in media.

The scope of work does not include the completion of a Phase I ESA or the completion of any remediation work at the sites in excess of the proposed limited remediation of PCB impacted tar and debris cleanup in the stream northeast of the Residential Subdivision.

1.5 Regulatory Framework

1.5.1 Land Usage

The Former U.S. Military Site is primarily a vacant "brownfield" site, with no existing buildings or structures, except for a trailer at the Mid-Canada Line antennae site. The Residential Subdivision is an active residential development.

Existing reports indicate that much of the previously developed portions of the former military base and radar site (i.e., the Former U.S. Military Site) contain large areas of exposed bedrock, with limited soil and vegetative cover. Existing reports indicate that portions of the former military base and radar site are regularly used by Hopedale residents as walking areas, picnic areas, "hangout" areas for children, and for berry picking or hunting. Small mammals such as mice, rabbits and partridge are reported to be present on and around the site. Hopedale residents reportedly hunt rabbits and partridge in the general site area.

1.5.2 Regulatory Considerations

NLDEC Policy Directive PPD05-01 allows a site owner to use either of two approaches when remediating chemical impacts on a site. Remediation of chemical impacts in various site media (e.g., soil, sediment, groundwater, surface water) can be completed using a criteria-based approach or a risk-based approach. Under the criteria-based remedial approach, the defined site impacts are remediated to levels below existing regulatory guidelines for the appropriate media. Under the risk-based remedial approach, the defined site impacts are remediated to levels below site-specific target levels (SSTLs) that are developed for the site during a site-specific human health and ecological (if necessary) risk assessment.

For simple sites and sites with limited impacts, a criteria-based approach to remediation is often applied to guide the extent of removal of impacted media from the site. For more complex sites and sites with extensive impacts from multiple chemicals of concern (COCs), a human health and/or ecological risk assessment is often completed, based on the actual site conditions and the actual human and ecological usage of the site, to derive SSTLs to determine remedial options or a risk management strategy for the site. Experience at other former military Pinetree sites in Newfoundland and Labrador indicates that a risk-based remedial approach is the most appropriate for a complex site such as the one in Hopedale.

In general, previous environmental assessment reports have used the Canadian Council of Ministers of the Environment (CCME) residential/parkland guidelines as screening levels for polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and metals in soil, the CCME interim sediment quality guidelines (ISQGs) and probable effects levels (PELs) as screening levels for PCBs, PAHs, VOCs and metals in freshwater sediment, and the Canadian Drinking Water Quality Guidelines (CDWQGs) as screening levels for surface water.

For this study the following guidelines are considered to be the appropriate screening levels for a risk-based remedial approach at the former military base and radar site and the Residential Subdivision area:

1. The Risk-Based Corrective Action (RBCA) Tier I Risk-Based Screening Levels (RBSLs), for a residential site with potable/non-potable groundwater and coarse soil, for petroleum hydrocarbons in soil and groundwater.
2. The CCME Soil Quality Guidelines for a residential/parkland site for PCBs, PAHs, VOCs and metals in soil.
3. The Ontario Ministry of Environment (OMOE) guideline for total oil and grease in freshwater sediment (also applied to marine sediment).
4. The CCME ISQGs and PELs for freshwater/marine sediment for PCBs, PAHs, VOCs and metals in freshwater and marine sediment.
5. The CCME freshwater aquatic life (FWAL) guidelines for PCBs, PAHs, VOCs, metals and other parameters in surface water that is not used as a source of potable water (e.g., Old Dump Pond and Big Lake).
6. The CDWQGs for PCBs, PAHs, VOCs, metals and other parameters in surface water and groundwater that is used as a source of potable water (e.g., Reservoir and BMEWS sites).
7. The OMOE guidelines for PCBs, metals and other parameters in non-potable groundwater (groundwater on the former military base and radar site and in the Residential Subdivision area is non-potable).
8. The CCME Transformer Decontamination Standards and Protocols (December 1995) for PCBs on the transformer carcass and debris.

As indicated in Section 1.5.1, portions of the former military base and radar site are regularly used by Hopedale residents as walking areas, picnic areas, “hangout” areas for children, and for berry picking or hunting; therefore, residential/parkland guidelines were selected for each individual site.

One (1) Tier I RBSL for petroleum hydrocarbons for a residential site with potable/non-potable groundwater and coarse grained soil (i.e., fuel oil or lube oil impacts) was selected for each individual site. Tier I RBSLs were selected based on the predominant type of product impacting soil and groundwater samples at the site, as indicated by the laboratory (i.e., resemblance), and the petroleum hydrocarbon fraction range with the highest concentrations at the site.

Potable water guidelines were applied to surface water in Reservoir Lake (i.e., the Reservoir site), which is used as the source of potable water for the Town of Hopedale, to surface water from the Second Reservoir, which is used as a back-up potable water source for the Town of Hopedale and to groundwater at the BMEWS site, which is located hydraulically upgradient of

Reservoir Lake. Non-potable guidelines were applied to groundwater and surface water at the remaining sites.

While these guidelines may be appropriate as screening levels for a risk-based remedial approach (i.e., where the remediation levels are established by a site-specific human health and ecological risk assessment), some of the screening level guidelines may be overly conservative if used as remediation levels for a criteria-based remedial approach for the former military base and radar site, based on the actual human and ecological receptor usage of the site. The noted screening level guidelines would be appropriate as remediation levels for a criteria-based remedial approach for the residential subdivision area.

2.0 METHODOLOGY

2.1 Field Procedures

The field component of this project consisted of the identification of debris and physical hazards, the excavation of test pits, borehole drilling and monitor well installation, the collection of soil, sediment, surface water, groundwater, benthic invertebrate, vegetation, berry, small mammal, larger mammal (e.g., rabbits), fish, PCB swab, tar and drum product samples, and the remediation of PCB-impacted tar and debris cleanup. Following an initial site visit completed during the period of October 26 – October 29, 2008, field work was performed during the period of July 14 – August 5, 2009 (Stage 1), August 29 – September 10, 2009 (Stage 2) and September 26 to October 3, 2009 (Stage 3). Field work and site supervision were conducted by environmental consulting field personnel, which included environmental technicians, environmental engineers and environmental scientists, and by local subcontractors. Drilling services were provided by Logan Geotech Inc. of Stewiacke, Nova Scotia. Excavator services were provided by B and R Enterprises of Springdale, NL. Debris removal was conducted by Garfield Flowers of Hopedale, NL. Table 2.1 provides a summary of fieldwork for this project (as described in the project scope) subdivided into individual study sites.

Table 2.1 Summary of Phase II/III ESA Scope of Work

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
BMEWS	Debris and physical hazards. PCB CEPA area (i.e., area of soil with concentrations of PCBs detected above guidelines stated in the *Canadian Environmental Protection Act*) - delineation needed. Possible PCBs in rabbits. Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons, metals and PCBs in groundwater. Seven (7) possible waste sites. Possible petroleum hydrocarbons, PCBs, volatile organic compounds (VOCs) and metals in soil and groundwater if waste sites are confirmed.	67	8	Test pit – soil (113) Monitor well - soil (15) Surface soil (38) Groundwater (8) Vegetation (6) Berries (5) Small mammals (10) PCB Swab (1)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Old Base 1	Debris and physical hazards. PCB CEPA area. Possible PCBs in rabbits. Possible waste site under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (12) Rabbit (1)
Main Base	**<u>Main Base Site (overall site)</u>** Possible metals in soils. Possible metals in vegetation, berries, small mammals and rabbits. 10 possible waste sites – possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites are confirmed. **<u>Old Base 2a</u>** PCB CEPA area. Possible PCBs in rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Old Base 2b</u>** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Radome</u>** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **<u>Near foundations</u>** Possible PCBs and metals in soil. **<u>TACAN East</u>** Possible petroleum hydrocarbons in soil. **<u>Near POL tanks</u>** Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater **<u>Area north and east of Main Base</u>** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in soil.	79	10	Test pit – soil (136) Monitor well - soil (15) Surface soil (74) Septic tank soil (1) Groundwater (10) Vegetation (27) Berries (10) Small mammals (22) Tar (1)
Roadway	Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	6	1	Test pit – soil (6) Monitor well – soil (1) Groundwater (1)
Sewage Outfall	Debris and physical hazards. Possible petroleum hydrocarbon, PCBs, VOCs or metals impacts in soil.	-	-	Surface soil (4)
Valley Drainage Ponds	Potential for contaminants migrating from the BMEWS, Old Base 1, Main Base, Sewage Outfall, Roadway and Pallet Line sites.	-	-	Sediment (7) Vegetation (7) Berries (7) Small mammals (8)
Mid Canada Line	Debris and physical hazards. Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (18) Vegetation (5) Berries (5) Small mammals (10)
Pallet Line	No previous investigation conducted. Transformer oil odour. Potential for petroleum hydrocarbons, PCBs or metals in soil. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	-	-	Surface soil (26)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Pit No. 1/Helipad	Debris and physical hazards. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/drum storage areas under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	18	3	Test pit – soil (25) Monitor well – soil (9) Surface soil (12)
Pit No. 2	Debris and physical hazards. Potential for contaminants migrating from the Pallet Line site. Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	36	3	Test pit – soil (59) Monitor well - soil (10) Surface soil (17) Groundwater (3)
Pit No. 3	Debris and physical hazards. Possible free phase petroleum product. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	16	6	Test pit – soil (23) Monitor well - soil (16) Surface soil (10) Groundwater (6)
Small Pond Bog	**Small Pond Bog** Debris and physical hazards. Delineate TPH, PCBs and metals in sediment. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (5) Benthic (1)
	Drainage Stream Northeast of Small Pond Bog No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Surface soil (4) Sediment (3)
	Drainage Stream from Pit No. 3 No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (3)
POL Compound	Debris and physical hazards. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste site in gully. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	3	4	Test pit – soil (4) Monitor well – soil (2) Surface soil (4) Groundwater (4)
Old Dump Pond	**Old Dump Pond** Debris and physical hazards. Delineate PCBs, metals, VOCs in sediment and VOCs and metals in water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (10) Surface water (3) Fish (4) Benthic (1)
	Drainage Streams (2) from Old Dump Pond No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (3)
	Area between subdivision and Old Dump Pond Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed.	9	6 + 5 auger bore-holes	Test pit – soil (13) Monitor well - soil (17) Auger – soil (11) Surface soil (5) Groundwater (6)
Pipeline	Debris and physical hazards. No previous investigation conducted in the wharf and construction camp areas. Potential for petroleum hydrocarbons in soil near existing sections of pipeline and former pipeline location.	-	10	Monitor well - soil (32) Surface soil (8) Groundwater (10)
Wharf Area	**Marine area near wharf and drainage outlets** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (17)

Site Name	Issues	Test Pits	Monitor Wells	Samples Collected
Old Dam	**Drainage Stream at Old Dam area** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	-	-	Sediment (5)
Reservoir	Debris and physical hazards. Delineate PCBs and metals in sediment and PCBs, metals and general chemistry in water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	-	-	Sediment (8) Surface water (3) Fish (1) Benthic (1)
Second Reservoir	No previous investigation conducted. Possible PCBs and metals in sediment and surface water. Test benthic invertebrates, grain size analysis for risk assessment.	-	-	Sediment (5) Surface water (3) Benthic (1)
Residential Subdivision	**Residential Subdivision** Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed. Two former waste disposal areas and on additional possible waste site – further investigations needed. Possible petroleum hydrocarbons in the vicinity of the remediated area.	15	18	Test pit – soil (22) Monitor well - soil (41) Surface soil (36) Groundwater (17) PCB Swab (1) Tar (1)
	Stream that passes through Residential Subdivision Possible petroleum hydrocarbons, PCBs, metals, PAHs and VOCs in sediment and surface water.	-	-	Sediment (4) Surface water (6)
Big Lake	Background PCBs, metals concentrations in sediment, surface water, fish and benthic invertebrates for use in risk assessments.	-	-	Sediment (3) Surface water (3) Fish (5) Benthic (1)
Clean Background Area	Background metals concentrations in soil, vegetation, berries, small mammals, rabbits and fish for use in risk assessments.	-	-	Surface soil (7) Sediment (3) Vegetation (7) Berries (7) Small mammals (2) Fish (1)
Total		**249**	**69 + 5 auger bore-holes**	**Test pit – soil (401)** **Monitor well – soil (158)** **Auger – soil (11)** **Surface soil (271)** **Sept tank soil (1)** **Sediment (77)** **Surface water (18)** **Groundwater (64)** **Vegetation (53)** **Berries (37)** **Small mammals (56)** **Benthic (5)** **Fish (11)** **Tar (2)** **PCB Swab (6)** **Drum Product (1)**

2.1.1 Surface Debris and Physical Hazards Survey

During the initial site inspection conducted in October 2008, an environmental engineer and an environmental technician identified several potential waste sites at the overall site. Potential waste sites were identified based on areas of visibly disturbed soil, areas where surface debris/partially buried debris was observed and in valleys located near the foundations where former site infrastructure was likely buried. The potential waste sites identified during the initial site inspection were investigated when the test pits were excavated. Details of the buried debris items encountered in test pits were logged by field personnel at the time of test pit excavation and are presented in the Test Pit Records in Appendices 2c to 21c. The identified areas of surface debris, buried debris and physical hazards are identified in Section 3.

With the exception of a transformer carcass found at the BMEWS site and surface debris observed in the stream located northeast of the Residential Subdivision, surface debris observed at the overall site was also left in place. Buried debris encountered in the test pits was left in place at all sites on the Former U.S. Military Site. Buried debris encountered in test pits in the Residential Subdivision was removed from the overall site, as described below. All liquid resembling free product that was found in drums throughout the overall site was collected and removed from the overall site.

2.1.2 Debris Cleanup

Visible debris within the stream located northeast of the Residential Subdivision and buried debris encountered in the test pits in the Residential Subdivision were removed using a John Deere 310D track mounted excavator supplied by B and R Enterprises of Springdale, NL. Debris was loaded into a tandem truck provided by Garfield Flowers of Hopedale and transported to a lay-down site at the Pit No. 1/Helipad site for temporary storage and inspection. At the lay-down site, large tarps were placed under and on top of the debris to prevent potential contaminants of concern from leaching into the underlying and surrounding soil. Debris was inspected to ensure that it did not contain solid or liquid contaminants. Drums and similar vessels were swabbed for PCB content. Where possible, empty metal drums were flattened after inspection and testing. The transformer carcass found at the BMEWS site was manually loaded onto an ATV trailer and transported to the lay-down site at the Pit No. 1/Helipad site. Photos taken of the remedial activities in the stream are provided in Appendix 21a. A photo of the transformer carcass is provided in Appendix 2a.

Prior to the removal of the transformer carcass from the BMEWS site, a PCB swab sample (i.e., PCB SWAB-1) was collected from the carcass. At the lay-down site, five (5) PCB swab samples (i.e., PCB SWAB-2 to PCB SWAB-6) were taken from the debris. Swab samples were collected over a 10 cm by 10 cm area (i.e., 100 cm^2) using swabs prepared by Maxxam Analytics Inc. Swab samples were submitted to Maxxam Analytics Inc. in Bedford, NS for analysis of the mass of PCBs present in each sample. Results of the PCB swab analysis are presented in Appendices 2e and 21e and discussed in Section 3.

Once the PCB swab results were received, the surface debris and transformer carcass in the lay-down area at the Pit No. 1/Helipad site were transported to the Hopedale Landfill with the tandem truck for disposal.

All liquid resembling free product that was found in drums throughout the overall site was collected and disposed of at the Hopedale landfill. One (1) sample of the liquid was collected into a clean sample jar and submitted to Maxxam Analytics Inc. for product characterization. Laboratory results indicated that the product resembled a combination of fuel oil and lube oil fractions and are presented in Appendix 25.

2.1.3 Limited Remediation of PCB-Impacted Tar

A previous site investigation conducted by the Royal Military College (Hopedale Former Military Site Soil Delineation Report, Hopedale, Newfoundland & Labrador, report dated May, 2007) indicated the presence of three (3) areas (i.e., Old Base 1, Old Base 2a and Old Base 2b) on the former military base and radar site with hardened PCB-impacted tar on exposed bedrock. The measured PCB concentrations in the tar from these areas ranged from 29,000 mg/kg to 1,000,000 mg/kg. The PCB-impacted tar was manually removed (using hand scrapers and powered chippers) from the surface of the bedrock, manually picked up and placed into 205 L open-top drums. The drums were filled ¾ full and were properly labelled for transportation. The drums were transported via plane from Hopedale to Goosebay, then via road and barge to the Newalta facility in Foxtrap, NL. Newalta provided a dedicated, specially equipped transportation vehicle for road transportion between Goose Bay and the final disposal facility. The vehicle met all Transportation of Dangerous Goods (TDG) requirements and was operated by licenced, specially trained personnel with experience in PCB waste transportation for drums. The transportion vehicle was inspected regularly for leaks or breaches of containment during transport.

Photos taken of the PCB-impacted tar remedial activities are provided in Appendices 3a and 4a.

The requirement for further remediation, including the removal and disposal of soil and vegetation and the installation of a concrete capping layer over the previously identified PCB-impacted tar areas, will be evaluated after the completion of the human health and ecological risk assessment. Two (2) additional areas of tar-like materials were observed at the Main Base Site and at in the Residential Subdivision, respectively. Samples of the tar-like materials were collected into clean sample jars and submitted to Maxxam Analytics Inc. for product characterization and PCB analysis. Laboratory results for tar analysis are presented in Section 3.

2.1.4 Phase II/III Environmental Site Assessment

The Phase II/III Environmental Site Assessment involved the excavation of test pits, borehole drilling complete with monitor well installation and the associated soil and groundwater sampling and analysis as well as the collection of surface soil, freshwater sediment, marine sediment, surface water, groundwater, benthic invertebrate, vegetation, berry, small mammal, larger mammal (e.g., rabbits) and fish samples.

Borehole and test pit locations were selected by the environmental consultants in target areas of concern. Actual borehole and test pit locations were established in the field by the environmental consultants and referenced to known site features. GPS coordinates were recorded at borehole, test pit and sample locations. Site location plans in Appendix 1 show test pit and borehole/monitor well locations, as well as sample locations for each site.

2.1.4.1 Test Pit Excavation and Sampling Program

A total of 249 test pits were excavated using a John Deere 310D track mounted excavator supplied by B and R Enterprises of Springdale, NL. The test pits were excavated to the groundwater table, bedrock or the maximum reach of the excavator to depths ranging from 0.1

to 5.0 metres below ground surface (mbgs), and were backfilled with excavated material upon completion. Subsurface conditions encountered in the test pits, including details of the buried debris, were logged by field personnel at the time of excavating and are presented in the Test Pit Records in Appendices 2c to 21c. The locations of the test pits were established based on the potential waste sites identified in October, 2008 and based on areas with known or potential impacts. GPS coordinates of each location were collected and are provided in Appendices 2b to 21b. Where possible, laminated tags showing the test pit numbers were placed at test pit locations.

A summary of test pits excavated during this investigation is provided below in Table 2.2.

Table 2.2 Test Pit Summary

Test Pit ID	GW Depth (mbgs)	TP Depth (m)	Bed-rock	Debris	Site Name	Test Pit ID	GW Depth (mbgs)	TP Depth (m)	Bed-rock	Debris	Site Name
TP1	Dry	0.51	*	*	Main Base	TP38	Dry	1.2	*	*	Main Base
TP2	Dry	0.76	*		Main Base	TP39	Dry	1.0	*	*	Main Base
TP3	0.89	0.89			Main Base	TP40	Dry	1.0	*	*	Main Base
TP4	Dry	0.25	*		Main Base	TP41	Dry	0.8	*	*	Main Base
TP5	Dry	0.51	*		Main Base	TP42	Dry	1.5	*	*	Main Base
TP6	Dry	0.64	*		Main Base	TP43	Dry	1.7	*	*	Main Base
TP7	Dry	0.76	*		Main Base	TP44	Dry	1.9	*	*	Main Base
TP8	Dry	1.02	*	*	Main Base	TP45	Dry	0.6	*		Main Base
TP9	Dry	0.64	*		Main Base	TP46	Dry	1.6	*	*	Main Base
TP10	0.2	0.20	*		Main Base	TP47	Dry	1.3		*	Main Base
TP11	Dry	0.36	*	*	Main Base	TP48	Dry	1.3	*	*	Main Base
TP12	Dry	0.89	*		Main Base	TP49	Dry	1.1	*	*	Main Base
TP13	1.14	1.14	*		Main Base	TP50	1.4	1.4	*	*	Main Base
TP14	Dry	0.38	*		Main Base	TP51	Dry	1.2	*	*	Main Base
TP15	Dry	0.51	*		Main Base	TP52	Dry	0.8	*	*	Main Base
TP16	Dry	0.25	*		Main Base	TP53	Dry	0.6	*	*	Main Base
TP17	Dry	1.02	*	*	Main Base	TP54	Dry	1.3	*		Main Base
TP18	Dry	1.40	*	*	Main Base	TP55	Dry	0.3	*	*	Main Base
TP19	Dry	1.27	*	*	Main Base	TP56	Dry	0.4	*	*	Main Base
TP20	Dry	1.27	*	*	Main Base	TP57	Dry	0.5	*	*	Main Base
TP21	Dry	1.02	*	*	Main Base	TP58	0.8	1.0	*	*	Main Base
TP22	Dry	0.38	*	*	Main Base	TP59	0.9	1.0	*	*	Main Base
TP23	Dry	0.64	*	*	Main Base	TP60	0.8	1.0	*		Main Base
TP24	1.14	1.14	*	*	Main Base	TP61	0.3	0.4	*		Main Base
TP25	Dry	1.02	*	*	Main Base	TP62	Dry	0.6	*	*	Main Base
TP26	Dry	0.64	*		Main Base	TP63	Dry	0.2	*		Main Base
TP27	Dry	0.97	*		Main Base	TP64	0.3	0.3	*		Main Base
TP28	Dry	0.58	*		Main Base	TP65	Dry	0.2	*		Main Base
TP29	Dry	0.51	*		Main Base	TP66	Dry	2.8	*	*	Main Base
TP30	Dry	1.32	*	*	Main Base	TP67	Dry	3.0	*	*	Main Base
TP31	Dry	0.89	*	*	Main Base	TP68	Dry	0.9	*	*	Main Base
TP32	Dry	0.76	*	*	Main Base	TP69	1.4	1.4		*	Main Base
TP33	Dry	1.78	*	*	Main Base	TP70	1.5	1.5	*		Main Base
TP34	Dry	1.07	*	*	Main Base	TP71	1.7	1.7	*		Main Base
TP35	Dry	0.71	*		Main Base	TP72	Dry	0.7	*	*	Main Base
TP36	Dry	1.42	*	*	Main Base	TP73	Dry	0.9	*	*	BMEWS
TP37	Dry	1.37	*	*	Main Base	TP74	Dry	0.9	*	*	BMEWS

Test Pit ID	GW Depth (mbgs)	TP Depth (m)	Bed-rock	Debris	Site Name
TP75	0.7	0.7	*	*	BMEWS
TP76	0.6	0.6	*		BMEWS
TP77	Dry	0.8	*		BMEWS
TP78	0.9	1.2		*	BMEWS
TP79	Dry	1.2	*	*	BMEWS
TP80	Dry	1.0		*	BMEWS
TP81	0.7	0.7	*		BMEWS
TP82	Dry	0.2	*		BMEWS
TP83	Dry	0.2	*		BMEWS
TP84	Dry	0.4	*		BMEWS
TP85	0.9	0.9	*		BMEWS
TP86	Dry	0.3	*		BMEWS
TP87	Dry	0.5	*		BMEWS
TP88	0.2	0.3	*		BMEWS
TP89	Dry	0.7	*		BMEWS
TP90	Dry	1.6	*		BMEWS
TP91	0.8	0.8	*	*	BMEWS
TP92	Dry	0.7	*		BMEWS
TP93	1.0	1.0	*	*	BMEWS
TP94	Dry	2	*	*	BMEWS
TP95	Dry	1.4	*	*	BMEWS
TP96	Dry	1.1	*	*	BMEWS
TP97	Dry	0.8	*	*	BMEWS
TP98	0.9	1.1	*	*	BMEWS
TP99	Dry	1.0	*	*	BMEWS
TP100	Dry	1.3	*	*	BMEWS
TP101	Dry	1.5		*	BMEWS
TP102	Dry	0.1	*		BMEWS
TP103	0.7	1.0	*	*	BMEWS
TP104	Dry	0.3	*	*	BMEWS
TP105	Dry	0.8		*	BMEWS
TP106	0.8	0.9	*	*	BMEWS
TP107	Dry	1.0	*	*	BMEWS
TP108	0.9	0.9	*		BMEWS
TP109	Dry	1.7	*	*	BMEWS
TP110	Dry	1.3	*	*	BMEWS
TP111	Dry	1.2		*	BMEWS
TP112	Dry	2.0	*	*	BMEWS
TP113	Dry	2.1	*		BMEWS
TP114	Dry	1.4	*	*	BMEWS
TP115	Dry	0.2	*		BMEWS
TP116	Dry	1.7	*	*	BMEWS
TP117	Dry	1.4			BMEWS
TP118	Dry	1.8	*		BMEWS
TP119	Dry	0.9	*		BMEWS
TP120	Dry	0.5	*		BMEWS
TP121	Dry	0.4	*		BMEWS
TP122	Dry	0.3	*		BMEWS
TP123	0.8	1.1	*	*	BMEWS
TP124	Dry	0.6	*		BMEWS
TP125	0.8	0.8	*		BMEWS

Test Pit ID	GW Depth (mbgs)	TP Depth (m)	Bed-rock	Debris	Site Name
TP126	Dry	0.8	*		BMEWS
TP127	0.8	0.8	*		BMEWS
TP128	Dry	0.9	*	*	BMEWS
TP129	Dry	1.5	*	*	BMEWS
TP130	Dry	0.3	*		BMEWS
TP131	Dry	0.8	*	*	BMEWS
TP132	0.7	0.7	*		BMEWS
TP133	Dry	0.2	*		BMEWS
TP134	Dry	0.9	*		BMEWS
TP135	Dry	0.7	*		BMEWS
TP136	Dry	0.6	*		BMEWS
TP137	Dry	0.4	*		BMEWS
TP138	0.7	0.7	*		BMEWS
TP139	Dry	1.1	*		BMEWS
TP140	Dry	0.3	*		POL Compound
TP141	Dry	0.2	*	*	POL Compound
TP142	0.1	0.3	*	*	POL Compound
TP143	Dry	0.8	*	*	Pit No. 1
TP144	Dry	1.5	*	*	Pit No. 1
TP145	Dry	0.6	*	*	Pit No. 1
TP146	Dry	1.0	*	*	Pit No. 1
TP147	Dry	2.0	*	*	Pit No. 1
TP148	Dry	1.4	*	*	Pit No. 1
TP149	Dry	0.3	*	*	Pit No. 1
TP150	Dry	0.6	*		Pit No. 1
TP151	Dry	0.5	*		Pit No. 1
TP152	Dry	1.4	*		Pit No. 1
TP153	Dry	0.8	*		Pit No. 1
TP154	Dry	0.4	*		Pit No. 1
TP155	Dry	0.6	*		Pit No. 1
TP156	Dry	0.3	*		Pit No. 1
TP157	2.1	2.2			Pit No. 1
TP158	Dry	1.5	*		Pit No. 1
TP159	Dry	0.6	*		Pit No. 1
TP160	1.0	1.0	*		Pit No. 1
TP161	1.6	1.8	*		Pit No. 3
TP162	1.5	1.7	*	*	Pit No. 3
TP163	0.5	0.5	*		Pit No. 3
TP164	1.7	1.7	*		Pit No. 3
TP165	0.8	0.8	*		Pit No. 3
TP166	Dry	0.6	*		Pit No. 3
TP167	Dry	0.5	*		Pit No. 3
TP168	Dry	0.9	*		Pit No. 3
TP169	Dry	1.5	*		Pit No. 3
TP170	Dry	1.6	*		Pit No. 3
TP171	Dry	0.1	*		Pit No. 3
TP172	Dry	0.3	*		Pit No. 3
TP173	Dry	0.2	*	*	Pit No. 3
TP174	Dry	0.7	*	*	Pit No. 3
TP175	0.5	0.6	*	*	Pit No. 3

Test Pit ID	GW Depth (mbgs)	TP Depth (m)	Bed-rock	Debris	Site Name
TP176	Dry	0.7	*		Pit No. 3
TP177	Dry	1.1	*		Pit No. 2
TP178	2.6	2.6	*		Pit No. 2
TP179	Dry	1.2	*		Pit No. 2
TP180	Dry	1.5	*		Pit No. 2
TP181	Dry	1.6	*		Pit No. 2
TP182	5.0	5.0	*		Pit No. 2
TP183	3.4	3.4	*		Pit No. 2
TP184	4.1	4.1	*		Pit No. 2
TP185	1.2	1.2	*	*	Pit No. 2
TP186	0.9	0.9	*	*	Pit No. 2
TP187	1.3	2.2	*	*	Pit No. 2
TP188	1.3	1.4	*		Pit No. 2
TP189	Dry	3.8	*		Pit No. 2
TP190	Dry	3.1	*		Pit No. 2
TP191	Dry	2.7	*		Pit No. 2
TP192	Dry	1.0	*		Pit No. 2
TP193	Dry	0.4	*		Pit No. 2
TP194	Dry	1.0	*		Pit No. 2
TP195	Dry	0.7	*		Pit No. 2
TP196	Dry	0.1	*		Pit No. 2
TP197	Dry	0.6	*		Pit No. 2
TP198	0.8	0.8	*		Pit No. 2
TP199	Dry	0.4	*		Pit No. 2
TP200	Dry	0.3	*		Pit No. 2
TP201	0.9	0.9	*		Pit No. 2
TP202	1.2	1.2	*		Pit No. 2
TP203	Dry	1.4	*		Pit No. 2
TP204	2.2	2.2	*		Pit No. 2
TP205	Dry	1.7	*		Pit No. 2
TP206	3.0	3.0	*		Pit No. 2
TP207	2.5	2.5	*		Pit No. 2
TP208	2.7	2.7	*		Pit No. 2
TP209	Dry	1.1	*		Pit No. 2
TP210	Dry	0.2	*		Pit No. 2
TP211	1.0	1.0	*		Pit No. 2
TP212	Dry	0.2	*		Pit No. 2
TP213	Dry	1.0	*		Roadway
TP214	Dry	0.7	*		Roadway
TP215	Dry	1.2	*		Roadway
TP216	0.6	0.6	*		Roadway
TP217	Dry	0.3	*		Roadway
TP218	Dry	1.1	*		Roadway
TP219	Dry	0.8	*		Main Base
TP220	Dry	1.5	*	*	Main Base
TP221	Dry	1.6	*	*	Main Base
TP222	Dry	1.7	*	*	Main Base
TP223	Dry	0.5	*		Main Base
TP224	Dry	0.2	*		Main Base
TP225	Dry	1.7	*	*	Main Base
TP226	Dry	0.3	*		Old Dump Pond
TP227	Dry	0.3	*		Old Dump Pond
TP228	2.8	2.8		*	Old Dump Pond
TP229	Dry	0.25	*	*	Old Dump Pond
TP230	Dry	0.6	*	*	Old Dump Pond
TP231	0.9	2.4	*	*	Old Dump Pond
TP232	1.5	1.8		*	Old Dump Pond
TP233	2.8	2.8		*	Old Dump Pond
TP234	1.2	2.3		*	Old Dump Pond
TP235	Dry	0.1	*		Subdivision
TP236	Dry	0.2	*		Subdivision
TP237	Dry	0.1			Subdivision
TP238	Dry	0.8		*	Subdivision
TP239	Dry	0.1			Subdivision
TP240	Dry	0.2			Subdivision
TP241	Dry	0.2	*		Subdivision
TP242	Dry	0.3			Subdivision
TP243	Dry	0.4			Subdivision
TP244	Dry	3.2			Subdivision
TP245	Dry	2.0			Subdivision
TP246	Dry	1.5	*		Subdivision
TP247	Dry	0.5		*	Subdivision
TP248	0.0	1.3		*	Subdivision
TP249	Dry	2.8			Subdivision

Notes :
mbgs = metres below ground surface
Bedrock: * Indicates that excavator refusal suggested probable bedrock at base of test pit.
Debris: * Indicates that debris (e.g. metal pipes, wood, crushed drums, etc.) was encountered in the test pit

Soils were sampled from the test pits by bulk sample methods. Soil samples were recovered from the test pits at frequent intervals over their respective depths, the number of which varied with the test pit depth. In general, soil samples were collected at near-surface, maximum depth, groundwater level and every 1 m of depth or change of strata. A total of 401 soil samples were collected from the test pits. The soil samples were visually examined in the field for any evidence of petroleum hydrocarbon or other potential impacts. The samples were placed in clean glass jars with aluminum foil under the lids. Head space soil vapour concentrations were measured in the sample jars using a MiniRAE 2000 PID. These PID readings are presented on the Soil Vapour Concentration tables in Appendices 2d to 21d. The samples were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Based on the measured soil vapor concentrations, field observations and site usage and history, select soil samples were submitted to Maxxam Analytics Inc. for required laboratory analysis, according to the chemical parameters of concern.

2.1.4.2 Surface Soil Sampling Program

A total of 271 near-surface (i.e., 0 - 0.4 m depth) bulk soil samples were collected at various locations on the site to characterize or delineate the extent of various chemicals of concern in soil. Surface soil samples were collected in clean background areas as well as in suspected impacted areas. Where possible, surface soil samples were collected from natural drainage routes to determine the highest concentrations of contaminants of concern. A summary of surface samples collected during this investigation is provided below in Table 2.3.

Table 2.3 Surface Soil Summary

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
BS1		0.20		*	BMEWS
BS2		0.24		*	BMEWS
BS3		0.20		*	BMEWS
BS4		0.09	*		BMEWS
BS5		0.10		*	BMEWS
BS6		0.22		*	BMEWS
BS7		0.12		*	BMEWS
BS8		0.30		*	BMEWS
BS9		0.20			BMEWS
BS10		0.25			BMEWS
BS11		0.24		*	BMEWS
BS12		0.20		*	BMEWS
BS13		0.25		*	BMEWS
BS14		0.15		*	BMEWS
BS15		0.20			BMEWS
BS16		0.12			BMEWS
BS17		0.20			BMEWS
BS18		0.18			BMEWS
BS19		0.25			BMEWS
BS20		0.25			BMEWS
BS21		0.13			BMEWS
BS22		0.15	*	*	BMEWS
BS23		0.20			BMEWS
BS24		0.15			BMEWS
BS25		0.15			BMEWS
BS26		0.15			BMEWS
BS27		0.20		*	BMEWS
BS28		0.20			BMEWS
BS29		0.13			BMEWS
BS30		0.15			BMEWS
BS31		0.22			BMEWS
BS32		0.20			BMEWS
BS33		0.13			BMEWS
BS34		0.20			BMEWS
BS35		0.15			BMEWS
BS36		0.10			BMEWS
BS37		0.07			BMEWS
BS38		0.07			BMEWS
BS39		0.08		*	POL Compound
BS40		0.14		*	POL Compound
BS41		0.10	*	*	POL Compound
BS42		0.13			POL Compound
BS43		0.14			Main Base
BS44		0.05	*	*	Main Base
BS45		0.08			Main Base
BS46		0.15		*	Main Base
BS47		0.10			Main Base
BS48		0.10			Main Base
BS49		0.10			Main Base
BS50		0.12			Main Base

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
BS51		0.15		*	Main Base
BS52		0.17			Main Base
BS53		0.08			Main Base
BS54		0.12			Main Base
BS55		0.15			Main Base
BS56		0.14			Main Base
BS57		0.17		*	Main Base
BS58		0.20		*	Main Base
BS59		0.20			Main Base
BS60		0.15		*	Main Base
BS61		0.15			Main Base
BS62		0.09			Main Base
BS63		0.20			Main Base
BS64		0.24			Main Base
BS65		0.15		*	Main Base
BS66		0.15			Main Base
BS67		0.14			Main Base
BS68		0.22			Main Base
BS69		0.25			Main Base
BS70		0.15		*	Main Base
BS71		0.12		*	Main Base
BS72		0.15			Main Base
BS73		0.20			Main Base
BS74		0.12		*	Main Base
BS75		0.05			Main Base
BS76		0.04			Main Base
BS77		0.15			Main Base
BS78		0.10	*	*	Main Base
BS79		0.08			Main Base
BS80		0.12			Main Base
BS81		0.12			Main Base
BS82		0.10			Main Base
BS83		0.05		*	Main Base
BS84		0.10		*	Main Base
BS85		0.14			Main Base
BS86		0.10			Main Base
BS87		0.12			Main Base
BS88		0.05			Main Base
BS89		0.20			Main Base
BS90		0.10			Main Base
BS91		0.12			Main Base
BS92		0.12			Main Base
BS93		0.10			Main Base
BS94		0.10			Main Base
BS95		0.05	*		Main Base
BS96		0.13			Main Base
BS97		0.15			Main Base
BS98		0.12		*	Main Base

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
BS99		0.15			Main Base
BS100		0.15		*	Main Base
BS101		0.12			Main Base
BS102		0.15		*	Main Base
BS103		0.15			Main Base
BS104		0.05	*	*	Main Base
BS105		0.09	*	*	Main Base
BS106		0.20			Main Base
BS107		0.12		*	Main Base
BS108		0.20			Main Base
BS109		0.20			Main Base
BS110		0.20			Main Base
BS111		0.18			Main Base
BS112		0.22			Main Base
BS113	*	0.18			Main Base
BS114		0.15	*		Pallet Line
BS115		0.10	*	*	Pallet Line
BS116	*	0.15	*	*	Pallet Line
BS117		0.10	*		Pallet Line
BS118		0.20	*		Pallet Line
BS119		0.30	*		Pallet Line
BS120		0.12	*		Pallet Line
BS121		0.03			Old Base 1
BS122		0.11			Old Base 1
BS123		0.05			Old Base 1
BS124		0.07			Old Base 1
BS125		0.05			Old Base 1
BS126		0.02			Old Base 1
BS127		0.02			Old Base 1
BS128		0.08			Old Base 1
BS129		0.05			Old Base 1
BS130		0.03			Old Base 1
BS131		0.05			Old Base 1
BS132		0.04			Old Base 1
BS133		0.05		*	Mid-Canada Line
BS134		0.05			Mid-Canada Line
BS135		0.10		*	Mid-Canada Line
BS136		0.02			Mid-Canada Line
BS137		0.06			Mid-Canada Line
BS138		0.04			Mid-Canada Line
BS139		0.05			Mid-Canada

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
					Line
BS140		0.05		*	Mid-Canada Line
BS141		0.05			Mid-Canada Line
BS142		0.07			Mid-Canada Line
BS143		0.05			Mid-Canada Line
BS144		0.10			Mid-Canada Line
BS145		0.05			Mid-Canada Line
BS146	*	0.05	*		Pallet Line
BS147	*	0.08	*		Pallet Line
BS148		0.04	*		Pallet Line
BS149		0.13	*		Pallet Line
BS150		0.06	*		Pallet Line
BS151		0.12			Pallet Line
BS152		0.10			Sewage Outfall
BS153		0.28	*		Sewage Outfall
BS154		0.12	*		Sewage Outfall
BS155		0.10		*	Sewage Outfall
BS156		0.05			Pallet Line
BS157		0.10	*		Pallet Line
BS158		0.09			Pallet Line
BS159		0.05	*		Pit No. 1
BS160		0.15			Pit No. 1
BS161		0.20			Pit No. 1
BS162		0.15			Pit No. 1
BS163		0.10	*		Pit No. 1
BS164		0.05	*		Pit No. 1
BS165		0.20			Pit No. 1
BS166		0.13	*		Pit No. 1
BS167		0.15			Pit No. 1
BS168		0.18			Pit No. 1
BS169		0.15		*	Pit No. 1
BS170		0.14			Pit No. 1
BS171		0.20			Pit No. 2
BS172		0.15			Pit No. 2
BS173		0.22			Pit No. 2
BS174		0.18			Pit No. 2
BS175		0.25			Pit No. 2
BS176		0.25			Pit No. 2
BS177		0.25			Pit No. 2

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
BS178		0.17	*		Pit No. 2
BS179		0.08			Pit No. 2
BS180	*	0.30			Pit No. 2
BS181		0.25			Pit No. 2
BS182		0.40			Pit No. 2
BS183		0.10			Pit No. 2
BS184		0.14			Pit No. 2
BS185		0.28		*	Pit No. 2
BS186		0.10			Pit No. 2
BS187		0.18			Pit No. 2
BS188		0.20			Subdivision
BS189		0.05	*		Subdivision
BS190		0.20			Subdivision
BS191		0.15			Subdivision
BS192		0.12			Subdivision
BS193		0.15			Subdivision
BS194		0.12			Subdivision
BS195		0.15			Subdivision
BS196		0.15	*		Subdivision
BS197		0.12			Subdivision
BS198		0.15			Subdivision
BS199		0.08			Subdivision
BS200		0.12			Subdivision
BS201		0.18			Subdivision
BS202		0.10			Subdivision
BS203	*	0.25			Subdivision
BS204		0.13			Subdivision
BS205		0.18			Subdivision
BS206		0.10			Subdivision
BS207		0.10			Subdivision
BS208		0.19			Subdivision
BS209		0.10			Subdivision
BS210		0.18			Subdivision
BS211		0.22			Subdivision
BS212		0.25			Subdivision
BS213		0.20			Subdivision
BS214		0.25			Subdivision
BS215		0.15			Subdivision
BS216		0.20			Subdivision
BS217		0.25			Subdivision
BS218		0.15	*		Subdivision
BS219		0.13			Subdivision
BS220		0.19			Subdivision
BS221		0.13			Subdivision
BS222		0.28			Subdivision
BS223		0.20			Subdivision
BS224		0.14			Old Dump Pond
BS225		0.09	*		Old Dump

Surface Soil ID	Water	Sample Depth (m)	Bed-rock	Debris	Site Name
					Pond
BS226		0.11	*		Old Dump Pond
BS227		0.19	*		Old Dump Pond
BS228		0.10	*		Old Dump Pond
BS229		0.22			Wharf Area
BS230		0.06	*		Wharf Area
BS231		0.10	*		Wharf Area
BS232		0.05	*		Wharf Area
BS233		0.18			Wharf Area
BS234		0.21			Wharf Area
BS235		0.22			Wharf Area
BS236		0.08	*		Wharf Area
BS237		0.20			Pit No. 3
BS238	*	0.17			Pit No. 3
BS239		0.20			Pit No. 3
BS240	*	0.25			Pit No. 3
BS241		0.15	*		Pit No. 3
BS242		0.08			Small Pond Bog
BS243		0.17			Small Pond Bog
BS244		0.20			Small Pond Bog
BS245		0.15			Main Base
BS246		0.15			Main Base
BS247		0.15			Old Base 1
BS248		0.15			Pallet Line
BS249		0.15			Background
BS250		0.15			Background
BS251		0.15			Background
BS252		0.15			Background
BS253		0.15			Background
BS254		0.15			Background
BS255		0.15			Background
BS256		0.15			Small Pond Bog
BS257		0.15			Mid-Canada Line
BS258		0.15			Mid-Canada Line
BS259		0.15			Mid-Canada Line
BS260		0.15			Mid-Canada Line
BS261		0.15			Mid-Canada Line
BS262		0.15			NR
BS263		0.15			NR
BS264		0.15			NR
BS265		0.15			Main Base
BS266		0.15			NR
BS267		0.15			Pit No. 3
BS268		0.15			Pit No. 3
BS269		0.15			Pit No. 3
BS270		0.15			Pit No. 3
BS271		0.15			Pit No. 3

Notes :
Water: * Indicates that water was encountered in the sample pit
Bedrock: * Indicates that refusal at base of sample pit was at bedrock
Debris: * Indicates that debris (e.g. metal, wood, concrete, asbestos, paint, etc.) was encountered in the sample pit
NR: Site coordinates not recorded

The near-surface soil samples were collected manually using clean sampling equipment. The soil samples were visually examined in the field for any evidence of petroleum hydrocarbon impacts. The samples were placed in clean glass jars with aluminum foil under the lids. Head space soil vapour concentrations were measured in the sample jars using a MiniRAE 2000 PID. These PID readings are presented on the Soil Vapour Concentration tables in Appendices 2d to 23d. The samples were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Based on the measured soil vapor concentrations, field observations and site usage and history, select soil samples were submitted to Maxxam Analytics Inc. for required laboratory analysis, according to the chemical parameters of concern.

2.1.4.3 Borehole / Monitor Well Installation and Sampling Program

A total of 74 boreholes were drilled using a track-mounted CME850 auger drill rig and were terminated at depths below ground surface ranging from 1.52 to 9.14 m. Boreholes were augered through overburden soils. Advancement through bedrock was conducted using wash boring techniques. Continuous soil sampling was conducted preceding casing advance. Boreholes were drilled by Logan Geotech Inc. of Stewiacke, Nova Scotia. A track-mounted drill was used since several areas of the site are not easily accessible. Road construction/brush removal was not required.

Subsurface conditions encountered in the boreholes were logged by field personnel at the time of drilling. Borehole/monitor wells were drilled to determine if contaminants of concern were leaching into groundwater, therefore borehole locations were chosen based on waste site locations identified through test pits excavation and in impacted areas indentified through test pit and surface soil sample analysis. Borehole/monitor wells were placed directly in areas with known impacts or downgradient of these areas. The locations of the boreholes were established in the field by field personnel through collection of GPS coordinates. A summary of borehole/monitor wells drilled during this investigation is provided below in Table 2.4.

Table 2.4 Monitor Well and Borehole Summary

Monitor Well ID	BH Depth (m)	Depth to water (mbgs)	MW screen depth (mbgs)	Site Name
MW1	5.64	2.62	1.07 - 5.64	Main Base
MW2	5.64	1.75	1.07 - 5.64	Main Base
MW3	5.64	3.13	1.07 - 5.64	Main Base
MW4	4.57	2.13	0.61 - 4.57	Main Base
MW5	5.64	4.63	1.07 - 5.64	Main Base
MW6	4.57	vandalized	0.91 - 4.57	Main Base
MW7	5.49	2.47	0.92 - 5.49	Roadway
MW8	4.57	3.17	1.52 - 4.57	BMEWS
MW9	4.57	0.52	0.61 - 4.57	BMEWS
MW10	4.57	2.53	0.61 - 4.57	BMEWS
MW11	4.57	1.92	0.61 - 4.57	BMEWS
MW12	4.88	1.49	0.92 - 4.88	BMEWS
MW13	4.57	0.37	0.91 - 4.57	Main Base
MW14	3.66	0.51	0.61 - 3.66	Main Base
MW15	3.66	0.76	0.61 - 3.66	Pit No. 2
MW16	3.66	0.58	0.61 - 3.66	Pit No. 2
MW17	3.05	0.25	0.61 - 3.05	Pit No. 2
MW18	9.14	8.07	6.09 - 9.14	Pit No. 1
MW19	6.10	dry	3.05 - 6.10	Pit No. 1
MW20	9.14	5.93	2.43 - 9.14	Pit No. 1
MW21	4.57	0.26	0.61 - 4.57	POL Compound
MW22	4.88	3.16	0.92 - 4.88	POL Compound
MW23	4.57	0.85	0.61 - 4.57	POL Compound
MW24	4.57	0.23	0.61 - 4.57	POL Compound
MW25	1.52	0.58	0.76 - 1.52	Pit No. 3
MW26	3.05	0.37	0.61 - 3.05	Pit No. 3
MW27	3.05	0.45	0.61 - 3.05	Pit No. 3
MW28	3.96	2.56	0.91 - 3.96	Pit No. 3
MW29	3.96	0.69	0.91 - 3.96	Pit No. 3
MW30	3.96	1.19	0.91 - 3.96	Pit No. 3
MW31	4.57	0.74	1.52 - 4.57	Old Dump Pond
MW32	4.57	0.42	1.52 - 4.57	Old Dump Pond
MW33	4.57	0.37	1.52 - 4.57	Old Dump Pond
MW34	6.10	1.61	1.53 - 6.10	Old Dump Pond
MW35	4.57	0.83	0.91 - 4.57	Subdivision
MW36	3.96	0.37	0.91 - 3.96	Subdivision
MW37	4.57	1.40	1.52 - 4.57	Subdivision
MW38	4.42	2.27	1.37 - 4.42	Subdivision
MW39	4.47	1.96	1.42 - 4.47	Subdivision
MW40	3.96	3.16	0.91 - 3.96	Subdivision
MW41	7.62	3.48	3.05 - 7.62	Subdivision
MW42	4.57	2.07	1.52 - 4.57	Subdivision
MW43	3.96	1.05	2.44 - 3.96	Subdivision
MW44	6.10	2.48	1.53 - 6.10	Subdivision
MW45	3.96	0.46	0.91 - 3.96	Subdivision
MW46	5.18	1.73	0.61 - 5.18	Subdivision

Monitor Well ID	BH Depth (m)	Depth to water (mbgs)	MW screen depth (mbgs)	Site Name
MW47	3.66	0.68	0.61 - 3.66	Subdivision
MW48	3.66	1.86	0.61 - 3.66	Subdivision
MW49	3.96	1.06	0.91 - 3.96	Subdivision
MW50	4.57	1.12	1.52 - 4.57	Subdivision
MW51	4.57	0.15	1.52 - 4.57	Subdivision
MW52	4.57	-0.21	0.91 - 4.57	Subdivision
MW53	3.81	2.14	0.76 - 3.81	Pipeline
MW54	3.05	0.69	0.61 - 3.05	Pipeline
MW55	3.05	0.94	0.61 - 3.05	Pipeline
MW56	3.05	1.11	0.61 - 3.05	Pipeline
MW57	3.73	1.98	0.68 - 3.73	Pipeline
MW58	4.57	1.52	2.13 - 4.57	Pipeline
MW59	4.67	3.00	1.01 - 4.67	Pipeline
MW60	4.57	2.33	0.91 - 4.57	Pipeline
MW61	4.57	1.78	0.91 - 4.57	Old Dump Pond
MW62	3.96	0.56	0.91 - 3.96	Old Dump Pond
MW63	4.11	1.09	1.06 - 4.11	BMEWS
MW64	7.87	7.66	4.21 - 7.87	BMEWS
MW65	7.62	7.29	3.96 - 7.62	BMEWS
MW66	5.64	3.38	1.07 - 5.64	Main Base
MW67	6.10	2.31	1.53 - 6.10	Main Base
MW68	4.57	0.93	0.91 - 4.57	Pipeline
MW69	3.66	1.76	0.61 - 3.66	Pipeline
AG-1	1.98	-	-	Old Dump Pond
AG-2	1.67	-	-	Old Dump Pond
AG-3	1.82	-	-	Old Dump Pond
AG-4	0.30	-	-	Old Dump Pond
AG-5	0.91	-	-	Old Dump Pond

Notes:
mbgs = Meters below ground surface
AG-1 to AG-5 = Auger probes

Where possible soil samples were collected by split-spoon methods at 0.61 m intervals from the boreholes during the performance of the Standard Penetration Test and N values were recorded. A total of 169 soil samples were collected from the boreholes. The soil samples were examined for any field evidence of impacts. The samples were placed in clean glass jars with aluminum foil under the lids. Head space soil vapour concentrations were measured in the sample jars using a MiniRAE 2000 photoionization detector (PID). The samples were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Based on the measured soil vapor concentrations, field observations and site usage and history, select soil samples were submitted to Maxxam Analytics Inc. for required laboratory analysis, according to the chemical parameters of concern.

Following drilling, monitor wells were installed in each of the boreholes, with the exception of five (5) augered boreholes at the Old Dump Pond site (i.e., AG-1 to AG-5). The monitor wells consisted of 50 mm diameter, flush-threaded, Schedule 40 PVC casing and No. 10 slot screen. No. 2 silica sand was placed around the screened section to inhibit silt intrusion into the well and facilitate well development. The screened section of the monitor well was placed to span the water table as measured at the time of drilling. A bentonite seal was placed above the sand pack, followed by backfill sand and gravel to the surface. Details of subsurface conditions encountered at the monitor well locations, as well as specific monitor well construction details and PID readings are presented on the Monitor Well Records provided in Appendices 2c to 21c.

Each monitor well was developed by extracting five (5) to ten (10) well volumes of groundwater. Following monitor well development, groundwater samples were collected into clean, new sample bottles and submitted for required laboratory analysis. Groundwater samples for metals analysis were filtered in the field using a 0.45 µm in-line filter and acidified. The samples were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Water level measurements and free-product surveys were carried out in each monitor well prior to monitor well development and groundwater sampling.

2.1.4.4 Sediment Sampling

A total of 77 sediment samples (freshwater and marine) were collected as part of the Phase II/III ESA. This included the collection of freshwater sediment samples from ponds and lakes at the overall site (i.e., Old Dump Pond, Small Pond Bog, Reservoir, Second Reservoir), drainage ditches and streams within the overall site and a clean background area (i.e., Big Lake). The sampling program also included the collection of marine sediment samples from Hopedale Harbour, near the wharf. A summary of sediment samples collected during this investigation is provided below in Table 2.5.

Table 2.5 Sediment Sample Summary

Sediment Sample ID	Waterbody	Site Name
SED-1 to SED-11	Hopedale Harbour	Wharf Area
SED-12 to SED-15	Stream flowing north between the BMEWS and Old Base 1 sites	Valley Drainage Ponds
SED-16 to SED-18	Stream flowing northwest from the BMEWS site	Valley Drainage Ponds
SED-19 to SED-24	Small Pond Bog	Small Pond Bog
SED-25 to SED-34	Old Dump Pond	Old Dump Pond
SED-35 to SED-37	Drainage stream flowing from Old Dump Pond towards Hopedale Harbour	Old Dump Pond
SED-38 to SED-45	Reservoir	Reservoir
SED-46 to SED-48	Drainage channel flowing towards Hopedale Harbour	Clean Background Area
SED-49, SED-50, SED, 53 SED-54	Stream flowing through the Old Dam (upstream of the dam)	Old Dam
SED-51	Stream flowing through the Old Dam (downstream of the dam)	Old Dam
SED-54 to SED-58	Second Reservoir	Second Reservoir
SED-59, SED-60, SED-64	Drainage stream from Pit No.3 to Small Pond Bog	Small Pond Bog
SED-61 to SED-63	Drainage stream northeast of small Pond Bog	Small Pond Bog
SED-65 to SED-68	Stream northeast of Residential Subdivision	New Subdivision
SED-69 to SED-71	Big Lake	Big Lake
SED-72	Drainage channel flowing into Hopedale Harbour	Wharf Area
SED-73 to SED-77	Drainage ditch flowing from Residential Subdivision into Hopedale Harbour	Wharf Area

Sediment samples from the ponds, lakes and Hopedale Harbour were collected using an Eckman grab sampler from a boat rented from Mr. Eddie Pottle in Hopedale. Sediment samples from the shallower drainage ditches and streams were collected from the shore using bulk sampling methods (i.e., 0.0 to 0.3 m deep). The sediment samples were examined for any field evidence of impacts. The samples were placed in clean glass jars and were placed on ice in sample coolers that were returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Based on field observations and site usage and history, select sediment samples were submitted to Maxxam Analytics Inc. for required laboratory analysis, according to the chemical parameters of concern.

2.1.4.5 Surface Water Sampling

A total of 18 surface water samples were collected from Old Dump Pond, Reservoir Lake, the Second Reservoir and a clean background area (i.e., Big Lake), as well as from the drainage stream through the residential subdivision. A summary of sediment samples collected during this investigation is provided below in Table 2.6.

Table 2.6 Surface Water Sample Summary

Surface Water Sample ID	Waterbody	Site Name
SW-1 to SW-3	Old Dump Pond	Old Dump Pond
SW-4 to SW-6	Reservoir	Reservoir
SW-7 to SW-9	Second Reservoir	Second Reservoir
SW-10 to SW-12	Big Lake	Big Lake
SW-13 to SW-14	Stream northeast of Residential Subdivision	Residential Subdivision
SW-15	Stream within the Residential Subdivision	Residential Subdivision
SW-16 to SW-18	Drainage ditch flowing from Residential Subdivision into Hopedale Harbour	Residential Subdivision

Surface water samples were collected near the same locations as some of the sediment samples. Surface water samples were collected before sediment samples and were placed into clean, new sample bottles. The samples were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Based on field observations and site usage and history, select surface water samples were submitted to Maxxam Analytics Inc. for required laboratory analysis, according to the chemical parameters of concern.

2.1.4.6 Benthic Invertebrate Sampling

A total of five (5) sediment samples were collected from Old Dump Pond, Reservoir Lake, the Second Reservoir, Big Lake and Small Pond Bog for benthic invertebrate inspection. A summary of benthic invertebrate samples collected during this investigation is provided below in Table 2.7.

Table 2.7 Benthic Invertebrate Sample Summary

Benthic Sample ID	Site Name
BENTHIC-1	Old Dump Pond
BENTHIC-2	Reservoir
BENTHIC-3	Second Reservoir
BENTHIC-4	Big Lake
BENTHIC-5	Small Pond Bog

Triplicate samples were collected at each sampling location using an Eckman grab sampler from a boat rented from Mr. Eddie Pottle in Hopedale The benthic invertebrate sediment samples were field screened using a 400 µm mesh and preserved. Samples were placed in clean glass jars and were placed on ice in sample coolers and returned to the environmental consultant's laboratory in St. John's, NL for sample selection and submission to the laboratory. Selected samples were submitted to Mr. William Morton in Guelph, Ontario for genus identification.

2.1.4.7 Fish Sampling

Fish sampling was required to obtain information for input into the human health and ecological risk assessments. This included the collection of fish samples from areas of concern (e.g., Old Dump Pond, Reservoir Lake and Small Pond Bog) as well as a clean background pond (i.e., pond where impacts are not likely to be present). Attempts to collect fish samples in the Second Reservoir were unsuccessful.

Fish samples were collected from the areas of concern and the clean background pond, if possible, for whole-body and tissue analysis of metals and PCBs and lipids. Five (5) minnow traps and five (5) fyke nets of various mesh sizes (3/4 inch to 4 in mesh) were used to collect fish samples at the sites. Each location was fished for one (1) to two (2) days. The minnow traps were set and left overnight at each location. The minnow traps were hauled the following morning. No bait was used in the traps. Fyke nets were set in the ponds/lakes and hauled every two (2) hours for the duration of sampling in each pond/lake. Angling was also performed during the one (1) to two (2) day sampling period in each pond/lake. Success rates in Old Dump Pond, and Big Lake were high and success rates in Reservoir Lake, the Second Reservoir and Big Lake were low.

A total of 268 fish were caught with nets or minnow traps. Permits for the collection of the fish samples were obtained from the federal Department of Fisheries and Oceans prior to proceeding with this sampling and are presented in Appendix 25. A summary of fish caught during this investigation is provided below in Table 2.5.

Table 2.8 Fish Sampling Summary

Fish Sample ID	Trap	Species	Total # Fish in Sample Bag	Site Name
FISH-1	Minnow	Three-spine stickleback	10	Old Dump Pond
FISH-2	Minnow	Three-spine stickleback	41	Old Dump Pond
FISH-3	Minnow	Three-spine stickleback	74	Old Dump Pond
FISH-4	Minnow	Three-spine stickleback	81	Old Dump Pond
FISH-5	Minnow	Three-spine stickleback	41	Reservoir
FISH-6	Minnow	Nine-spine stickleback	11	Clean Background Area
FISH-7	Net	Brook trout	1	Big Lake
FISH-8	Net	Brook trout	3	Big Lake
FISH-9	Net	Brook trout	4	Big Lake
FISH-10	Net	Brook trout	1	Big Lake
FISH-11	Net	Brook trout	1	Big Lake

2.1.4.8 Vegetation Sampling

Vegetation sampling was required to obtain information for input into the human health and ecological risk assessments. This included the collection of vegetation samples from areas of concern as well as clean background areas (i.e., areas where impacts are not likely to be present).

A total of 53 vegetation samples, consisting of grasses, leaves, moss and lichen, were collected at or near the ground surface by hand. Approximately 200 grams of sample were collected at each location. During collection, samples were placed into pre-cleaned laboratory-supplied plastic bags. The collected samples were stored transported in sample coolers and stored in a freezer until they were delivered to Maxxam Analytics Inc. for laboratory analysis of PCBs, and metals. A summary of vegetation samples collected during this investigation is provided below in Table 2.9.

Table 2.9 Vegetation Sample Summary

Vegetation Sample ID	Site Name
VEG-1 to VEG-7	Valley Drainage Ponds
VEG-8 to VEG-34	Main Base
VEG-35	**Not recorded – sample not submitted for analysis*
VEG-36 to VEG-41	BMEWS
VEG-42 to VEG-46	Mid-Canada Line
VEG-47 to VEG-53	Clean Background Area

2.1.4.9 Berry Sampling

Berry sampling was required to obtain information for input into the human health and ecological risk assessments. This included the collection of berry samples from areas of concern as well as clean background areas (i.e., areas where impacts are not likely to be present).

A total of 37 berry samples, consisting of marsh berries, blueberries and blackberries, were collected by hand. Approximately 200 grams of berries were collected at each location from areas of up to 10 m^2. During collection, samples were placed into pre-cleaned laboratory-supplied plastic bags. The collected samples were transported in sample coolers and stored in a freezer until they were delivered to Maxxam Analytics Inc. for laboratory analysis of PCBs, and metals. A summary of berry samples collected during this investigation is provided below in Table 2.10.

Table 2.10 Berry Sample Summary

Berry Sample ID	Site Name
BERRY-1 to BERRY-10	Main Base
BERRY-11 to BERRY-17	Clean Background Area
BERRY-18, BERRY-19, BERRY-27	**Not recorded – samples not submitted for analysis*
BERRY-20 to BERRY-26	Valley Drainage Ponds
BERRY-28 to BERRY-32	BMEWS
BERRY-33 to BERRY-37	Mid Canada Line

2.1.4.10 Small Mammal and Larger Mammal Sampling

Small and larger mammal sampling was required to obtain information for input into the human health and ecological risk assessments. This included the collection of small mammal samples from areas of concern as well as clean background areas (i.e., areas where impacts are not likely to be present).

A total of 56 small mammal (i.e., deer mouse, squirrel and red backed vole) samples were collected from the areas of concern and the clean background areas, where possible, for whole-body analysis of metals and/or PCBs and lipids, dependent on the contaminants of potential concern in the area. The small mammals samples were caught with traps and were placed into pre-cleaned laboratory-supplied plastic bags. The collected samples were stored in a sample cooler until they were delivered to Maxxam Analytics Inc. labroratory for whole-body laboratory analysis of PCBs and metals. Permits for the collection of small mammals were obtained from the provincial Department of Wildlife prior to sampling and are presented in Appendix 25.

One larger mammal (i.e., arctic hare) sample was collected from the Main Base site for tissue and liver analysis of metals, PCBs and lipids. The arctic hare was shot on an opportunistic basis. Larger mammals were not observed at the remaining sites. Permits for the collection of the larger mammals were obtained from the provincial Department of Wildlife prior to proceeding with this sampling and are presented in Appendix 25. A summary of small and larger mammal samples collected during this investigation is provided below in Table 2.11.

Table 2.11 Small Mammal and Larger Mammal Sample Summary

Sample ID	Species	Site Name
SM-1	Deer Mouse	BMEWS
SM-2	** Not recorded*	BMEWS
SM-3	** Not recorded*	BMEWS
SM-4	** Not recorded*	BMEWS
SM-5	** Not recorded*	BMEWS
SM-6	Deer Mouse	Main Base
SM-7	Deer Mouse	Main Base
SM-8	Deer Mouse	Main Base
SM-9	Deer Mouse	Main Base
SM-10	Deer Mouse	Main Base
SM-11	Deer Mouse	Main Base
SM-12	Deer Mouse	Main Base
SM-13	Deer Mouse	Main Base
SM-14	Deer Mouse	Main Base
SM-15	Deer Mouse	Main Base
SM-16	** Not recorded*	BMEWS
SM-17	** Not recorded*	BMEWS
SM-18	Deer Mouse	BMEWS
SM-19	Deer Mouse	BMEWS
SM-20	** Not recorded*	BMEWS
SM-21	Deer Mouse	Main Base
SM-22	Deer Mouse	Main Base
SM-23	Deer Mouse	Main Base
SM-24	Deer Mouse	Main Base
SM-25	Deer Mouse	Main Base
SM-26	Deer Mouse	Main Base
SM-27	Deer Mouse	Main Base
SM-28	Squirrel	Main Base
SM-29	Deer Mouse	Mid Canada Line
SM-30	Deer Mouse	Mid Canada Line
SM-31	Deer Mouse	Mid Canada Line
SM-32	Deer Mouse	Mid Canada Line
SM-33	Deer Mouse	Mid Canada Line
SM-34	Deer Mouse	Mid Canada Line
SM-35	Deer Mouse	Mid Canada Line
SM-36	Deer Mouse	Mid Canada Line
SM-37	Deer Mouse	Mid Canada Line
SM-38	Deer Mouse	Mid Canada Line
SM-39	Deer Mouse	Main Base
SM-40	Deer Mouse	Main Base
SM-41	Deer Mouse	Main Base
SM-42	Squirrel	Main Base
SM-43	Deer Mouse	Clean Background Area
SM-44	Red-backed Vole	Clean Background Area
SM-45	Deer Mouse	Valley Drainage Ponds

Sample ID	Species	Site Name
SM-46	Deer Mouse	Valley Drainage Ponds
SM-47	Deer Mouse	Valley Drainage Ponds
SM-48	Deer Mouse	Valley Drainage Ponds
SM-49	Deer Mouse	Valley Drainage Ponds
SM-50	Red-backed Vole	Valley Drainage Ponds
SM-51	Deer Mouse	Valley Drainage Ponds

Sample ID	Species	Site Name
SM-52	Deer Mouse	Valley Drainage Ponds
SM-53	* *Not recorded*	* *Not recorded*
SM-54	* *Not recorded*	* *Not recorded*
SM-55	* *Not recorded*	* *Not recorded*
SM-56	Deer Mouse	* *Not recorded*
Rabbit-1	Arctic Hare	Main Base

2.2 Laboratory Analysis

2.2.1 Laboratory Work

Maxxam Analytics conducted all laboratory analysis. Tables 2.12, 2.13 and 2.14 provide a summary of laboratory work for the Phase II/III ESA, subdivided by site. More detailed laboratory analysis schedules for individual sites are provided in Section 3. During this investigation there were a total of 388 soil (i.e., 142 test pit, 75 monitor well, 3 auger and 168 surface soil), 64 groundwater, 18 surface water, 53 vegetation, 34 berry, 52 small mammal, 5 benthic and 7 fish samples submitted for analyses of various chemical parameters. Methodologies utilized by Maxxam Analytics in analysis of the samples are noted on laboratory reports in Appendix 24.

Table 2.12 Summary of Laboratory Analyses (Soil and Sediment)

Site Name	Soil/Sediment Analysis						
	TPH/BTEX	TPH Frac.	PCBs	PAHs	VOCs	Metals	TOC & Grain Size
BMEWS	22	1	34	1	-	30	-
Old Base 1	1	-	11	-	-	7	-
Main Base	47	1	43	14	2	37	
Roadway	2	-	3	-	-	1	-
Sewage Outfall	3	-	3	-	-	2	-
Valley Drainage Ponds	7	-	7	-	7	7	-
Mid Canada Line	3	-	6	-	-	11	-
Pallet Line	6	-	4	-	-	6	-
Pit No. 1/Helipad	16	-	9	2	-	13	-
Pit No. 2	30	-	19	-	-	17	-
Pit No. 3	29	2	13	-	-	11	-
Small Pond Bog	14	-	13	2	-	12	3
POL Compound	5	1	6	3	1	3	-
Old Dump Pond	21	-	10	1	13	21	3
Pipeline	11	-	5	-	2	1	-
Wharf Area	19	-	12	-	1	10	-
Old Dam	5	-	5	-	-	5	-
Reservoir	-	-	8	-	-	8	3
Second Reservoir	-	-	5	-	-	5	3
Residential Subdivision	40	-	19	6	5	33	
Big Lake	-	-	3	-	-	3	3
Clean Background Area	10	-	-	-	-	-	-
Total	**291**	**5**	**238**	**29**	**31**	**233**	**15**

Table 2.13 Summary of Laboratory Analyses (Groundwater and Surface Water)

Site Name	Groundwater/Surface Water Analysis						
	TPH/BTEX	TPH Frac.	PCBs	PAHs	VOCs	Metals	RCAP-MS
BMEWS	5	1	4	-	-	3	-
Main Base	8	-	6	1	1	7	-
Roadway	-	-	-	-	-	1	-
Pit No. 1/Helipad	2	-	1	-	-	-	-
Pit No. 2	3	-	1	1	-	2	-
Pit No. 3	6	-	1	1	-	3	-
POL Compound	4	-	4	-	-	4	-
Old Dump Pond	5	-	6	-	4	7	3
Pipeline	10	-	1	-	-	1	-
Wharf Area	-	-	3	-	-	3	3
Reservoir	-	-	3	-	-	3	3
Second Reservoir	-	-	3	-	-	3	3
Residential Subdivision	24	-	14	12	7	11	-
Big Lake	-	-	1	-	-	3	3
Total	**67**	**1**	**48**	**15**	**12**	**51**	**15**

Table 2.14 Summary of Laboratory Analyses (Vegetation, Berries, Small Mammals and Rabbits)

Site Name	Vegetation/Berry Analysis		Small Mammal/Rabbit Analysis		
	PCBs	Metals	PCBs	Metals	Lipids
BMEWS	-	11	7	7	-
Main Base	23	14	22	6	-
Valley Drainage Ponds	14	14	10	5	-
Mid Canada Line	-	10	7	7	-
Old Dump Pond	-	-	3	3	3
Reservoir	-	-	1	1	1
Big Lake	-	-	2	2	2
Clean Background Area	-	14	1	1	1
Total	**37**	**63**	**53**	**32**	**7**

2.2.2 Quality Assurance/Quality Control

Replicate sampling is a standard QA/QC procedure carried out by Maxxam Analytics and comprises 10% of the total number of samples being analyzed. In addition, field duplicate samples were submitted for analysis to check for natural sample variance and the consistency of field techniques and laboratory analysis. The analytical results of the duplicate samples analyzed for this sampling program were acceptably consistent with the original samples. Duplicate samples are included on the laboratory work summary table and individual site laboratory analysis schedules. Also, analytical results for duplicate samples are provided in analytical summary tables in Appendices 2e to 23d. Note that on the analytical summary tables, field sample duplicates are denoted by the extension “Field-Dup”, while laboratory duplicates generated by Maxxam Analytics are denoted by the extension “Lab-Dup”.

Table 2.15 Summary of Laboratory Analyses of Laboratory/Field Duplicate

Sample Matrix	Laboratory Duplicate Samples Analyzed						
	TPH/ BTEX	TPH Frac.	PCBs	PAHs	VOCs	Metals	TOC & Grain Size
Laboratory Duplicates							
Soil and Sediment	22	0	9	3	3	17	1
Groundwater and Surface Water	3	0	6	0	2	4	5
Vegetation and Berries	-	-	2	-	-	6	-
Small Mammal, Rabbit and Fish	-	-	4	-	-	3	-
Field Duplicates							
Groundwater and Surface Water	10	0	5	6	1	8	0
Total	**35**	**0**	**26**	**9**	**6**	**38**	**6**

3.0 RESULTS OF THE PHASE II/III ESA INVESTIGATION

3.1 BMEWS

3.1.1 Site Description

The BMEWS site, which has an area of approximately one (1) hectare, is located on top of a hill approximately 2 km northwest of Hopedale, as shown on Drawing 121410103-EE-01b. The site formerly included four troposcatter antennae (two large and two small) that served as a Ballistic Missile Early Warning System (BMEWS). The site also included operations buildings. Historical photographs reportedly indicated the presence of two large aboveground storage tanks at the BMEWS site; however, the fuel tanks and pipelines have been removed. All that currently remains at the site are the antennae bases (i.e., concrete foundations) and building foundations.

Terrain in the vicinity of the BMEWS site is moderately to steeply sloped and surface drainage (apparent groundwater flow direction) appears to be in all directions. There are two drainage courses near the site that could potentially transport water from the BMEWS site to Reservoir Lake (i.e., the primary source of potable water for the town of Hopedale). Vegetation at the site is limited and consists of patches of grasses and some low bushes. Bedrock and boulder outcroppings are common at the site. Photos taken of the site during investigations are presented in Appendix 2a.

3.1.2 Field Work

Field work at this site comprised the excavation of 67 test pits (i.e., TP73 to TP139), the installation of eight (8) monitor wells (i.e., MW8 to MW12 and MW63 to MW65), and the collection of 38 surface soil samples (i.e., BS1 to BS38), eight (8) groundwater samples (i.e,. MW8 to MW12 and MW63 to MW65), six (6) vegetation samples (i.e., BEF-36 to BEG-41), five (5) berry samples (i.e, BERRY-28 to BERRY-32), 10 small mammal samples (i.e., SM-1 to SM-5 and SM-16 to SM-20) and one (1) swab sample (i.e., PCB Swab-1). Coordinates of each sample location are provided in Appendix 2b. A site plan (Drawing No. 121410103-EE-02a) showing the location of these as well as general site features is provided in Appendix 1.

3.1.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 2c.

Excavator refusal suggested probable bedrock at the base in all but six (6) test pits (i.e., TP78, TP80, TP101, TP105, TP111 and TP117). The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.10 metres below ground surface (mbgs) in TP102 to 2.10 mbgs in TP114. Bedrock was encountered in monitor wells at depths ranging from 0.15 mbgs in MW10 to 2.13 mbgs in MW9.

Dark brown to black organics with trace sand, gravel and/or cobbles (OL) were encountered at or near the surface of TP79, TP84, TP86 to TP88, TP90, TP121 to TP125, TP127, TP133 to TP139 and MW10, and ranged in thickness from 0.15 m in MW10 to 1.2 m in TP79. This layer extended to bedrock at all locations, with the exception of TP90, TP134 to TP136, TP138, TP139, which were underlain by a layer of silty sand (SM).

Light to dark brown sand (SP), with occasional cobbles, gravel or organics was encountered at or near the surface of MW8, MW9, MW11, MW63 and MW65 and extended to depths ranging from 0.30 mbgs in MW11 and MW63 to 2.13 mbgs in MW9. This layer extended to bedrock at all locations, with the exception of MW8, which was underlain by a layer of silty sand (SM).

Light to dark brown or black silty sand (SM), with occasional gravel, cobbles, boulders and/or organics, was encountered at or near the surface in TP83, TP85, TP89, TP100, TP103, TP107 to TP115, TP126, TP128 to TP130 and TP132, and below a layer of organics (OL) in TP90, TP134 to TP136, TP138 and TP139, and ranged in thickness from 0.20 m in TP83 to 2.10 m in TP113. With the exception of TP111, this layer extended to bedrock at all test pit locations.

Brown to grey or black silty sand and gravel mixtures (GM), with occasional organics, cobbles and boulders were encountered at or near the surface in TP73 to TP78, TP81, TP82, TP101, TP102, TP104 to TP106, TP116 to TP120 and TP131, and ranged in thickness from 0.10 m in TP102 to 1.80 m in TP118. Gravel and cobbles, with trace brown coarse silty sand (GM) were encountered at the surface to a depth of 1.00 m in TP80. With the exception of TP78, TP80 and TP117 this layer extended to bedrock at all test pit locations.

3.1.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, 11 potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in 31 of the 67 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 2c and in 13 of 38 surface soil samples, as identified in Table 2.3. Buried debris at the BMEWS site was generally found in test pits located along the perimeter of the site and near the northwest end of the road and in a few surface soil samples located near the foundations. Items encountered in test pits and surface soil samples at the site consisted of the following:

- Trace metal
- Steel
- Corrugated steel
- Metal plate
- Aluminum
- Girders
- Wire
- Cable
- Rebar
- Pipes
- Concrete
- Wood
- Wood chips
- Compressed air containers
- Compressed tank cylinders
- Crushed 45-gallon steel drums
- Insulated cable
- Rubber wire
- Plastic
- Plastic hose

A transformer carcass was removed from the site. Prior to its removal from the site, a PCB swab sample was collected from the transformer (i.e. PCB SWAB-1). Results of the PCB swab analysis are provided in Section 3.8.1. A photo of the transformer carcass removed from the site is provided in Appendix 2a.

3.1.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.52 mbgs in MW9 to 7.66 mbgs in MW64. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 23 and 24, 2009 in TP75, TP76, TP78, TP81, TP85, TP88, TP91, TP93, TP98, TP103, TP106, TP108, TP123, TP127, TP132 and TP138 at depths ranging from 0.20 mbgs to 1.00 mbgs. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution. Groundwater seepage was not observed in any of the surface soil pits during sampling.

Based on local topography and site observations the direction of groundwater flow is inferred to be in all directions, including to the south towards Reservoir Lake and west into the Valley Drainage Ponds. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-02a in Appendix 1.

3.1.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.1.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the BMEWS site are provided on the Monitor Well Records in Appendix 2c and in Appendix 2d. The soil vapour concentrations measured ranged from 0.0 ppm in BS15, BS18 and BS28 to 191 ppm in TP117-BS2. Mineral oil odours were detected during the excavation of test pits TP117, TP118, TP119 and TP120, which were collected under/near a concrete pad where transformers may have been formerly located. Chemical odours were detected during surface soil sample collection in BS16 and BS20, which were collected in an area of abandoned drums.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in seven (7) soil samples collected at the site (i.e., TP82-BS1, TP102-BS1, TP117-BS1, TP117-BS2 and TP118-BS2). Five of these samples were analyzed for TPH and had concentrations of modified TPH in excess of 1,000 mg/kg. Soil samples BS20, TP79-BS2, TP103-BS2 and TP139-BS2 had soil vapour concentrations less than 50 ppm; however, modified TPH concentrations were greater than 1,000 mg/kg. Soil vapour concentrations were not recorded for samples MW64-SS1 and MW65-SS2; modified TPH concentrations were greater than 1,000 mg/kg in these samples.

3.1.8 Laboratory Analysis and Results

A laboratory analysis schedule for the BMEWS site is presented in Table 3.1 below.

Table 3.1 Laboratory Analysis Schedule (BMEWS)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment/ Swab	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
PCB CEPA area - delineation needed. Possible PCBs in rabbits. Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons, metals and PCBs in groundwater. 7 possible waste sites. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites are confirmed.	TP73 to TP139 BS1 to BS38 MW8 to MW12, MW63 to MW65 VEG-36 to VEG-41 BERRY-28 to BERRY-32 SM-1 to SM-5, SM-16 to SM-20 PCB SWAB-1	Soil: TPH (23) PCBs (34) PAHs (1) Metals (30) Swab: PCBs (5)	Ground-water: TPH (6) PCBs (4) Metals (3)	Veg: Metals (6) Berries: Metals (5)	No rabbits trapped SM: PCBs (7) Metals (7)	-

Results of laboratory analysis of soil, groundwater, vegetation, berry and small mammal samples obtained from this site are presented in Tables 2.1 to 2.14 in Appendix 2e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 23 soil samples collected from the site, including four (4) surface soil samples, 13 test pit samples and six (6) monitor well samples. TPH fractionation was conducted on one (1) test pit sample (i.e., TP117-BS2). Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Tables 2.1 and 2.2 in Appendix 2b. Modified TPH was detected in 21 soil samples, with concentrations ranging from 49 mg/kg in TP127-BS2 to 94,000 mg/kg in BS20. Concentrations of modified TPH exceeded the applicable Tier I RBSL (i.e., 140 mg/kg) in 16 soil samples (i.e., BS19, BS20, TP79-BS2, TP82-BS1, TP101-BS2, TP102-BS1, TP103-BS2, TP107-BS2, TP117-BS2, TP118-BS2, TP123-BS2, TP139-BS2, MW11-SS1, MW63-SS1, MW54-SS1 and MW65-SS2). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of gas, fuel oil, weathered fuel oil and lube oil fractions.

Benzene was not detected in any of the soil samples analyzed. Detected concentrations of toluene, and ethylbenzene were below the applicable Tier I RBSLs. The concentration of xylenes in TP117-BS2 (12 mg/kg) exceeded the applicable Tier I RBSL of 11 mg/kg. The detection limits for benzene and ethylbenzene in BS20 were above the Tier I RBSL, therefore it is not possible to determine if the Tier I RBSL was exceeded for these parameters. None of the remaining detected levels of BTEX parameters in soils exceeded the applicable Tier I RBSLs.

PCBs in Soil

PCB analysis was conducted on 34 soil samples collected from the site, including 18 surface soil samples, 11 test pit samples and five (5) monitor well samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 2.3 in Appendix 2e. Detected concentrations of PCBs in BS3 (1.6 mg/kg), BS5 (24 mg/kg), BS9 (21 mg/kg), BS12 (2.7 mg/kg), BS13 (3.1 mg/kg), BS14 (100 mg/kg), BS29 (1.7 mg/kg) and TP107-BS2 (3.4 mg/kg) exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

PAHs in Soil

PAH analysis was conducted on one (1) soil sample collected from the site. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 2.4 in Appendix 2e. Detectable concentrations of PAH parameters were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

Metals in Soil

Available metals analysis was conducted on 30 soil samples collected from the site, including 15 surface soil samples, 10 test pit samples and five (5) monitor well samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 2.5 in Appendix 2e. Concentrations of various metals were detected in all 30 soil samples, several of which exceeded applicable CCME criteria for metals in soil on a residential/parkland site. The concentrations of cadmium detected in BS1 (15 mg/kg) and BS7 (11 mg/kg) exceeded the applicable CCME residential/parkland guideline of 10 mg/kg. The concentrations of zinc detected in BS1 (4,800 mg/kg), BS6 (460 mg/kg), BS7 (1,100 mg/kg), BS15 (260 mg/kg), BS22 (240 mg/kg), BS32 (350 mg/kg), TP75-BS2 (210 mg/kg), TP101-BS2 (560 mg/kg), TP107-BS2

(590 mg/kg), TP111-BS2 (350 mg/kg) and MW10-SS1 (250 mg/kg) exceeded the applicable CCME residential/parkland guideline of 200 mg/kg. The elevated reportable detection limits (RDLs) for selenium (2 and 5 mg/kg) were above the CCME residential/parkland guideline of 1 mg/kg, therefore it is not possible to determine if concentrations of selenium in soil exceeded the CCME guideline. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on six (6) groundwater samples collected from the site. TPH fraction was conducted on one (1) groundwater sample (i.e., MW11). Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Tables 2.6 and 2.7 in Appendix 2e. Modified TPH was detected in four (4) groundwater samples (i.e., MW8, MW64, MW65 and MW11) at concentrations ranging from 0.2 mg/L in MW11 to 2 mg/L in MW8. Concentrations of modified TPH were below the applicable Tier I RBSL for fuel oil impacts (i.e., 3.2 mg/L) in all groundwater samples. Laboratory analytical results indicated that products impacting groundwater samples on this site resembled weathered fuel oil or lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on four (4) groundwater samples collected from the site. Results of laboratory analysis for these groundwater samples for PCBs are presented in Table 2.8 in Appendix 2e. PCBs were not detected in the groundwater samples analyzed.

Metals in Groundwater

Available metals analysis was conducted on three (3) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for available metals are presented in Table 2.9 in Appendix 2e. Concentrations of various metals were detected in the groundwater samples. The concentration of aluminum detected in MW65 (250 µg/L) exceeded the applicable CDWQG of 200 µg/L. The concentrations of manganese detected in MW12 (312 µg/L) and MW63 (158 µg/L) exceeded the applicable CDWQG of 50 µg/L (an aesthetic guideline). None of the other detected concentrations of metals exceeded the applicable CDWQG, where such guidelines exist.

Metals in Vegetation

Available metals analysis was conducted on six (6) vegetation samples collected from the site. Results of the laboratory analysis of these vegetation samples for available metals are presented in Table 2.10 in Appendix 2e. Various metals were detected in all vegetation samples; however, there are no federal or provincial guidelines for available metals concentrations in vegetation samples.

Metals in Berries

Available metals analysis was conducted on five (5) berry samples collected from the site. Results of the laboratory analysis of these berry samples for available metals are presented in Table 2.11 in Appendix 2e. Various metals were detected in all berry samples; however, there are no federal or provincial guidelines for available metals concentrations in berry samples.

PCBs in Small Mammals

PCB analysis was conducted on seven (7) small mammals caught at the site. The results of the laboratory analysis of small mammals for PCBs are presented in Table 2.12 in Appendix 2e. PCBs were detected in five (5) of the small mammals analyzed (SM-4, SM-5, SM-16, SM-17 and SM-20) with concentrations ranging from 0.08 mg/kg in SM-17 to 0.51 mg/kg in SM-4. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.

Metals in Small Mammals

Available metals analysis was conducted on seven (7) small mammals caught at the site. The results of the laboratory analysis of small mammals for metals are presented in Table 2.13 in Appendix 2e. Concentrations of various available metals were detected in all of the small mammal samples analyzed. There are presently no provincial or federal criteria for available metal levels in small mammals.

PCB Swab Analysis

PCB swab analysis was conducted on the swab sample collected from the transformer carcass removed from the site (i.e., PCB SWAB-1). The results of the laboratory analysis of the swab are presented in Table 2.14 in Appendix 2e. Laboratory analysis of the swab sample indicated that PCBs were not present in the swab sample, therefore the transformer carcass was disposed of at the Hopedale landfill.

3.1.9 Conclusions

A Phase II/III ESA was completed at the BMEWS site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of the assessment are summarised below.

1. A transformer carcass was removed from the site. PCBs were not present in the swab sample collected from the transformer carcass, therefore it was disposed of at the Hopedale landfill.
2. The observed stratigraphy was generally similar at all test pit and monitor well locations, and consisted of continuous layers of sand, silty sand, sand and gravel mixtures and/or organic soil, all with varying percentages of cobbles and boulders and overlying bedrock. Excavator refusal on presumed bedrock occurred at depths ranging from 0.10 m to 2.10 m. Bedrock was encountered in 61 of the 67 test pits investigated at this site. Bedrock was encountered in monitor wells at depths ranging from 0.15 m to 2.13 m.

3. Various buried debris was observed within the overburden layer in 31 of the 67 test pits. Buried debris was generally found in test pits located along the perimeter of the site and near the end of the road, and in some surface soil samples collected near the foundations.

4. Groundwater was encountered at depths ranging from 0.20 m to 7.66 m below ground surface in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be in all directions, including to the south towards Reservoir Lake and west into the Valley Drainage Ponds.

5. This site was considered to have a residential/parkland site designation with potable groundwater and coarse-grained soil.

6. There was olfactory evidence of mineral oil and chemical impacts on soil at the site, particularly near a concrete pad where transformers may have been formerly located and in an area of abandoned drums. No free phase petroleum hydrocarbons were observed on soil or groundwater at the site.

7. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in 16 soil samples (i.e., BS19, BS20, TP79-BS2, TP82-BS1, TP101-BS2, TP102-BS1, TP103-BS2, TP107-BS2, TP117-BS2, TP118-BS2, TP123-BS2, TP139-BS2, MW11-SS1, MW63-SS1, MW54-SS1 and MW65-SS2). Concentrations of xylenes exceeding the applicable Tier I RBSL were detected in one (1) soil sample (i.e., TP117-BS2). TPH and BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.

8. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon/xylenes** remediation of site soil would be required in the vicinity of samples **BS19, BS20, TP79, TP82, TP101, TP102, TP103, TP107, TP117, TP118, TP123, TP139, MW11, MW63, MW54 and MW65** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon/xylenes remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

9. Drawing No. 121410103-EE-02b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil, in the area of the former operations buildings, west of the access road and in the north-eastern portion of the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated combined area of approximately **19,000 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).

10. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in eight (8) soil samples (i.e., BS3, BS5, BS9, BS12, BS13, BS14, BS29 and TP107-BS2). Low levels of PCBs were also detected in 12 other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCBs were not detected in the groundwater samples analyzed.

11. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of samples **BS3, BS5, BS9, BS12, BS13, BS14, BS29 and TP107** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
12. Drawing No. 121410103-EE-02c in Appendix 1 shows the estimated extent of the PCB-impacted soil near the former antennae bases. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **4,800 m^2** has PCB levels in soil above 1.3 mg/kg.
13. No concentrations of PAH parameters exceeded the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed from the site.
14. Concentrations of VOC parameters were not analyzed in soil samples collected from the site.
15. Concentrations of cadmium and zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in 12 soil samples (i.e., BS1, BS6, BS7, BS15, BS22, BS32, TP75-BS2, TP101-BS2, TP107-BS2, TP111-BS2 and MW10-SS1). Concentrations of aluminum and/or manganese exceeding the applicable CDWQG were detected in three (3) groundwater samples (i.e., MW12, MW63 and MW65).
16. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **BS1, BS6, BS7, BS15, BS22, BS32, TP75, TP101, TP107, TP111, and MW10** and metals remediation of site groundwater would be required in the vicinity of monitor wells **MW12, MW63 and MW65** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for each contaminant.
17. Drawing No. 121410103-EE-02d in Appendix 1 shows the estimated extent of the metals-impacted soil and groundwater at the site.
18. Drawing No. 121410103-EE-02d in Appendix 1 shows the estimated extent of the metals-impacted soil and groundwater at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **9,200 m^2** has metals levels in soil above the applicable CCME criteria and an estimated area of **1,500 m^2** has metals levels in groundwater above CDWQGs.
19. The extent of TPH, PCB and metals impacts in soil and metals impacts in groundwater exceeding the generic guidelines have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.2 Old Base 1

3.2.1 Site Description

The Old Base 1 site is located on a rock outcrop, southwest of the Main Base site. The site formerly consisted of a troposcanner communications dish and possibly an emergency shelter for the United States Air Force (USAF). All that currently remains at the site are the concrete communications dish foundations. During previous environmental investigations, a tar spill was discovered flowing down a rock outcrop northeast of the communications dish foundations. The spill material was reported as having very high PCB levels (1,020,000 mg/kg).

Old Base 1 slopes steeply to the north and south and moderately to the west. Surface drainage (apparent groundwater flow direction) appears to be in all directions. Drainage from the PCB impacted-tar area is expected to be to the north towards the Valley Drainage Ponds. The site is predominately covered with loose granular sand that is believed to have been introduced to the site during the 1985 demolition. Vegetation at the site is limited and consists of patches of grasses. Bedrock and boulder outcroppings are common at the site. Photos taken of the site during investigations are presented in Appendix 3a.

3.2.2 Field Work

Field work at this site comprised the collection of 12 surface soil samples (i.e., BS121 to BS132 and BS247), one (1) rabbit (i.e., Rabbit-1) and the removal of PCB-impacted tar. Test pits were not dug at this site, as soil cover was very limited. Coordinates of each sample location are provided in Appendix 3b. A site location map (Drawing No. 121410103-EE-03a) showing the location of the soil samples as well as general site features is provided in Appendix 1.

3.2.3 Limited Remediation of PCB-Impacted Tar

Removal of PCB-impacted tar and rock at the Former U.S. Military Site was conducted between July 17, 2009 and July 19, 2009. PCB-impacted tar in the previously identified “CEPA area” at the Old Base 1 site, north of the access road (i.e., in the vicinity of BS126), was also removed during this period. Impacted bedrock was chipped away using chipping hammers. Shovels and brooms were used to remove the tar, rock and dust from the spill area. Impacted materials were placed into 205 L drums lined with plastic hazardous materials bags. Bedrock chipping and tar removal continued until no visible evidence of staining remained at the site. The PCB-impacted materials were transported to the Newalta facility in Foxtrap, NL. Groundwater was not encountered during chipping.

A total of 16 barrels of PCB-impacted materials were removed from the overall site and were weighed and disposed of at the Newalta facility in Foxtrap, NL. Photos taken during the remediation of PCB-impacted tar are provided in Appendix 3a.

3.2.4 Stratigraphy

Basic stratigraphic information was recorded during the collection of surface soil samples. Dark brown to black fine soil was encountered in surface soil samples BS121 and BS122, brown coarse gravelly sand was encountered in BS123, dark brown organics were encountered in

BS124 to BS129 and brown to grey silty sand was encountered in BS130 to BS132. Sample refusal did not occur at bedrock in any of the surface soil samples. Surface soil samples were collected at maximum depth.

3.2.5 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, one (1) potential waste site was identified at the site. Surface soil samples were excavated to investigate the size and contents of this potential waste site.

Buried debris was not encountered in any of the surface soil samples, as identified in Table 2.3.

3.2.6 Groundwater Conditions

Groundwater seepage was not observed in any of the surface soil sample pits during sampling. Based on local topography and site observations the direction of groundwater flow is inferred to be in all directions, including to the north towards Valley Drainage Ponds. The assumed direction of groundwater flow, based on site topography, is shown on Drawing No. 121410103-EE-03a in Appendix 1.

3.2.7 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. There was no visual evidence of free phase petroleum hydrocarbons in surface soil pits.

3.2.8 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Old Base 1 site are provided in Appendix 3c. The soil vapour concentrations measured ranged from 2.0 ppm in BS121 to 3.9 ppm in BS132. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. No soil vapour concentrations exceeded 50 ppm in soil samples measured from the site.

3.2.9 Laboratory Analysis and Results

A laboratory analysis schedule for the Old Base 1 site is presented in Table 3.2 below.

Table 3.2 Laboratory Analysis Schedule (Old Base 1)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
PCB CEPA area. Possible PCBs in rabbits. Possible waste site under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	BS121 to BS132, BS247 Rabbit -1	TPH (1) PCBs (11) Metals (7)	-	-	PCBs (2)	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 3.1 to 3.3 in Appendix 3d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>Petroleum Hydrocarbons in Soil</u>

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on one (1) surface soil sample collected from the site. Results of the laboratory analysis of this soil sample for petroleum hydrocarbons are presented in Table 3.1 in Appendix 3d. Modified TPH was detected in surface soil sample BS127 at a concentration of 220 mg/kg. The concentrations of modified TPH exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg). Laboratory analytical results indicated that products impacting the surface soil sample resembled fuel/lube oil fractions. BTEX parameters were not detected in surface soil sample BS127.

<u>PCBs in Soil</u>

PCB analysis was conducted on 11 surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 3.2 in Appendix 3d. Detectable concentrations of PCBs ranged from 1.5 mg/kg in BS129 to 170 mg/kg in BS121. The detected concentrations of PCBs in nine (9) samples (i.e., BS121 to BS124, BS126 and BS129 to BS132) exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

<u>Metals in Soil</u>

Available metals analysis was conducted on seven (7) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 3.3 in Appendix 3d. Concentrations of various metals were detected in all seven (7) soil samples, several of which exceeded applicable CCME criteria for metals in soil on a residential/parkland site. The concentrations of cadmium detected in BS121 (18 mg/kg), BS122 (15 mg/kg), BS126 (29 mg/kg), BS128 (22 mg/kg) and BS131 (11 mg/kg) exceeded the applicable CCME residential/parkland guideline of 10 mg/kg. The concentrations of copper detected in BS121 (150 mg/kg), BS122 (84 mg/kg), BS126 (200 mg/kg) and BS128 (100 mg/kg) exceeded the applicable CCME residential/parkland guideline of 63 mg/kg. The concentrations of lead detected in BS121 (3,000 mg/kg), BS122 (220 mg/kg) and BS126 (280 mg/kg) exceeded the applicable CCME residential/parkland guideline of 140 mg/kg. The concentrations of zinc detected in BS121 (1,800 mg/kg), BS122 (970 mg/kg), BS124 (420 mg/kg), BS126 (960 mg/kg) and BS128 (420 mg/kg) exceeded the applicable CCME residential/parkland guideline of 200 mg/kg. None of the other detected levels of available metals in soils exceeded the applicable CCME residential/parkland criteria.

PCBs in Small Mammals

PCB analysis was conducted on one (1) rabbit caught at the site (i.e., Rabbit-1). The results of the laboratory analysis of the hind quarter and liver for PCBs are presented in Table 3.4 in Appendix 3d. PCBs were detected in both samples analyzed at concentrations ranging from 0.09 mg/kg in Rabbit-1 Hind Quarter to 0.16 mg/kg in Rabbit-1 Liver. There are presently no provincial or federal criteria for PCB levels in rabbits, but any detected level is considered undesirable.

3.2.10 Conclusions

A Phase II/III ESA was completed at the Old Base 1 site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. Limited remediation of PCB-impacted tar was conducted at the previously identified "CEPA area" until no visible evidence of staining remained at the site.
2. The observed surface soil consisted of brown sand, gravelly sand, silty sand and dark brown organics. Bedrock was not encountered in any of the surface soil samples.
3. Buried debris was not encountered in any of the surface soil samples.
4. Groundwater was not observed in any of the near-surface soil samples at the site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be in all directions, including to the north towards the Valley Drainage Ponds.
5. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
6. No olfactory evidence of petroleum hydrocarbons was detected on soil at the site. No free phase petroleum hydrocarbons were observed on soil at the site.
7. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in one (1) soil sample (i.e., BS127). BTEX parameters were not detected in the soil sample analyzed.
8. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of sample **BS127** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTL criteria determined for this contaminant.

9. Drawing No. 121410103-EE-03b in Appendix 1 shows the estimated extent of the petroleum-impacted soil, in the northern portion of the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **300 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).
10. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in nine (9) soil samples (i.e., BS121 to BS124, BS126 and BS129 to BS132).
11. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of samples **BS121 to BS124, BS126 and BS129 to BS132** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTL criteria determined for this contaminant.
12. Drawing No. 121410103-EE-03c in Appendix 1 shows the estimated extent of the PCB-impacted soil in the area of the communications dish foundations and near the road. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **4,000 m^2** has PCB levels in soil above 1.3 mg/kg.
13. Concentrations of PCBs were detected in both the hind quarter and liver samples from Rabbit-1.
14. VOC analysis was not conducted on soil samples collected from the site.
15. Concentrations of cadmium, copper, lead and zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in six (6) soil samples (i.e., BS121, BS122, BS124, BS126, BS128 and BS131).
16. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **BS121, BS122, BS124, BS126, BS128 and BS131** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil would be governed by SSTLs determined for each contaminant.
17. Drawing No. 121410103-EE-03e in Appendix 1 shows the estimated extent of the metals-impacted soil at the site. Based on available analytical and field data, an estimated area of approximately **1,700 m^2** has metals levels in soil above the applicable CCME criteria.
18. The extent of TPH, PCB and metals impacts in soil exceeding the generic guidelines have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.3 Main Base

3.3.1 Site Description

The Main Base (also referred to as “the old base”, “the upper site” and the “TACAN site” in previous environmental reports), which has an area of approximately 45 hectares, is located on the top of a hill approximately 1.2 km northwest of Hopedale. The site served as the Tactical Air Navigation Site (TACAN) when the site was operational and included the radar complex, maintenance building, generator building, accommodations buildings and several additional buildings required to service the complex. All that remains of the former site infrastructure are the concrete foundations.

Terrain in the vicinity of the Main Base site is moderately sloped and surface drainage (apparent groundwater flow direction) appears to be in all directions. There are distinct drainage courses at the site that drain to the northwest through the former sewage outfall and to the southeast towards Pit No. 2. The site consists of gravel, bedrock outcrops and minimal low vegetation. Photos taken of the site during investigations are presented in Appendix 4a.

3.3.2 Field Work

Field work at this site comprised the excavation of 79 test pits (i.e., TP1 to TP72, TP219 to TP225), the installation of 10 monitor wells (i.e., MW1 to MW6, MW13, MW14, MW66 and MW67), and the collection of 74 surface soil samples (i.e., BS43 to BS113, BS245, BS246 and BS265), one (1) septic tank soil sample (i.e., Septic Tank), 10 groundwater samples (i.e, MW1 to MW6, MW13, MW14, MW66 and MW67), 27 vegetation samples (i.e., VEG-8 to VEG-34), 10 berry samples (i.e., BERRY-1 to BERRY-10), 22 small mammal samples (i.e., SM-6 to SM-15, SM-21 to SM-28 and SM-39 to SM-42) and one (1) tar sample (Tar-2). Coordinates of each sample location are provided in Appendix 4b. A site location map (Drawing No. 121410103-EE-03) showing the location of these as well as general site features is provided in Appendix 1.

There was no evidence of a debris burning area used to burn debris during the decommissioning program in the mid 1980s at the site. This area was identified in previous environmental reports.

3.3.3 Limited Remediation of PCB-Impacted Tar

Removal of PCB-impacted tar and rock at the Former U.S. Military Site was conducted between July 17, 2009 and July 19, 2009. PCB-impacted tar in the previously identified "CEPA area" at the Main site, in the southeast corner of the site (i.e., near BS91 at Old Base 2a and near BS110 at Old Base 2b), was removed during this period. Impacted bedrock was chipped away using chipping hammers. Shovels and brooms were used to remove the tar, rock and dust from the spill area. Impacted materials were placed into 205 L drums lined with plastic hazardous materials bags. Bedrock chipping and tar removal continued until no visible evidence of staining remained at the site. The PCB-impacted materials were transported to the Newalta facility in Foxtrap, NL. Groundwater was not encountered during chipping.

A total of 16 barrels of PCB-impacted materials were removed from the overall site and were weighed and disposed of at the Newalta facility in Foxtrap, NL. Photos taken during the remediation of PCB-impacted tar are provided in Appendix 4a.

3.3.4 Stratigraphy

The stratigraphic information recorded during the investigation is presented on the Monitor Well and Test Pit Records in Appendix 4c.

Excavator refusal suggested probable bedrock at the base of all but three (3) test pits (i.e., TP3, TP47 and TP69). The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.20 mbgs in TP10, TP63 and TP65 to 3.00 mbgs in TP67. Bedrock was encountered in all monitor wells at depths ranging from 0.00 mbgs (i.e., at ground surface) in MW13 to 1.83 mbgs in MW66 and MW67.

Grey or brown silty to coarse grained sand and organics (OL) were encountered at or near the surface in TP63 to TP65, TP223, TP224, MW66 and MW67 and ranged in thickness from 0.20 m in TP63 and TP64 to 0.50 m in TP223. This layer extended to bedrock at all test pit locations and was underlain by a layer of sand and gravel (SM) in MW66 and a layer of coarse sand (SW) in MW67.

Brown to grey silty sand (SM), with occasional cobbles was encountered at or near the surface in TP7, TP13, TP18, TP21, TP31, TP32, TP36, TP37, TP44, TP48 to TP53, TP55 to TP57, TP68, TP70 to TP72, TP225, MW2, MW3, MW5 and MW66 and ranged in thickness from 0.30 m in TP55 to 1.90 m in TP44. This layer extended to bedrock at all test pit and monitor well locations.

Brown to grey silty to coarse sand with cobbles and/or boulders (SP) was encountered at or near the surface in TP17, TP24, TP27, TP29, TP34, TP38, TP41 to TP43, TP46, TP54, TP58 to TP62, TP66, TP219 and MW4 and ranged in thickness from 0.40 m in TP61 to 2.80 m in TP66. This layer extended to bedrock at all test pit and monitor well locations.

Light to dark brown sand (SW) was encountered at the surface in MW6 and MW14 and extended to bedrock at depths of 0.76 mbgs and 1.37 mbgs, respectively.

Light to dark brown silty sand and gravel (GM), with occasional boulders and/or cobbles were encountered at or near the surface in TP1, TP2, TP4, TP8 to TP12, TP14 to TP16, TP19, TP20, TP22, TP23, TP25, TP26, TP28, TP30, TP33, TP35, TP39, TP40, TP45, TP47, TP67, TP69, TP220 to TP222, MW1 and MW66 and ranged in thickness from 0.20 m in TP10 to 3.00 m in TP67. With the exception of TP47 and TP69, this layer extended to bedrock at all test pit locations.

Brown and black coarse sand and gravel (GP) was encountered at or near the surface in TP3, TP5 and TP6 and ranged in thickness from 0.51 m in TP5 to 0.89 m in TP3. This layer extended to bedrock in TP5 and TP6.

3.3.5 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, 10 potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in 49 of the 79 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 3c, and in 19 of 74 surface soils samples as identified in Table 2.3. Buried debris at the site was generally found in the south-western portion of the site (i.e., in areas formerly referred to as Old Base 2a and Old Base 2b), along the road at the centre of the site, in the north-eastern portion of the site (i.e., area formerly referred to as

Tacan East), and in the area north of the main access road near the Sewage Outfall. Items encountered in test pits and surface soil samples at the BMEWS site consisted of the following:

- Wood
- Pipes
- Plastic
- Metal
- Metal plates
- Metal ring
- Metal beams
- Metal barbed wire
- Rebar
- Girders
- Pieces of building structure
- H-beams
- Aluminum sheathing
- Insulation
- Ceramic tiles
- Vinyl tile
- Asbestos
- Electrical equipment
- Wiring
- Water boiler
- Furnace pieces
- Radiator
- Door of a stove
- Pieces of tar
- Tar felt
- Fibreglass
- Guy wire
- Oil drums
- 45-gallon crushed drums

3.3.6 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.37 mbgs in MW13 to 4.63 mbgs in MW5. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits between July 19 to 23, 2009 in TP3, TP10, TP13, TP24, TP50, TP58 to TP61, TP69 to TP71 at depths ranging from 0.20 mbgs in TP10 to 1.70 mbgs in TP71. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be in all directions, including to the northwest through the former sewage outfall and to the southeast towards Pit No. 2. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-03a in Appendix 1.

3.3.7 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were observed on soil in TP7 during the investigation. An oil sheen was also observed on the groundwater encountered in BS113. There was no visual evidence of free phase petroleum hydrocarbons on surface soil at the site or in any of the remaining test pits. No product was detected on groundwater in the monitor wells with the product interface probe.

3.3.8 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Main Base site are provided on the Monitor Well Records in Appendix 3c and in Appendix 4d. The soil vapour concentrations measured ranged from 0.0 ppm in soil samples BS43, BS50, BS52, BS53, BS56, BS57, BS108, BS109, BS110, BS111, BS112 and BS113 to 302 ppm in MW14-SS2. Petroleum hydrocarbon odours were detected in test pits TP7 and TP43. A chemical odour was detected in BS110. A mineral oil odour was detected in TP225.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in six (6) soil samples collected at the site (i.e., TP7-BS1, TP9-BS2, MW6-SS1, MW6-SS2, MW14-SS1 and MW14-SS2). One (1) of the soil samples that had a soil vapour concentration greater than 50 ppm (i.e., MW6-SS1) that was analyzed for TPH and had a modified TPH concentration in excess of 1,000 mg/kg. An additional seven (7) soil samples had soil vapour concentrations less than 50 ppm; however, TPH concentrations were greater than 1,000 mg/kg. Soil vapour concentrations were not recorded for seven (7) soil samples that had modified TPH concentrations greater than 1,000 mg/kg.

3.3.9 Laboratory Analysis and Results

A laboratory analysis schedule for the Main Base site is presented in Table 3.3 below.

Results of laboratory analysis of soil obtained from this site are presented in Tables 4.1 to 4.17 in Appendix 4e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>Petroleum Hydrocarbons in Soil</u>

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 48 soil samples collected from the site, including eight (8) surface soil samples, 33 test pit samples, seven (7) monitor well samples and one (1) septic tank sample. TPH fractionation was conducted on one (1) monitor well sample. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Tables 4.1 and 4.2 in Appendix 4e. Modified TPH was detected in 31 soil samples, with concentrations ranging from 20 mg/kg in TP52-BS1 to 71,000 mg/kg in BS110. Concentrations of modified TPH exceeded the applicable Tier I RBSL (i.e., 140 mg/kg) in 36 soil samples (i.e., TP3-BS2, TP6-BS2, TP7-BS2, TP10-BS1, TP15-BS2, TP16-BS1, TP18-BS2, TP21-BS2, TP24-BS2, TP30-BS2, TP33-BS2, TP37-BS1, TP41-BS1, TP42-BS2, TP43-BS2, TP53-BS1, TP54-BS2, TP58-BS2, TP62-BS1, TP221-BS2, TP224-BS1, TP225-BS2, BS48, BS81, BS97, BS104, BS110, BS112, MW1-SS1, MW2-SS1, MW3-SS1, MW4-SS1, MW5-SS1, MW6-SS1, MW14-SS3 and Septic Tank). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of gas, fuel oil, weathered fuel oil and lube oil fractions. The detected levels of BTEX parameters in soil samples were below the applicable Tier I RBSLs.

Table 3.3 Laboratory Analysis Schedule (Main Base)

Issues	Sample Locations	Sample Matrix			
		Soil/ Sediment/ Tar	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish
Main Base Site (overall site) Possible metals in soils. Possible metals in vegetation, berries, small mammals and rabbits. 10 possible waste sites – possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites are confirmed. **Old Base 2a** PCB CEPA area. Possible PCBs in rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **Old Base 2b** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **Radome** PCB CEPA area - delineation needed. Possible PCBs in vegetation, berries, small mammals and rabbits. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbon, PCBs or metals impacts in groundwater. **Near foundations** Possible PCBs and metals in soil. **TACAN East** Possible petroleum hydrocarbons in soil. **Near POL tanks** Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. **Area north and east of main base** No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in soil.	TP1 to TP72, TP219 to TP225 BS43 to BS113, BS245, BS246, BS265 MW1 to MW6, MW13, MW14, MW66, MW67 Septic Tank VEG-8 to VEG-34 BERRY-1 to BERRY-10 SM-6 to SM-15, SM-21 to SM-28, SM-39 to SM-42 Tar-2	Soil: TPH (48) PCBs (43) PAHs (14) VOCs (2) Metals (37) Tar: Free Product ID (1) PCBs (1)	TPH (8) PCBs (6) PAHs (1) VOCs (1) Metals (7)	Veg: PCBs (13) Metals (13) Berries: PCBs (10) Metals (1)	Small mammals: PCBs (22) Metals (6)

PCBs in Soil

PCB analysis was conducted on 43 soil samples collected from the site, including 20 surface soil samples, 20 test pit samples, two (2) monitor well samples and one (1) septic tank sample. Results of the laboratory analysis of soil samples for PCBs are presented in Table 4.3 in Appendix 4e. Detected concentrations of PCBs in 14 soil samples, TP13-BS2 (2.3 mg/kg), TP20-BS2 (6.2 mg/kg), TP21-BS2 (3.2 mg/kg), TP220-BS1 (3.4 mg/kg), BS43 (1.7 mg/kg), BS44 (2.2 mg/kg), BS53 (1.3 mg/kg), BS81 (1.7 mg/kg), BS91 (1.3 mg/kg), BS95 (2.3 mg/kg, 1.8 mg/kg in the Lab-Dup), BS100 (5.5 mg/kg), BS110 (53 mg/kg), BS113 (1.4 mg/kg) and Septic Tank (72 mg/kg), exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

PAHs in Soil

PAH analysis was conducted on 14 soil samples collected from the site, including 12 test pit samples, one (1) monitor well sample and one (1) septic tank sample. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 4.4 in Appendix 4e. The benzo(a)pyrene Total Potency Equivalent (TPE) in TP43-BS2 (28.2 mg/kg) exceeded the applicable CCME soil quality guideline for the protection of human health for a residential site of 5.3 mg/kg. The remaining concentrations of PAH parameters detected in soil samples were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

VOCs in Soil

VOC analysis was conducted on two (2) soil samples collected from the site, including one (1) test pit sample and one (1) septic tank sample. Results of the laboratory analysis of these soil samples for VOCs is presented in Table 4.5 in Appendix 4e. The concentrations of tetrachloroethylene (500 µg/kg) and toluene (25,000 µg/kg) in the Septic Tank sample exceeded their respective CCME soil quality guidelines for a residential site of 200 µg/kg and 370 µg/kg. The remaining concentrations of VOC parameters detected in soil samples collected from the site were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist. The RDL for trichlorofluoromethane (30 mg/kg) was greater than the CCME soil quality guideline for a residential/parkland site (10 mg/kg), therefore it is not possible to determine if the guideline was exceeded in soil samples collected from the site.

Metals in Soil

Available metals analysis was conducted on 37 soil samples collected from the site, including 10 surface soil samples, 24 test pit samples, two (2) monitor well samples and one (1) septic tank sample. Results of the laboratory analysis of soil samples for available metals are presented in Table 4.6 in Appendix 4e. Concentrations of various metals were detected in all 37 soil samples, several of which exceeded the applicable CCME criteria for metals in soil at a residential/parkland site. The concentration of antimony in Septic Tank (25 mg/kg) exceeded the applicable CCME residential/parkland guideline of 20 mg/kg. The concentrations of arsenic and barium detected in TP62-BS1 (76 mg/kg and 2,700 mg/kg, respectively) exceeded their respective CCME residential/parkland guidelines of 12 mg/kg and 500 mg/kg. The concentration of chromium in TP49-BS2 (65 mg/kg) exceeded the applicable CCME residential/parkland guideline of 64 mg/kg. The concentrations of copper in six (6) soil samples, TP41-BS1 (77 mg/kg), TP57-BS1 (100 mg/kg), TP58-BS2 (66 mg/kg), TP62-BS1 (130 mg/kg), BS84 (2,200 mg/kg) and Septic Tank (87 mg/kg), exceeded the applicable CCME residential/parkland guideline of 63 mg/kg. The concentrations of lead in four (4) soil samples, TP41-BS1 (580 mg/kg), TP58-BS2 (210 mg/kg), TP62-BS1 (840 mg/kg) and BS47 (320 mg/kg), exceeded the applicable CCME residential/parkland guideline of 140 mg/kg. The concentration of tin in Septic

Tank (250 mg/kg) exceeded the applicable CCME residential/parkland guideline of 50 mg/kg The concentrations of zinc in 11 soil samples, TP18-BS2 (400 mg/kg), TP21-BS2 (550 mg/kg), TP58-BS2 (270 mg/kg), TP62-BS1 (270 mg/kg), TP62-BS1 (310 mg/kg), TP69-BS2 (350 mg/kg), BS47 Lab-Dup (200 mg/kg), BS65 (820 mg/kg), BS78 (210 mg/kg), BS84 (800 mg/kg) and Septic Tank (1,500 mg/kg), exceeded the applicable CCME residential/parkland guideline of 200 mg/kg. The elevated RDL for selenium (2 mg/kg) was above the CCME residential/parkland guideline of 1 mg/kg, therefore it is not possible to determine if concentrations of selenium in soil exceeded the CCME guideline. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on eight (8) groundwater samples collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Table 4.7 in Appendix 4e. Modified TPH was detected in all seven (7) groundwater samples (i.e., MW2 to MW6, MW15 and MW66) at concentrations ranging from 0.1 mg/L in groundwater sample MW66 to 5.6 mg/L in MW4. Concentrations of modified TPH were below the applicable Tier I RBSL for fuel oil impacts (i.e., 20 mg/L) in all groundwater samples. Laboratory analytical results indicated that products impacting groundwater samples on this site resembled gasoline, weathered fuel oil or lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on six (6) groundwater samples collected from the site. Results of laboratory analysis for these groundwater samples for PCBs are presented in Table 4.8 in Appendix 4e. PCBs were not detected in the groundwater samples analyzed.

PAHs in Groundwater

PAH analysis was conducted on one (1) groundwater sample collected from the site (i.e., MW67). Results of the laboratory analysis of this groundwater sample for PAHs are presented in Table 4.9 in Appendix 4e. PAH parameters were not detected above the RDLs in the groundwater sample.

VOCs in Groundwater

VOC analysis was conducted on one (1) groundwater sample collected from the site (i.e., MW67). Results of the laboratory analysis of this groundwater sample for VOCs are presented in Table 4.10 in Appendix 4e. Concentrations of VOC parameters were below the applicable OMOE groundwater standards for non-potable groundwater, where such standards exist.

Metals in Groundwater

Available metals analysis was conducted on six (6) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for available metals are presented in Table 4.11 in Appendix 4e. Concentrations of various metals were detected in the groundwater samples. The concentration of copper detected in groundwater sample MW2 (76.8 µg/L) exceeded the applicable OMOE groundwater standard of 23 µg/L. None of the other detected concentrations of metals exceeded the applicable OMOE groundwater standards, where such guidelines exist.

PCBs in Vegetation

PCB analysis was conducted on 13 vegetation samples collected from the site. Results of the laboratory analysis of vegetation samples for PCBs are presented in Table 4.12 in Appendix 4e. PCBs were detected in seven (7) vegetation samples at concentrations ranging from 0.13 mg/kg in VEG-33 to 1.6 mg/kg in VEG-15. There are presently no provincial or federal criteria for PCB levels in vegetation, but any detected level is considered undesirable.

Metals in Vegetation

Available metals analysis was conducted on 13 vegetation samples collected from the site. Results of the laboratory analysis of these vegetation samples for available metals are presented in Table 4.13 in Appendix 4e. Various metals were detected in all vegetation samples; however, there are no federal or provincial guidelines for available metals concentrations in vegetation samples.

PCBs in Berries

PCB analysis was conducted on 13 berry samples collected from the site. Results of the laboratory analysis of berry samples for PCBs are presented in Table 4.14 in Appendix 4e. PCBs were not detected in any of the berry samples collected from the site. There are presently no provincial or federal criteria for PCB levels in berries, but any detected level is considered undesirable.

Metals in Berries

Available metals analysis was conducted on one (1) berry sample collected from the site. Results of the laboratory analysis of these berry samples for available metals are presented in Table 4.15 in Appendix 4e. Concentrations of copper, manganese and zinc were detected above the RDLs in the berry sample; however, there are no federal or provincial guidelines for available metals concentrations in berry samples.

PCBs in Small Mammals

PCB analysis was conducted on 22 small mammals caught at the site. The results of the laboratory analysis of small mammals for PCBs are presented in Table 4.16 in Appendix 4e. PCBs were detected in 20 of the small mammals analyzed at concentrations ranging from 0.2 mg/kg in SM-41 to 6.8 mg/kg in SM-8. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.

Metals in Small Mammals

Available metals analysis was conducted on six (6) small mammals caught at the site. The results of the laboratory analysis of small mammals for metals are presented in Table 4.17 in Appendix 4e. Concentrations of various available metals were detected in all of the small mammal samples analyzed. There are presently no provincial or federal criteria for available metal levels in small mammals.

Free Product Identification

Free product identification analysis was conducted on one (1) tar sample collected from the site. GPS coordinates were not recorded for the sample, therefore it is not shown on site drawings in Appendix 1. The results of the laboratory free product identification analysis conducted on the sample are presented in Table 4.18 in Appendix 4e. Laboratory analytical results indicate that no product could be identified within the sample within the analysis ranges.

PCBs in Tar

PCB analysis was conducted on one (1) tar sample collected from the site. GPS coordinates were not recorded for the sample, therefore it is not shown on site drawings in Appendix 1. The results of the laboratory analysis of tar for PCBs are presented in Table 4.19 in Appendix 4e. PCBs were not detected in the tar sample.

3.3.10 Conclusions

A Phase II/III ESA was completed at the Main Base site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. Limited remediation of PCB-impacted tar was conducted at the two (2) previously identified “CEPA area” until no visible evidence of staining remained at the site.
2. The observed stratigraphy was generally similar at all test pit and monitor well locations, and consisted of discontinuous layers of sand and organics (OL), silty sand (SM), silty sand and gravel (GM), sand (SW) or sand with cobbles and/or boulders (SP) overlying bedrock. Excavator refusal on presumed bedrock occurred at depths ranging from 0.20 m in to 3.00 m. Bedrock was encountered 76 of the 79 test pits investigated at this site and in all 10 monitor wells.
3. Various buried debris was observed within the overburden layer in 49 of the 79 test pits. Buried debris was generally found in test pits located in the south-western portion of the site (i.e., in areas formerly referred to as Old Base 2a and Old Base 2b), along the road at the centre of the site, in the north-eastern portion of the site (i.e., area formerly referred to as Tacan East), and in the area north of the main access road near the Sewage Outfall.
4. Groundwater was encountered at depths ranging from 0.20 to 4.63 mbgs in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be in all

directions, including to the northwest through the former sewage outfall and to the southeast towards Pit No. 2.

5. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
6. There was olfactory evidence of petroleum hydrocarbon impacts on soil in TP7 and TP43, of chemical impacts on soil in BS110 and of mineral oil impacts on soil in TP225. Free liquid phase petroleum hydrocarbons were observed on soil at TP7 and an oil sheen was also observed on the water encountered in BS113.
7. TPH concentrations exceeding the applicable Tier I RBSLs (i.e., 140 mg/kg) were detected in 37 soil samples (i.e., TP3-BS2, TP6-BS2, TP7-BS2, TP10-BS1, TP15-BS2, TP16-BS1, TP18-BS2, TP21-BS2, TP24-BS2, TP30-BS2, TP33-BS2, TP37-BS1, TP41-BS1, TP42-BS2, TP43-BS2, TP53-BS1, TP54-BS2, TP58-BS2, TP62-BS1, TP221-BS2, TP224-BS1, TP225-BS2, BS48, BS81, BS97, BS104, BS110, BS112, MW1-SS1, MW2-SS1, MW3-SS1, MW4-SS1, MW5-SS1, MW6-SS1, MW14-SS3 and Septic Tank). Concentrations of BTEX parameters in soil samples were below the applicable Tier I RBSLs. TPH and BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.
8. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP3, TP6, TP7, TP10, TP15, TP16, TP18, TP21, TP24, TP30, TP33, TP37, TP41, TP42, TP43, TP53, TP54, TP58, TP62, TP221, TP224, TP225, BS48, BS81, BS97, BS104, BS110, BS112, MW1, MW2, MW3, MW4, MW5, MW6, MW14 and Septic Tank** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
9. Drawing No. 121410103-EE-03b in Appendix 1 shows the estimated extent of the petroleum-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated combined area of approximately **13,300 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).
10. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in 14 soil samples (i.e., TP13-BS2, TP20-BS2, TP21-BS2, TP220-BS1, BS43, BS44, BS53, BS81, BS91, BS95, BS100, BS110, BS113 and Septic Tank). Low levels of PCBs were also detected in 13 other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCBs were not detected in the groundwater samples analyzed.
11. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of samples **TP13, TP20, TP21, TP220, BS43, BS44, BS53, BS81, BS91, BS95, BS100, BS110, BS113 and Septic Tank** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

12. Drawing No. 121410103-EE-03c in Appendix 1 shows the estimated extent of the PCB-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **6,000 m^2** has PCB levels in soil above 1.3 mg/kg.

13. PAH concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in one (1) soil sample (i.e., TP43-BS2). The benzo(a)pyrene Total Potency Equivalent (TPE) in TP43-BS2 exceeded the applicable guideline. PAHs were not detected in the groundwater sample analyzed.

14. Based on NLDEC policy directive PPD05-01, **PAH** remediation of site soil would be required in the vicinity of sample **TP43** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PAH remediation of site soil would be governed by SSTLs determined for the contaminant based on actual site conditions.

15. Drawing No. 121410103-EE-03d in Appendix 1 shows the estimated extent of the PAH-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **600 m^2** has PAH levels in soil above the applicable CCME criteria.

16. VOC concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in one (1) soil sample (i.e., Septic Tank). The tetrachloroethylene and toluene concentrations in soil sample collected from the Septic Tank exceeded the applicable guideline. Concentrations of VOC parameters were below the applicable OMOE guidelines in the groundwater sample analyzed.

17. Based on NLDEC policy directive PPD05-01, **VOC** remediation of soil from the **septic tank** would be required in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, VOC remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions. Based on available analytical and field data, an estimated area of approximately **300 m^2** has VOC levels in soil above the applicable CCME guideline.

18. Concentrations of antimony, arsenic, barium, chromium, copper, lead, tin and zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in 13 soil samples (i.e., TP18-BS2, TP21-BS2, TP41-BS1, TP49-BS2, TP57-BS1, TP58-BS2, TP62-BS1, TP69-BS2, BS47, BS65, BS78, BS84 and Septic Tank). Concentrations of copper exceeding the applicable OMOE groundwater standards were detected in one (1) groundwater sample (i.e., MW2).

19. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **TP18, TP21, TP41, TP49, TP57, TP58, TP62, TP69, BS47, BS65, BS78, BS84 and Septic Tank** and metals remediation of site groundwater would be required in the vicinity of monitor well **MW2** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for each contaminant.

20. Drawing No. 121410103-EE-03e in Appendix 1 shows the estimated extent of the metals-impacted soil and groundwater at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **3,300 m^2** has metals levels in soil above the applicable CCME criteria and an estimated **600 m^2** has metals levels in groundwater above the applicable OMOE criteria.
21. The tar sample (i.e., Tar-2) did not resemble petroleum products and did not contain detectable concentrations of PCBs.
22. The extent of TPH, PCB and metals impacts in soil and the extent of metals impacts in groundwater above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.
23. It is recommended that the septic tank be removed from the site.

3.4 Roadway

3.4.1 Site Description

The main access road provides access to the Former U.S. Military Site from the wharf area. The Roadway site investigated as part of the Phase II/III ESA consisted of the upper portion of the main access road, beginning near the turn-off to the BMEWS site, passing the Old Base 1 site and looping around the Main Base, as shown on Drawing No. 121410103-EE-03a in Appendix 1. The road is composed of compacted sand and gravel and is lined with low vegetation and shrubs.

The Roadway follows the topography of the surrounding terrain and surface runoff appears to be in all directions. Photos taken of the site during investigations are presented in Appendix 3a.

3.4.2 Field Work

Field work at this site comprised the excavation of six (6) test pits (i.e., TP213 to TP218), the installation of one (1) monitor well (i.e., MW7) and the collection of one (1) groundwater sample (i.e., MW7).). Coordinates of each sample location are provided in Appendix 5b. A site location map (Drawing No. 121410103-EE-03a) showing the location of these as well as general site features is provided in Appendix 1.

3.4.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 5c.

Excavator refusal suggested probable bedrock at the base of all test pits along the Roadway. The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.30 mbgs in TP217 to 1.20 mbgs in TP215. Bedrock was encountered in monitor well MW7 at a depth of 0.15 mbgs.

Brown coarse sand (SW) was encountered at the surface of MW7 and extended to bedrock at a depth of 0.15 mbgs.

Brown to black silty sand and gravel (SP) were encountered at or near the surface in TP213 to TP216 and ranged in thickness from 0.60 m in TP216 to 1.20 m in TP215. This layer extended to bedrock at all test pit locations.

Light brown medium silty sand (SM) was encountered at or near the surface in TP217 and TP218 and ranged in thickness from 0.30 m in TP217 to 1.10 m in TP218. This layer extended to bedrock at both test pit locations.

3.4.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, one (1) potential waste site was identified at the site. Test pits were excavated to investigate the size and contents of this potential waste site. Buried debris was not encountered in any of the six (6) test pits dug at the site, as indicated in Table 2.3.

3.4.5 Groundwater Conditions

The groundwater level was measured in monitor well MW7 on October 15, 2009, and measured 2.47 mbgs. Groundwater levels at monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 31, 2009 in TP216 at a depth of 0.60 mbgs. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be in all directions. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-03a in Appendix 1.

3.4.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.4.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Roadway site are provided on the Monitor Well Records in Appendix 5c and in Appendix 5d. The soil vapour concentrations measured ranged from 0.8 ppm in TP213-BS1 to 90 ppm in TP216-BS1. Petroleum hydrocarbon odours were detected on soil sample MW7-SS1.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in one (1) soil sample collected from the site (i.e., TP216-BS1), which also had a modified TPH concentration in excess of 1,000 mg/kg.

3.4.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Roadway site is presented in Table 3.4 below.

Table 3.4 Laboratory Analysis Schedule (Roadway)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	TP213 to TP218 MW7	TPH (2) PCBs (3) Metals (1)	Metals (1)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 5.1 to 5.4 in Appendix 5e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>Petroleum Hydrocarbons in Soil</u>

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on two (2) soil samples collected from the site, including one (1) test pit sample and one (1) monitor well soil sample. Results of the laboratory analysis of the soil sample for petroleum hydrocarbons are presented in Table 5.1 in Appendix 5e. Modified TPH was detected in both soil samples. The concentration of TPH in TP216-BS1 (16,000 mg/kg) and MW7-SS1 (160 mg/kg) exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg). Laboratory analytical results indicated that products impacting the soil samples resembled weathered fuel oil or lube oil fractions. BTEX parameters were not detected in soil samples collected from the site.

<u>PCBs in Soil</u>

PCB analysis was conducted on three (3) soil samples collected from the site, including two (2) test pit samples and one (1) monitor wells sample. Results of the laboratory analysis of soil samples for PCBs are presented in Table 5.4 in Appendix 5e. Concentrations of PCBs were not detected or were below the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

Metals in Soil

Available metals analysis was conducted on one (1) monitor well soil sample collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 5.3 in Appendix 5e. Concentrations of various metals were detected in the soil sample. The elevated RDL for selenium (2 mg/kg) was greater than the CCME guideline (1 mg/kg), therefore it is not possible to determine if the concentration of selenium exceeded the criteria. None or the remaining concentrations of available metals exceeded applicable CCME criteria for metals in soil on a residential/parkland site.

Metals in Groundwater

Available metals analysis was conducted on one (1) groundwater sample collected from the site. Results of the laboratory analysis of this groundwater sample for available metals are presented in Table 5.4 in Appendix 5e. Concentrations of various metals were detected in the groundwater sample. None of the detected concentrations of metals exceeded the applicable OMOE criteria for non-potable groundwater, where such criteria exists.

3.4.9 Conclusions

A Phase II/III ESA was completed at the Roadway site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy was generally similar at all test pit and monitor well locations, and consisted of brown coarse sand (SW), brown to black silty sand and gravel (SP) or light brown medium silty sand (SM). Excavator refusal on presumed bedrock occurred in all six (6) test pits at depths ranging from 0.30 mbgs to 1.20 mbgs. Bedrock was encountered in monitor well MW7 at a depth of 0.15 mbgs.
2. No buried debris was encountered in test pits along the Roadway.
3. Groundwater was encountered at a depth of 2.47 mbgs in MW7 and at a depth of 0.60 mbgs in TP216. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be in all directions.
4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. There was olfactory evidence of petroleum hydrocarbon impacts on soil in MW7-SS1. No free phase petroleum hydrocarbons were observed on surface soil or groundwater throughout the site.
6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in two (2) soil samples (i.e., TP216-SS1 and MW7-SS1). BTEX parameters were not detected in the soil samples analyzed. Groundwater samples were not analyzed for TPH and BTEX parameters.
7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP216 and MW7** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach,

petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

8. Drawing No. 121410103-EE-03b in Appendix 1 shows the estimated extent of the petroleum-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated combined area of approximately **600 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).
9. Low levels of PCBs were detected in one (1) soil sample collected from the site, however none of the soil samples analyzed had PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg).
10. Metals concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were not detected in the soil sample analyzed. The elevated RDLs for selenium were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium exceeded the criteria at the site. Metals concentrations exceeding the applicable OMOE criteria for groundwater on a residential/parkland site were not detected in the soil sample analyzed.
11. The extent of TPH impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.5 Sewage Outfall

3.5.1 Site Description

The Sewage Outfall is located north of the Main Base, on the north side of the main access road. During operation of the Former U.S. Military Base the site served as a sewage outfall for the Main Base site. There is currently a drainage course that originates at the Main Base site and flows north through the Sewage Outfall.

Terrain in the vicinity of the site is moderately to steeply sloped towards the northwest and surface drainage (apparent groundwater flow direction) appears to be to the northwest towards the Valley Drainage Ponds. Photos taken of the site during investigations are presented in Appendix 6a.

3.5.2 Field Work

Field work at this site comprised the collection of four (4) surface soil samples (i.e., BS152 to BS155). A site location map (Drawing No. 121410103-EE-03a) showing the location of these as well as general site features is provided in Appendix 1.

3.5.3 Stratigraphy

Basic stratigraphic information was recorded during the collection of surface soil samples. Medium to dark brown soil was encountered in surface soil samples BS152 to BS154. Surface soil sample BS155 was collected under a burnt pit and consisted of grey mud. Sample refusal occurred at bedrock in surface soil samples BS153 and BS154 at depths of 0.28 and 0.12 mbgs, respectively. Sample refusal did not occur at bedrock in the BS153 and BS155.

3.5.4 Debris and Physical Hazards

No potential waste sites were identified at the site during the initial site inspection conducted in October 2008; however buried debris was encountered in one (1) of the four (4) surface soil samples, as identified in Table 2.3. Buried debris encountered in soil sample BS155 consisted of metal debris.

3.5.5 Groundwater Conditions

Groundwater seepage was not observed in any of the surface soil sample pits during sampling. Based on local topography and site observations the direction of groundwater flow is inferred to be to the northwest towards the Valley Drainage Ponds. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-03a in Appendix 1.

3.5.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. There was no visual evidence of free phase petroleum hydrocarbons in the surface soil pits.

3.5.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Sewage Outfall site are provided in Appendix 6c. The soil vapour concentrations were 0.0 ppm in all surface soil samples. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the soil samples collected from the site; however, the modified TPH concentration in BS154 was 1,000 mg/kg.

3.5.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Sewage Outfall site is presented in Table 3.5 below.

Table 3.5 Laboratory Analysis Schedule (Sewage Outfall)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible petroleum hydrocarbon, PCBs, VOCs or metals impacts in soil.	BS152 to BS155	TPH (3) PCBs (3) Metals (2)	-	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 6.1 to 6.3 in Appendix 6d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on three (3) surface soil samples collected from the site. Results of the laboratory analysis of these soil samples for petroleum hydrocarbons are presented in Table 6.1 in Appendix 6d. Modified TPH was detected in the three (3) soil samples at concentrations ranging from 290 mg/kg in BS153 to 1,000 mg/kg in BS154. The concentrations of TPH in BS152 (910 mg/kg), BS153 (290 mg/kg) and BS154 (1,000 mg/kg) exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg). Laboratory analytical results indicated that soil samples collected from the site had one product in the fuel/lube oil range. Concentrations of BTEX parameters were below the applicable Tier I RBSLs in soil samples collected from the site.

PCBs in Soil

PCB analysis was conducted on three (3) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 6.2 in Appendix 6d. Concentrations of PCBs in BS152 (3 mg/kg) exceeded the applicable CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg. Concentrations of PCBs in the remaining soil samples were below the applicable CCME soil quality guideline.

Metals in Soil

Available metals analysis was conducted on three (3) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 6.3 in Appendix 6d. Concentrations of various metals were detected in all soil samples. The concentrations of copper detected in BS152 (100 mg/kg) and BS154 (65 mg/kg) exceeded the applicable CCME residential/parkland guideline of 63 mg/kg. The concentration of tin detected in BS152 (64 mg/kg) exceeded the applicable CCME residential/parkland guideline of 50 mg/kg. The concentrations of zinc detected in BS152 (1,500 mg/kg) and BS154 (540 mg/kg) exceeded the applicable CCME residential/parkland guideline of 200 mg/kg. Elevated RDLs were reported for selenium for samples BS152 (2 mg/kg), BS153 (5 mg/kg) and BS154 (2 mg/kg), therefore it is not possible to determine if concentrations of selenium exceeded the CCME guideline for selenium (1 mg/kg) at the site. None of the remaining detected concentrations of available metals exceeded the applicable CCME criteria for metals in soil on a residential/parkland site.

3.5.9 Conclusions

A Phase II/III ESA was completed at the Sewage Outfall, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy was generally similar at all surface soil sample locations, and consisted of brown soil. Sample BS155 was collected beneath a burnt pit, where buried metal debris was observed. Refusal on presumed bedrock occurred at depths of 0.28 mbgs in BS153 and 0.12 mbgs in BS154. Bedrock was not encountered at the remaining surface soil sampling locations investigated at this site.
2. Groundwater was not encountered during surface soil sampling at the site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be northwest towards the Valley Drainage Ponds.
3. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
4. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil at the site. No free phase petroleum hydrocarbons were observed on surface soil throughout the site.
5. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in all three (3) soil samples analyzed (i.e., BS152, BS153, and BS154). No BTEX parameters exceeding the applicable Tier I RBSLs were detected in the soil samples analyzed.
6. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **BS152, BS153, and BS154** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
7. Drawing No. 121410103-EE-03b in Appendix 1 shows the estimated extent of the petroleum-impacted soil. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, there is an estimated area of approximately **450 m^2** that has TPH levels in soil above 140 mg/kg.
8. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in soil sample BS152. Low levels of PCBs were also detected in BS154, however these did not exceed applicable CCME criteria.
9. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of **BS152** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

10. Drawing No. 121410103-EE-03c in Appendix 1 shows the estimated extent of the PCB-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an area of approximately **200 m^2** has PCB levels in soil above 1.3 mg/kg.
11. VOC analysis was not conducted on soil samples collected from the site.
12. Metals concentrations exceeding the applicable CCME criteria for soil on a residential/ parkland site were detected in soil samples BS152 (i.e., copper, tin, zinc) and BS154 (i.e., copper and zinc). The elevated RDLs for selenium were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium exceeded the criteria at the site.
13. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **BS152 and BS154** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil would be governed by SSTLs determined for each contaminant.
14. Drawing No. 121410103-EE-03e in Appendix 1 shows the estimated extent of the metals-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an area of approximately **450 m^2** has metals levels in soil above the applicable CCME criteria.
15. The extent of TPH and metals impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.6 Valley Drainage Ponds

3.6.1 Site Description

The Valley Drainage Ponds are located within a deeply incised U-shaped valley with steep-sided, rounded mountain slopes. The site is located between the hilltop BMEWS, Old Base 1 and Main Base sites. The site consists of dense vegetation with ponds and wetlands. Based on local topography, the site is expected to receive surface runoff and groundwater recharge from the Former U.S. Military Site.

Terrain at the site slopes slightly to the north and surface drainage (apparent groundwater flow direction) appears to be to the north. Photos taken of the site during investigations are presented in Appendix 7a.

3.6.2 Field Work

Field work at this site comprised the collection of seven (7) freshwater sediment samples (i.e., SED-12 to SED-18), seven (7) vegetation samples (i.e., VEG-1 to VEG-7), seven (7) berry samples (i.e., BERRY-20 to BERRY-26) and eight (8) small mammal samples (i.e., SM-45 to SM-52).). Coordinates of each sample location are provided in Appendix 7b. Site location maps (Drawing No. 121410103-EE-02a and Drawing No. 121410103-EE-03) showing the location of these as well as general site features are provided in Appendices 1.

3.6.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.6.4 Soil Vapour Concentrations

The soil vapour concentrations measured in sediment samples from the Valley Drainage Ponds site are provided in Appendix 7c. Vapour concentrations measured ranged from 1.8 ppm in sediment sample SED-16 to 3.6 ppm in sediment sample SED-15. No petroleum hydrocarbon odours were detected on the sediment samples collected at the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. No soil vapour concentrations exceeded 50 ppm in sediment samples collected at the site and all concentrations of modified TPH in sediment samples analyzed from the site were below 1,000 mg/kg.

3.6.5 Laboratory Analysis and Results

A laboratory analysis schedule for the Valley Drainage Ponds site is presented in Table 3.6 below.

Table 3.6 Laboratory Analysis Schedule (Valley Drainage Ponds)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Potential for contaminants migrating from the BMEWS, Old Base 1, Main Base, Sewage Outfall, Roadway and Pallet Line sites.	SED-12 to SED-18 VEG-1 to VEG-7 BERRY-20 to BERRY-26 SM-45 to SM-52	TPH (7) PCBs (7) VOCs (7) Metals (7)	-	Veg.: PCBs (7) Metals (7) Berries: PCBs (7) Metals (7)	PCBs (8) Metals (3)	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 7.1 to 7.10 in Appendix 7d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on all seven (7) freshwater sediment samples collected from the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Table 7.1 in Appendix 7d. Modified TPH was detected in four (4) of the sediment samples at concentrations ranging from 98 mg/kg in SED-17 to 360 mg/kg in SED-13. The detected concentrations of modified TPH were below the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg). Laboratory analytical results indicated the samples resembled fuel/lube oil fractions. BTEX parameters were not detected in soil samples collected from the site. There are no applicable guidelines for BTEX parameters in freshwater sediment.

PCBs in Sediment

PCB analysis was conducted on all seven (7) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 7.2 in Appendix 7d. Concentrations of PCBs were not detected above the RDL (0.05 mg/kg) in any of the sediment samples collected from the site. The RDL is greater than the CCME freshwater ISQG for PCBs, therefore it is not possible to determine if this guideline was exceeded.

VOCs in Sediment

PCB analysis was conducted on all seven (7) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 7.3 in Appendix 7d. Concentrations of VOC parameters were not detected above the RDLs in any of the sediment samples collected from the site.

Metals in Sediment

Available metals analysis was conducted on all seven (7) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for available metals are presented in Table 7.4 in Appendix 7d. Concentrations of various metals were detected in all sediment samples. None of the detected concentrations of available metals exceeded the applicable CCME freshwater ISQGs or PELs.

PCBs in Vegetation

PCB analysis was conducted on all seven (7) vegetation samples collected from the site. Results of the laboratory analysis of vegetation samples for PCBs are presented in Table 7.5 in Appendix 7d. PCBs were not detected above the RDL (<0.3 mg/kg) in any of the vegetation samples analyzed. There are presently no provincial or federal criteria for PCB levels in vegetation, but any detected level is considered undesirable.

Metals in Vegetation

Available metals analysis was conducted on all seven (7) vegetation samples collected from the site. Results of the laboratory analysis of these vegetation samples for available metals are presented in Table 7.6 in Appendix 7d. Various metals were detected in all vegetation samples; however, there are no federal or provincial guidelines for available metals concentrations in vegetation samples.

PCBs in Berries

PCB analysis was conducted on all seven (7) berry samples collected from the site. Results of the laboratory analysis of berry samples for PCBs are presented in Table 7.7 in Appendix 7d. PCBs were not detected above the RDL (<0.05 mg/kg) in any of the berry samples analyzed. There are presently no provincial or federal criteria for PCB levels in berries, but any detected level is considered undesirable.

Metals in Berries

Available metals analysis was conducted on all seven (7) berry samples collected from the site. Results of the laboratory analysis of these berry samples for available metals are presented in Table 7.8 in Appendix 7d. Various metals were detected in all berry samples; however, there are no federal or provincial guidelines for available metals concentrations in berry samples.

PCBs in Small Mammals

PCB analysis was conducted on all eight (8) small mammals caught at the site. The results of the laboratory analysis of small mammals for PCBs are presented in Table 7.9 in Appendix 7d. PCBs were detected in six (6) of the small mammals analyzed (SM-45, SM-46, SM-47, SM-48, SM-49 and SM-52) at concentrations ranging from 0.1 mg/kg in SM-49 to 3.6 mg/kg in SM-46. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.

Metals in Small Mammals

Available metals analysis was conducted on three (3) small mammals caught at the site. The results of the laboratory analysis of small mammals for metals are presented in Table 7.10 in Appendix 7d. Concentrations of various available metals were detected in all of the small mammal samples analyzed. There are presently no provincial or federal criteria for available metal levels in small mammals.

3.6.6 Conclusions

A Phase II/III ESA was completed at the Valley Drainage Ponds, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of this assessment are summarised below.

1. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be to the north.
2. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
3. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on sediment at the site.
4. TPH concentrations did not exceed the applicable OMOE Guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg) in sediment samples analyzed. Concentrations of BTEX parameters in were not detected in sediment samples analyzed.

5. PCBs were not detected above the RDL (i.e., 0.05 mg/kg) in sediment collected from the site; therefore PCB concentrations were below the applicable CCME PEL for freshwater sediment (i.e., 0.277 mg/kg). It is not possible to determine if concentrations of PCBs exceeded the CCME ISQG for freshwater sediment (i.e., 0.0341 mg/kg).
6. VOCs were not detected in sediment samples collected from the site.
7. Metals concentrations did not exceed the applicable CCME ISQGs or PELs for freshwater sediment in sediment samples analyzed.
8. PCBs were detected in six (6) of the small mammals analyzed (SM-45, SM-46, SM-47, SM-48, SM-49 and SM-52) at concentrations ranging from 0.1 mg/kg in SM-49 to 3.6 mg/kg in SM-46. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.
9. Based on field evidence and analytical results, no petroleum hydrocarbon, PCB, VOC or metals impacts on soils have been identified at the site. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified. The environmental consultants are not aware of any reason to recommend additional testing for contaminants in soil at this site.

3.7 Mid-Canada Line

3.7.1 Site Description

The Mid-Canada Line site is located approximately 700 m southeast of the Main Base on top of a hill. The site formerly included a Mid-Canada Line antenna and small buildings. The concrete foundations from the former antenna and buildings currently remain at the site. The site also currently includes two fenced antennae and a communications trailer.

Terrain in the vicinity of the Mid-Canada Line site is moderately sloped and surface drainage (apparent groundwater flow direction) appears to be to in all directions, including to the west towards Pit No. 2. Vegetation at the site is limited and consists of patches of grasses and some low bushes. Bedrock and boulder outcroppings are common at the site. Photos taken of the site during investigations are presented in Appendix 8a.

3.7.2 Field Work

Field work at this site comprised the collection of 18 surface soil samples (i.e., BS133 to BS145 and BS257 to BS261), five (5) vegetation samples (i.e., VEG-42 to VEG-46), five (5) berry samples (i.e., BERRY-33 to BERRY-37) and 10 small mammals (i.e., SM-29 to SM-38). Coordinates of each sample location are provided in Appendix 8b. A site location map (Drawing No. 121410103-EE-04a) showing the location of these as well as general site features is provided in Appendix 1.

3.7.3 Stratigraphy

No test pits were dug or monitor wells were drilled at the site during the Phase II/III ESA; however, basic stratigraphic information was recorded during the collection of surface soil samples. Surface soil samples generally consisted of light brown coarse sand with occasional gravel (SP). Sample refusal did not occur at bedrock in any of the surface soil samples, which were collected from a maximum depth of 0.10 mbgs. Extensive bedrock outcrops were observed at the site. The depth to bedrock throughout the remainder of the site is expected to be shallow.

3.7.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, one (1) potential waste site was identified at the site. Surface soil samples were excavated to investigate the size and contents of this potential waste site.

Buried debris was encountered at three (3) of the 18 surface soil sample locations, as identified in Table 2.3. Buried debris encountered in soil sample BS133, BS135 and BS140 consisted of asbestos, paint chips and rust, respectively.

3.7.5 Groundwater Conditions

Groundwater seepage was not observed in any of the surface soil sample pits excavated during sampling. Based on local topography and site observations the direction of groundwater flow is inferred to be in all directions. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-04a in Appendix 1.

3.7.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. There was no visual evidence of free phase petroleum hydrocarbons in surface soil pits.

3.7.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Mid-Canada Line site are provided in Appendix 8c. Vapour concentrations measured ranged from 3.8 ppm in soil sample BS133 to 7.5 ppm in soil sample BS141. No petroleum hydrocarbon odours were detected in surface soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. No soil vapour concentrations exceeded 50 ppm in samples collected at the site and concentrations of modified TPH in soil samples analyzed did not exceed 1,000 mg/kg.

3.7.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Mid-Canada Line site is presented in Table 3.7 below.

Table 3.7 Laboratory Analysis Schedule (Mid-Canada Line)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible metals in soil. Possible metals in vegetation, berries, small mammals and rabbits. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	BS133 to BS145, BS257 to BS261 VEG-42 to VEG-46 BERRY-33 to BERRY-37 SM-29 to SM-38	TPH (3) PCBs (6) Metals (11)	-	Veg: Metals (5) Berries: Metals (5)	Small mammals: PCBs (7) Metals (7) No rabbits caught	-

Results of laboratory analysis of soil, vegetation, berry and small mammal samples obtained from this site are presented in Tables 8.1 to 8.7 in Appendix 8d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on three (3) surface soil samples collected from the site. Results of the laboratory analysis of the soil sample for petroleum hydrocarbons are presented in Table 8.1 in Appendix 8d. Modified TPH was detected in all three (3) surface soil samples at a concentrations ranging from 24 mg/kg in BS145 to 39 mg/kg in BS140. Concentrations of modified TPH were below the applicable Tier I RBSL (i.e., 690 mg/kg) in all soil samples analyzed. Laboratory analytical results indicate that the products impacting the samples were in the lube oil range. BTEX parameters were not detected in the soil samples analyzed.

PCBs in Soil

PCB analysis was conducted on six (6) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 8.2 in Appendix 8d. Concentrations of PCBs were detected in four (4) soil samples (i.e., BS137, BS139, BS142 and BS144), ranging from 0.17 mg/kg in BS139 to 0.70 mg/kg in BS142. None of the detected concentrations of PCBs exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

Metals in Soil

Available metals analysis was conducted on 11 surface soil samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 8.3 in Appendix 8d. Concentrations of various metals were detected in all 11 soil samples, several of which exceeded applicable CCME criteria for metals in soil on a residential/parkland site. The concentrations of cadmium (i.e., 13 mg/kg), chromium (i.e., 1,200 mg/kg) and molybdenum (i.e., 81 mg/kg) detected in BS135 exceeded the applicable CCME residential/parkland guidelines of

10 mg/kg, 64 mg/kg and 10 mg/kg, respectively. The concentrations of copper in BS135 (i.e., 210 mg/kg) and BS140 (i.e., 140 mg/kg) exceeded the applicable CCME residential/parkland guidelines of 63 mg/kg. The concentrations of lead in BS135 (i.e., 3,200 mg/kg) and BS142 (i.e., 440 mg/kg) exceeded the applicable CCME residential/parkland guidelines of 140 mg/kg. The concentrations of zinc in BS135 (i.e., 22,000 mg/kg), BS140 (i.e., 470 mg/kg) and BS142 (i.e., 450 mg/kg) exceeded the applicable CCME residential/parkland guidelines of 200 mg/kg. The elevated RDL for selenium (2 mg/kg) was greater than the CCME guideline (1 mg/kg), therefore it is not possible to determine if the concentration of selenium exceeded the criteria. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Metals in Vegetation

Available metals analysis was conducted on five (5) vegetation samples collected from the site. Results of the laboratory analysis of these vegetation samples for available metals are presented in Table 8.4 in Appendix 8d. Various metals were detected in all vegetation samples; however, there are no federal or provincial guidelines for available metals concentrations in vegetation samples.

Metals in Berries

Available metals analysis was conducted on five (5) berry sample collected from the site. Results of the laboratory analysis of these berry samples for available metals are presented in Table 8.5 in Appendix 8d. Concentrations of boron, copper, manganese and zinc were detected above the RDLs in select berry samples; however, there are no federal or provincial guidelines for available metals concentrations in berry samples.

PCBs in Small Mammals

PCB analysis was conducted on seven (7) small mammals caught at the site. The results of the laboratory analysis of small mammals for PCBs are presented in Table 8.6 in Appendix 8d. PCBs were detected in four (4) of the small mammals analyzed at concentrations ranging from 0.09 mg/kg in SM-32 to 0.016 mg/kg in SM-32. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.

Metals in Small Mammals

Available metals analysis was conducted on seven (7) small mammals caught at the site. The results of the laboratory analysis of small mammals for metals are presented in Table 8.7 in Appendix 8d. Concentrations of various available metals were detected in all of the small mammal samples analyzed. There are presently no provincial or federal criteria for available metal levels in small mammals.

3.7.9 Conclusions

A Phase II/III ESA was completed at the Mid-Canada Line site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy was generally similar at all surface soil sample locations, and consisted of light brown coarse sand with occasional gravel (SP). Bedrock was not encountered at any of the surface soil sampling locations investigated at this site.
2. Groundwater was not encountered during surface soil sampling at the site. Based on local topography and site observations, the direction of groundwater flow from the centre of the site is inferred to be in all directions, including to the west towards Pit No. 2.
3. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
4. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil at the site. No free phase petroleum hydrocarbons were observed on surface soil throughout the site.
5. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 690 mg/kg) were not detected in any of the soil samples analyzed. No BTEX parameters exceeding the applicable Tier I RBSLs were detected in the soil samples analyzed.
6. Low levels of PCBs were detected in three (3) soil samples collected from the site, however none of the soil samples analyzed had PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg).
7. Metals concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in soil samples BS135, BS140 and BS142 (i.e., cadmium, chromium, copper, lead, molybdenum and/or zinc). The elevated RDLs for selenium were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium exceeded the criteria at the site.
8. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **BS135, BS140 and BS145** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil would be governed by SSTLs determined for each contaminant.
9. Drawing No. 121410103-EE-04c in Appendix 1 shows the estimated extent of metals-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an area of approximately **500 m^2** has metals levels in soil above the applicable CCME criteria.
10. The extent of metals impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.8 Pallet Line

3.8.1 Site Description

The Pallet Line site is located between the Old Base 1 site and BMEWS on the south side of the main access road, as shown in Drawing No. 121410103-EE-05a in Appendix 1. During operation of the Former U.S. Military Site, the site was used as a storage area.

The site is a heavily worked area consisting of sand and gravel. Terrain at the site slopes moderately to the southeast. Surface drainage (apparent groundwater flow direction) is expected to be to the southeast towards Pit No. 1 and Pit No. 3.

3.8.2 Field Work

Field work at this site comprised the collection of 26 surface soil samples (i.e., BS114 to BS120, BS146 to BS151, BS156 to BS158 and BS248. Coordinates of each sample location are provided in Appendix 9a. A site location map (Drawing No. 121410103-EE-05a) showing the location of surface soil samples as well as general site features is provided in Appendix 1.

3.8.3 Stratigraphy

No test pits were excavated or monitor wells were drilled at the site during the Phase II/III ESA. Surface soil samples generally consisted of dark brown to black sand or gravel. Refusal occurred at assumed bedrock in 12 of the 13 surface soil samples (i.e., BS114 to BS120 and BS146 to BS150) at depths ranging from 0.04 mbgs in BS148 to 0.30 mbgs in BS119. The depth to bedrock throughout the remainder of the site is expected to be shallow.

3.8.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, one (1) potential waste site was identified at the site. Surface soil samples were excavated to investigate the size and contents of this potential waste site.

Buried debris was encountered in two (2) of the 16 surface soil samples, as identified in Table 2.3. Buried debris encountered in soil samples BS115 and BS116 consisted of wood debris.

3.8.5 Groundwater Conditions

Groundwater seepage was observed at surface soil samples locations BS116, BS146 and BS147 on July 30, 2009 during sampling. Based on local topography and site observations the direction of groundwater flow is inferred to be to the southeast towards Pit No. 1 and Pit No. 3. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-05a in Appendix 1.

3.8.6 Free Phase Petroleum Hydrocarbons

An oil sheen was observed on groundwater encountered in BS146 during the investigation. There was no visual evidence of free phase petroleum hydrocarbons on surface soil at the site or in any of the remaining surface soil pits.

3.8.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Pallet Line site are provided in Appendix 9b. The soil vapour concentrations measured were 0.0 ppm in all soil samples collected from the site. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the soil samples collected from the site; however, modified TPH concentrations were greater than 1,000 mg/kg in BS116.

3.8.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Pallet Line site is presented in Table 3.8 below.

Table 3.8 Laboratory Analysis Schedule (Pallet Line)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
No previous investigation conducted. Transformer oil odour. Potential for petroleum hydrocarbons, PCBs or metals in soil. Possible waste site. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	BS114 to BS120, BS146 to BS151, BS156 to BS158, BS248	TPH (6) PCBs (4) Metals (6)	-	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 9.1 to 9.3 in Appendix 9c. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on six (6) surface soil samples collected from the site. Results of the laboratory analysis of the soil sample for petroleum hydrocarbons are presented in Table 9.1 in Appendix 9c. Modified TPH was detected in all six (6) soil samples at concentrations ranging from 260 mg/kg in soil sample BS146 to 2,600 mg/kg in soil sample BS116. The concentration of TPH in soil samples BS116 (2,600 mg/kg) and BS147 (690 mg/kg) exceeded the applicable Tier I RBSL for lube oil impacts (i.e., 690 mg/kg). Laboratory analytical results indicated that products impacting the soil samples resembled fuel oil or lube oil fractions.

PCBs in Soil

PCB analysis was conducted on four (4) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 9.2 in Appendix 9c. The concentration of PCBs in sample BS146 (2.1 mg/kg) exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg. The remaining concentrations of PCBs were not detected or were below the applicable CCME guideline.

Metals in Soil

Available metals analysis was conducted on six (6) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 9.3 in Appendix 9c. Concentrations of various metals were detected in the soil samples. The elevated RDL for selenium (2 mg/kg) was greater than the CCME guideline (1 mg/kg), therefore it is not possible to determine if concentrations of selenium in samples collected from the site exceeded the criteria. None or the remaining concentrations of available metals exceeded applicable CCME criteria for metals in soil on a residential/parkland site.

3.8.9 Conclusions

A Phase II/III ESA was completed at the Pallet Line site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy was generally similar at all surface soil sample locations, and consisted of dark brown to black sand and gravel. Refusal on presumed bedrock occurred in 10 of the 13 surface soil samples at depths ranging from 0.04 mbgs in BS148 to 0.30 mbgs in BS119.
2. Groundwater was encountered in three (3) of 13 surface soil pits during surface soil sampling at the site. Based on local topography and site observations, the direction of groundwater flow is inferred to be to the southeast towards Pit No. 1 and Pit No. 3.
3. There was no olfactory evidence of petroleum hydrocarbon impacts on surface soil at the site. However, an oil sheen was observed on water encountered in BS146.
4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 690 mg/kg) were detected in two (2) soil samples analyzed (i.e., BS116 and BS147). BTEX parameters were not detected in the soil samples analyzed.
6. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **BS116 and BS147** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
7. Drawing No. 121410103-EE-05b in Appendix 1 shows the estimated extent of the petroleum-impacted soil. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, there is an estimated area of approximately **3,000 m^2** that has TPH levels in soil above 690 mg/kg.
8. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in soil sample BS146. Low levels of PCBs were also detected in BS149, however these did not exceed applicable CCME criteria.

9. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of **BS146** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
10. Drawing No. 121410103-EE-05c in Appendix 1 shows the estimated extent of the PCB-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an area of approximately **300 m^2** has PCB levels in soil above 1.3 mg/kg.
11. Metals concentrations did not exceed the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed. The elevated RDLs for selenium were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium exceeded the criteria at the site.
12. The extent of TPH and PCB impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.9 Pit No. 1/Helipad

3.9.1 Site Description

The Pit No. 1/Helipad site is located south of the Main Base on the north side of the main access road, as shown on Drawing No. 121410103-EE-05a in Appendix 1. The site is a heavily worked area consisting of gravel and boulders with low vegetation along the perimeter. Terrain at the site slopes moderately to the west. Surface drainage (apparent groundwater flow direction) is expected to be to the east towards Pit No. 3. Photos taken of the site during investigations are presented in Appendix 10a.

3.9.2 Field Work

Field work at this site comprised the excavation of 18 test pits (i.e., TP143 to TP160), the installation of three (3) monitor wells (i.e., MW18 to MW20) and the collection of 12 surface soil samples (i.e., BS159 to BS170) and two (2) groundwater samples (i.e., MW18 and MW20). Coordinates of each sample location are provided in Appendix 10b. A site location map (Drawing No. 121410103-EE-05a) showing the location of these as well as general site features is provided in Appendix 1.

3.9.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 10c.

Excavator refusal suggested probable bedrock at the base of all test pits at the site, with the exception of TP157 (depth of 2.2 m). The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.30 mbgs in TP149 and TP256 to 2.00 mbgs in TP147.

Bedrock was encountered in all monitor wells at depths ranging from 0.30 mbgs in MW19 to 2.44 mbgs in MW18 and MW20.

Dark brown organics with sand and/or cobbles (OL) were encountered at or near the surface in MW18 and MW19 and extended to bedrock at depths of 2.44 mbgs and 0.30 mbgs, respectively. Dark brown sand and cobbles (SP) with trace organics were encountered in MW20 and extended to bedrock at a depth of 2.44 mbgs.

Dark brown and black sand (SP) with occasional boulders was encountered in TP143 and TP144 and extended to bedrock at 0.80 mbgs and 1.50 mbgs, respectively.

Brown, grey or black silty sand (SM) with occasional trace cobbles was encountered at or near the surface of TP152, TP153, TP155 to TP158 and ranged in thickness from 0.30 m in TP156 to 2.20 m in TP157. This layer extended to bedrock at all test pit locations.

Light brown to grey silty sand and gravel (GM) and occasional boulders were encountered at or near the surface in TP143, TP145 to TP151, TP154, TP159 and TP160 and ranged in thickness from 0.30 m in TP149 to 2.00 m in TP147. This layer extended to bedrock at all test pit locations, with the exception of TP143 which was underlain by sand materials (SP).

3.9.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, two (2) potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in seven (7) of the 18 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 10c and in one (1) of the 12 surface soil samples, as identified in Table 2.3. Buried debris at the site was generally found in test pits located along the eastern perimeter of Pit No. 1. Items encountered in test pits and surface samples at the site consisted of the following:

- Metal
- Corrugated steel
- Steel wire
- Cable
- Tar felt
- Crushed drums
- Plastic
- Plastic pipes
- Rubber track

3.9.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 5.93 mbgs in MW20 to 8.07 mbgs in MW18. Monitor well MW19 was dry on October 15, 2009. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 28, 2009 in TP157 and TP160 at depths of 2.10 mbgs and 1.00 mbgs, respectively. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be to the east towards Pit No. 3. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-05a in Appendix 1.

3.9.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.9.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Pit No. 1/helipad site are provided on the Monitor Well Records in Appendix 10c and Appendix 10d. The soil vapour concentrations measured ranged from 0.0 ppm in soil samples collected from TP154 to TP160 to 11.9 in TP153-BS1. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the soil samples collected at the site; however concentrations of modified TPH exceed 1,000 mg/kg in four (4) soil samples collected from the site (i.e., TP143-BS2, TP147-BS2, BS169 and MW18-SS4).

3.9.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Pit No. 1/Helipad site is presented in Table 3.9 below.

Table 3.9 Laboratory Analysis Schedule (Pit No. 1/helipad)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/drum storage areas under boulder pile. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	TP143 to TP160 BS159 to BS170 MW18 to MW20	TPH (16) PCBs (9) PAHs (2) Metals (13)	TPH (2) PCBs (1)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 10.1 to 10.6 in Appendix 10e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 16 soil samples collected from the site, including 10 test pit samples, four (4) surface soil samples and two (2) monitor well samples. Results of the laboratory analysis of these soil samples for petroleum hydrocarbons are presented in Table 10.1 in Appendix 10e. Modified TPH was detected in 15 soil samples at concentrations ranging from 41 mg/kg in TP160-BS1 to 2,800 mg/kg in TP143-BS2. The concentrations of TPH in TP143-BS2 (2,800 mg/kg), TP147-BS2 (1,600 mg/kg), TP152-BS2 (830 mg/kg), BS169 (1,700 mg/kg) and MW18-SS4 (2,300 mg/kg) exceeded the applicable Tier I RBSL for lube oil impacts (i.e., 690 mg/kg). Laboratory analytical results indicated that products impacting the soil samples resembled a mixture of weathered fuel oil, fuel oil and lube oil fractions. BTEX parameters were not detected in soil samples collected from the site.

PCBs in Soil

PCB analysis was conducted on nine (9) soil samples collected from the site, including five (5) test pit samples, three (3) surface soil samples and one (1) monitor wells sample. Results of the laboratory analysis of soil samples for PCBs are presented in Table 10.2 in Appendix 10e. Concentrations of PCBs in TP152-BS1 (20.0 mg/kg) and MW18-SS4 (11.0 mg/kg) exceeded the applicable CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg. Concentrations of PCBs in the remaining soil samples were below the applicable CCME soil quality guideline.

PAHs in Soil

PAH analysis was conducted on two (2) soil samples collected from the site. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 10.3 in Appendix 10e.

Detectable concentrations of PAH parameters were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

Metals in Soil

Available metals analysis was conducted on 13 soil samples collected from the site, including nine (9) test pit samples, three (3) surface soil samples and one (1) monitor well sample. Results of the laboratory analysis of soil samples for available metals are presented in Table 10.4 in Appendix 10e. Concentrations of various metals were detected in all soil samples. None of the detected concentrations of available metals exceeded applicable CCME criteria for metals in soil on a residential/parkland site.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on two (2) groundwater samples collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Table 10.5 in Appendix 10e. Modified TPH was detected in both groundwater samples at concentrations ranging from 0.2 mg/kg in groundwater sample MW18 to 0.4 mg/kg in MW20. Concentrations of modified TPH were below the applicable Tier I RBSL for lube oil impacts (i.e., 20 mg/L) in both groundwater samples. Laboratory analytical results indicated that products impacting groundwater samples on this site resemble possible lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on one (1) groundwater sample collected from the site. Results of laboratory analysis for this groundwater sample for PCBs are presented in Table 10.6 in Appendix 10e. PCBs were not detected in the groundwater sample above the RDL (<0.05 µg/L).

3.9.9 Conclusions

A Phase II/III ESA was completed at the Pit No. 1/Helipad site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy in test pits at the site generally consisted of continuous layers of organics (OL), sand (SP), silty sand (SM) and silty sand and gravel (GM) with varying percentages of cobbles and/or boulders coarse overlying bedrock. Bedrock was encountered in 17 of 18 test pits investigated at this site and in all three (3) monitor wells at depths ranging from 0.3 mbgs in TP149 and MW19 to 2.44 mbgs in MW18 and MW20.
2. Various buried debris was observed within the overburden layer in seven (7) of the 18 test pits and within one (1) of the 12 surface soil samples. Buried debris at the site was generally found in test pits located along the eastern perimeter of Pit No. 1.
3. Groundwater was encountered at depths ranging from 1.00 mbgs to 8.07 mbgs in test pits and monitor wells completed at this site. Based on local topography and site

observations, the direction of groundwater flow at the site is inferred to be to the east towards Pit No. 3.

4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.

5. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil or groundwater at the site.

6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 690 mg/kg) were detected in five (5) soil samples (i.e., TP143-BS2, TP147-BS2, TP152-BS2, BS169 and MW18-SS4). BTEX parameters were not detected in soil samples analyzed. TPH and BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.

7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP143, TP147, TP152, TP153, BS169 and MW18** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

8. Drawing No. 121410103-EE-05b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **5,700 m^2** has TPH levels in soil above the Tier I RBSL (690 mg/kg).

9. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in two (2) soil samples (i.e., TP152-BS1 and MW18-SS4). Low levels of PCBs were also detected in five (5) other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCBs were not detected in the groundwater sample analyzed.

10. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of samples **TP152 and MW18** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

11. Drawing No. 121410103-EE-05c in Appendix 1 shows the estimated extent of the PCB-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **600 m^2** has PCB levels in soil above 1.3 mg/kg. Based on field evidence of impacts and the noted depth to bedrock on the site, it is expected that approximately 822 m^3 of impacted soil from this area exceed the applicable PCB criteria.

12. PAH concentrations were below the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed.

13. Available metals concentrations were below the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed.
14. Available metals analysis and VOC analysis were not conducted on groundwater samples.
15. The extent of TPH and PCB impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.10 Pit No. 2

3.10.1 Site Description

The Pit No. 2 site is located southeast of the Main Base on the south side of the main access road, as shown on Drawing No. 121410103-EE-04a in Appendix 1. The site is a heavily worked area consisting of gravel and boulders with low vegetation along the perimeter. Terrain at the site slopes moderately to the south. Surface drainage (apparent groundwater flow direction) is expected to be to the south towards the Small Pond Bog and the Residential Subdivision. Photos taken of the site during investigations are presented in Appendix 11a.

3.10.2 Field Work

Field work at this site comprised the excavation of 36 test pits (i.e., TP177 to TP212), the installation of three (3) monitor wells (i.e., MW15 to MW17) and the collection of 17 surface soil samples (i.e., BS171 to BS178) and three (3) groundwater samples (i.e., MW15 to MW17). Coordinates of each sample location are provided in Appendix 11b. A site location map (Drawing No. 121410103-EE-04a) showing the location of these as well as general site features is provided in Appendix 1.

3.10.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 11c.

Excavator refusal suggested probable bedrock at the base of all test pits at the site. The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.10 mbgs in TP196 to 5.00 mbgs in TP182. Bedrock was encountered in one (1) of the three (3) monitor wells (i.e., MW16) at a depth of 0.76 mbgs. Monitor wells MW15 and MW17 extended to depths of 3.66 mbgs and 3.05 mbgs, respectively.

Light brown to brown silty sand and gravel (GM) with occasional cobbles or boulders were encountered at or near the surface in TP177, TP178, TP186 to TP189, TP193 to TP196 and TP199 and ranged in thickness from 0.10 m in TP196 to 3.30 m in TP189. This layer extended to bedrock at all test pit locations with the exception of TP188 and TP189 which were underlain by a layer of silty sand (SM).

Light to dark brown coarse sand (SW) with occasional peat and cobbles was encountered at the surface of MW15 to MW17 and extended to depths ranging from 0.76 mbgs in MW16 to 2.44 mbgs in MW17. This layer extended to bedrock in MW16.

Brown to grey or brown silty sand (SM) was encountered at or near the surface in TP179 to TP185, TP190 to TP192, TP197, TP198, TP202 to TP205, TP207 to TP209 and TP211, below a layer of silty sand and gravel (GM) in TP188 and TP189 and below a layer of organics (OL) in TP191 and TP202 and ranged in thickness from 0.60 m in TP197 to 5.00 m in TP182. Light brown silty sand (SM) with trace organics was encountered at or near the surface in TP200, TP201 and TP210 and ranged in thickness from 0.20 m in TP210 to 0.90 in TP201. These layers extended to bedrock at all test pit locations.

Dark brown to black organics (OL) were encountered at or near the surface in TP191, TP202, T203 and TP212 and ranged in thickness from 0.20 m in TP212 to 0.50 m in TP191. Dark brown to black organics (OL) and medium silty (SM) sand were encountered at or near the surface in TP206 at a thickness of 0.60 m. These layers extended to bedrock in all test pit locations with the exception of TP202 which was underlain by a layer of silty sand (SM).

3.10.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, two (2) potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in three (3) of the 36 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 4c and in one (1) of the 17 surface soil samples, as identified in Table 2.3. Buried debris at the site was generally found in test pits located in the centre of Pit 2 and in a surface soil sample located near the roadway. Items encountered in test pits and surface samples at the site consisted of the following:

- 45-gallon drums
- Sheet aluminum
- Wood

3.10.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.25 mbgs in MW17 to 0.76 mbgs in MW15. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 30, 2009 and July 31, 2009 in TP178, TP182 to TP188, TP198, TP201, TP202, TP204, TP206 to TP208 and TP211 at depths ranging from 0.80 mbgs in TP198 to 5.00 mbgs in TP182. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be to the south towards the Small Pond Bog and the Residential Subdivision. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-04a in Appendix 1.

3.10.6 Free Phase Petroleum Hydrocarbons

There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits at the site. However, on October 15, 2009, 1 mm of product was detected above the water table in MW17 with the product interface probe.

3.10.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Pit No. 2 site are provided on the Monitor Well Records in Appendix 11c and in Appendix 11d. The soil vapour concentrations measured ranged from 0.0 ppm in soil samples collected from TP177 to TP196 to 12.3 ppm in MW16-SS2. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the soil samples collected at the site; however concentrations of modified TPH exceeded 1,000 mg/kg in two (2) soil samples collected from the site (i.e., BS176 and BS179).

3.10.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Pit No. 2 site is presented in Table 3.10 below.

Table 3.10 Laboratory Analysis Schedule (Pit No. 2)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	TP177 to TP212 BS171 to BS187 MW15 to MW17	TPH (30) PCBs (19) Metals (17)	TPH (3) PCBs (1) PAHs (1) Metals (2)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 11.1 to 11.7 in Appendix 11e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 30 soil samples collected from the site, including 15 test pit samples, 13 surface soil samples and two (2) monitor well samples. Results of the laboratory analysis of these soil samples for petroleum hydrocarbons are presented in Table 11.1 in Appendix 11e. Modified TPH was detected in 11 soil samples at concentrations ranging from 22 mg/kg in TP209-BS1 to 1,600 mg/kg in BS179. The concentrations of TPH in BS172 (330 mg/kg), BS175 (510 mg/kg), BS176 (1,300 mg/kg), BS178 (630 mg/kg) and BS179 (1,600 mg/kg) exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg). Laboratory analytical results indicated that products impacting the soil samples resembled weathered fuel oil or lube oil fractions. BTEX parameters were not detected in soil samples collected from the site.

PCBs in Soil

PCB analysis was conducted on 19 soil samples collected from the site, including 15 test pit samples, two (2) surface soil samples and two (2) monitor wells samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 11.2 in Appendix 11e. PCBs were not detected above the RDL (0.05 mg/kg) in soil samples collected from the site.

Metals in Soil

Available metals analysis was conducted on 17 soil samples collected from the site, including 14 test pit samples, one (1) surface soil sample and two (2) monitor well samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 11.3 in Appendix 11e. Concentrations of various metals were detected in all soil samples. The elevated RDL for selenium (2 mg/kg) was greater than the CCME guideline (1 mg/kg), therefore it is not possible to determine if the concentration of selenium exceeded the criteria. None or the remaining concentrations of available metals exceeded applicable CCME criteria for metals in soil on a residential/parkland site.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on three (3) groundwater samples collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Table 11.4 in Appendix 11e. Modified TPH was detected in one (1) groundwater sample (i.e., MW16) at a concentration of 0.3 mg/L which is below the applicable Tier I RBSLs for fuel oil impacts (i.e., 20 mg/L). Laboratory analytical results indicated that products impacting the groundwater samples on this site resembled weathered fuel oil and lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on one (1) groundwater sample collected from the site. Results of laboratory analysis for this groundwater sample for PCBs are presented in Table 11.5 in Appendix 11e. PCBs were not detected in the groundwater sample above the RDL (0.05 µg/L).

PAHs in Groundwater

PAH analysis was conducted on one (1) groundwater sample collected from the site. Results of the laboratory analysis of this groundwater sample for PAHs are presented in Table 11.6 in Appendix 11e. PAH parameters were not detected above the RDLs in the groundwater sample.

Metals in Groundwater

Available metals analysis was conducted on two (2) groundwater samples collected from the site. Results of the laboratory analysis of this groundwater samples for available metals are presented in Table 11.7 in Appendix 11e. Concentrations of various metals were detected in the groundwater samples. None of the detected concentrations of metals exceeded the applicable OMOE criteria for non-potable groundwater, where such criteria exists.

3.10.9 Conclusions

A Phase II/III ESA was completed at the Pit No. 2 site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of this assessment are summarised below.

1. The observed stratigraphy in test pits at the site generally consisted of continuous and discontinuous layers of dark brown to black organics (OL), silty sand (SM), coarse sand (SM) and sand and gravel (GM) with varying percentages of peat, cobbles and/or boulders coarse overlying bedrock. Bedrock was encountered in all 36 test pits investigated at this site and in one (1) of three (3) monitor wells at depths ranging from 0.10 mbgs in TP196 to 5.00 mbgs in TP182.
2. Various buried debris was observed within the overburden layer in three (3) of the 36 test pits and within one (1) of the 17 surface soil samples. Buried debris at the site was generally found in test pits located in the centre of Pit 2 and in a surface soil sample located near the roadway and consisted of 45-gallon drums, sheet aluminum and wood.
3. Groundwater was encountered at depths ranging from 0.25 mbgs to 5.00 mbgs in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be to be to the south towards the Small Pond Bog and the Residential Subdivision.
4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil or groundwater at the site; however, 1 mm of product was detected above the water table in MW7 on October 15, 2009.
6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in six (6) soil samples (i.e., BS172, BS175, BS176, BS178 and BS179). BTEX parameters were not detected in soil samples analyzed. TPH and BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.

7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **BS172, BS175, BS176, BS178 and BS179** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
8. Drawing No. 121410103-EE-04b in Appendix 1 shows the estimated extent of the petroleum-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **2,400 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).
9. PCB concentrations were below the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg). A low level of PCBs was detected in one (1) soil sample analyzed at this site; however it did not exceed applicable CCME criteria. PCBs were not detected in the groundwater sample analyzed.
10. PAHs were not detected in the groundwater sample analyzed.
11. Available metals concentrations were below the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed. The elevated RDLs for selenium in soil were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of available metals in groundwater were below the applicable OMOE groundwater standards.
12. The extent of TPH impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.11 Pit No. 3

3.11.1 Site Description

The Pit No. 3 site is located south of the Main Base and east of Pit No. 1/Helipad, on the north side of the main access road, as shown on Drawing No. 121410103-EE-05a in Appendix 1. The site is a heavily worked area consisting of gravel, boulders and bedrock outcroppings with low vegetation and some trees along the perimeter. Terrain at the site slopes moderately to the southwest. Surface drainage (apparent groundwater flow direction) is expected to be to the southeast towards the Small Pond Bog and the Residential Subdivision.

3.11.2 Field Work

Field work at this site comprised the excavation of 16 test pits (i.e., TP161 to TP176), the installation of six (6) monitor wells (i.e., MW25 to MW30), and the collection of 10 surface soil samples (i.e., BS237 to BS241 and BS267 to BS271) and six (6) groundwater samples (i.e., MW25 to MW30). Coordinates of each sample location are provided in Appendix 12a. A site location map (Drawing No. 121410103-EE-05a) showing the location of these as well as general site features is provided in Appendix 1.

3.11.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 12b.

Excavator refusal suggested probable bedrock at the base of all test pits at the site. The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.10 mbgs in TP171 to 1.80 mbgs in TP161. Bedrock was encountered in three (3) of the six (6) monitor wells (i.e., MW28 to MW30) at depths ranging from 1.22 mbgs in MW30 to 1.63 mbgs in MW28.

Brown silty sand and gravel (GM) were encountered at or near the surface in TP164, TP174 and TP175 and ranged in thickness from 0.50 m in TP164 to 0.70 m in TP174. This layer extended to bedrock in TP174 and TP175, and was underlain with a layer of silty sand (SM) in TP164.

Light brown to grey silty sand (SM) was encountered at or near the surface in TP161, TP162, TP166, TP167 and TP168, below a layer of organics (OL) in TP163, TP165, TP169 and TP170, and below a layer of silty sand and gravel (GM) in TP164. This layer was intersected with a layer of dark brown sand and cobbles (SP) in TP161 and TP162. The layer ranged in thickness from 0.30 m in TP163 to 1.30 m in TP170. This layer extended to bedrock at all test pit locations.

Light brown silty sand (SM) with trace organics was encountered at or near the surface in TP171, TP172 and TP173 and extended to bedrock at depths of 0.1, 0.3 and 0.2 mbgs, respectively. Light brown silty sand (SM) cobbles and boulders were encountered at the surface of TP176 and extended to bedrock at 0.70 mbgs.

Dark brown to black organics were encountered at or near the surface in TP163, TP165, TP169 and TP170 at thickness ranging from 0.1 m to 0.3 m. This layer of organics was underlain by a layer of silty sand (SM).

3.11.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, two (2) potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in four (4) of the 16 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 12b. Debris was not encountered in any of the surface soil samples, as identified in Table 2.3. Buried debris at the site was found in one (1) test pit (i.e., TP162) located near the centre of Pit 3 and in test pits (i.e., TP173, TP174 nd TP-175) located along the road to Pit 3. Items encountered in test pits at the site consisted of the following:

- Piping
- Rusted steel
- Corrugated steel

3.11.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.37 mbgs in MW26 to 2.56 mbgs in MW28. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 29, 2009 and July 31, 2009 in TP161 to TP165 and TP175 at depths ranging from 0.50 mbgs in TP175 to 1.70 mbgs in TP164. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution. Groundwater seepage was also encountered in surface soil samples BS238 and BS240 on August 4, 2009.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be southeast towards the Small Pond Bog and the Residential Subdivision. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-05a in Appendix 1.

3.11.6 Free Phase Petroleum Hydrocarbons

Oil was observed floating along the edges of the stream near surface soil sample BS239 during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.11.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Pit No. 3 site are provided on the Monitor Well Records in Appendix 12b and in Appendix 12c. The soil vapour concentrations measured ranged from 0.0 ppm in 13 test pit samples to 740 ppm in TP161-BS2. Petroleum hydrocarbon odours were detected soil samples collected from TP161 to TP170, BS237, BS238, BS241 and MW25 to MW30.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in 20 soil samples collected from the site. The soil samples that had a soil vapour concentration greater than 50 ppm that were analyzed for TPH had modified TPH concentrations in excess of 1,000 mg/kg. Soil samples TP171-BS1, BS237, BS238, BS241 and MW28-SS1 had soil vapour concentrations less than 50 ppm; however, modified TPH concentrations were greater than 1,000 mg/kg. Soil vapour concentrations were not recorded for soil sample BS271; however the concentration of modified TPH in this sample also exceeded 1,000 mg/kg.

3.11.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Pit No. 3 site is presented in Table 3.11 below.

Table 3.11 Laboratory Analysis Schedule (Pit No. 3)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible free phase petroleum product. Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste sites/ drum storage areas. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste sites/drum storage areas are confirmed.	TP161 to TP176 BS237 to BS241, BS267 to BS271 MW25 to MW30	TPH (31) PCBs (13) PAHs (2) Metals (11)	TPH (6) PCBs (1) PAHs (1) Metals (3)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 12.1 to 12.10 in Appendix 12d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>Petroleum Hydrocarbons in Soil</u>

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 30 soil samples collected from the site, including 13 test pit samples, 10 surface soil samples and seven (7) monitor well samples. In addition, TPH fractionation was conducted on one (1) test pit sample and one (1) monitor well sample. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Tables 12.1 and 12.2 in Appendix 12d. Modified TPH was detected in 28 soil samples at concentrations ranging from 170 mg/kg in soil sample BS269 to 77,000 mg/kg in soil sample TP169-BS1. The concentrations of TPH in 28 soil samples (TP161-BS1, TP161-BS2, TP162-BS2, TP164-BS1, TP165-BS2, TP166-BS1, TP167-BS1, TP169-BS2, TP171-BS1, TP172-BS1, TP176-BS1, BS237, BS238, BS239, BS240, BS241, BS267, BS268, BS269, BS270, BS271, MW27-SS1, MW25-SS2, MW27-SS3, MW28-SS1, MW29-SS2 and MW30-SS2) exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg). Laboratory analytical results indicated that products impacting the soil samples resembled weathered fuel oil, fuel oil or lube oil fractions or had one product in the fuel oil range. BTEX parameters were not detected in soil samples collected from the site.

PCBs in Soil

PCB analysis was conducted on 13 soil samples collected from the site, including seven (7) test pit samples, four (4) surface soil samples and two (2) monitor wells samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 12.3 in Appendix 12d. PCBs were not detected above the RDL (0.05 mg/kg) or were below the applicable CCME guideline for a residential/parkland site in soil samples collected from the site.

PAHs in Soil

PAH analysis was conducted on two (2) soil sample collected from the site. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 12.4 in Appendix 12d. Detectable concentrations of PAH parameters were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

Metals in Soil

Available metals analysis was conducted on 11 soil samples collected from the site, including five (5) test pit samples, four (4) surface soil samples and two (2) monitor well samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 12.5 in Appendix 12d. Concentrations of various metals were detected in all soil samples. The concentration of zinc detected in soil sample TP174-BS1 (420 mg/kg) exceeded the CCME guideline for a residential/parkland site. The elevated RDL for selenium (2 mg/kg) was greater than the CCME guideline (1 mg/kg), therefore it is not possible to determine if concentrations of selenium in soil samples collected from the site exceeded the criteria. None or the remaining concentrations of available metals exceeded applicable CCME criteria for metals in soil on a residential/parkland site.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on six (6) groundwater samples collected from the site. In addition, TPH fraction analysis was conducted on one (1) groundwater sample collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Tables 12.4 and 12.5 in Appendix 12d. Modified TPH was detected in all four (4) groundwater samples at concentrations ranging from 0.4 mg/L in MW28 to 20 mg/L in MW26. The concentrations of modified TPH in groundwater samples collected from the site were below the applicable Tier I RBSLs for fuel oil impacts (i.e., 20 mg/L), with the exception of MW26 which equalled the Tier I RBSL. Laboratory analytical results indicated that products impacting the groundwater samples on this site resembled weathered fuel oil and fuel oil fractions or possibly lube oil. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on one (1) groundwater sample collected from the site. Results of laboratory analysis for this groundwater sample for PCBs are presented in Table 12.8 in Appendix 12d. PCBs were not detected in the groundwater sample above the RDL (0.05 µg/L).

PAHs in Groundwater

PAH analysis was conducted on one (1) groundwater sample collected from the site. Results of the laboratory analysis of this groundwater sample for PAHs are presented in Table 12.9 in Appendix 12d. Detected concentrations of PAH parameters in the groundwater sample were below the OMOE criteria for non-potable groundwater, where such criteria exists.

Metals in Groundwater

Available metals analysis was conducted on three (3) groundwater samples collected from the site. Results of the laboratory analysis of this groundwater samples for available metals are presented in Table 12.10 in Appendix 12d. Concentrations of various metals were detected in the groundwater samples. None of the detected concentrations of metals exceeded the applicable OMOE criteria for non-potable groundwater, where such criteria exists.

3.11.9 Conclusions

A Phase II/III ESA was completed at the Pit No. 3 site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy in test pits at the site generally consisted of continuous and discontinuous layers of dark brown to black organics (OL), silty sand with organics (SM), silty sand (SM) or silty sand and gravel (SM) with varying percentages of cobbles and/or boulders coarse overlying bedrock. Bedrock was encountered in all 16 test pits investigated at this site and in three (3) of six (6) monitor wells at depths ranging from 0.10 mbgs in TP171 to 1.80 mbgs in TP161.
2. Various buried debris was observed within the overburden layer in four (4) of the 16 test pits. Buried debris at the site was found in a test pit located near the centre of Pit 3 and in test pits located along the road to Pit 3 and consisted of piping, rusted steel and corrugated steel.
3. Groundwater was encountered at depths ranging from 0.37 mbgs to 5.00 mbgs in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be to be to be southeast towards the Small Pond Bog and the Residential Subdivision.
4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. There was olfactory evidence of petroleum hydrocarbon impacts on soil samples collected from TP161 to TP170, BS237, BS238, BS241 and MW25 to MW30. An oil sheen was observed on surface water along the edges of the stream near BS239.
6. TPH concentrations exceeding the applicable Tier I RBSLs (i.e., 140/690 mg/kg) were detected in 28 soil samples (i.e., TP161-BS1, TP161-BS2, TP162-BS2, TP164-BS1, TP165-BS2, TP166-BS1, TP167-BS1, TP169-BS2, TP171-BS1, TP172-BS1, TP176-BS1, BS237, BS238, BS239, BS240, BS241, BS267, BS268, BS269, BS270, BS271, MW27-SS1, MW25-SS2, MW27-SS3, MW28-SS1, MW29-SS2 and MW30-SS2). BTEX parameters were not detected in soil samples analyzed. TPH and BTEX

concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed, with the exception of the concentration of TPH in MW20 which equalled the Tier I RBSL (i.e., 20 mg/L).

7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP161, TP162, TP164, TP165 to TP167, TP169, TP171, TP172, TP176, BS237, BS238, BS239, BS240, BS241, BS267 to BS271, MW25 and MW27 to MW30** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

8. Drawing No. 121410103-EE-05b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **7,000 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).

9. PCB concentrations were below the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg). Low levels of PCBs were detected in two (2) soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCBs were not detected in the groundwater sample analyzed.

10. PAH concentrations in soil were below the applicable CCME criteria. PAH concentrations in groundwater were also below the applicable OMOE groundwater standards .

11. A concentration of zinc exceeding the applicable CCME criteria for soil on a residential/ parkland site were detected in one (1) soil sample analyzed (i.e., TP174-BS1). The elevated RDLs for selenium in soil were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of available metals in groundwater were below the applicable OMOE groundwater standards.

12. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of sample **TP174** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for the contaminant.

13. Drawing No. 121410103-EE-05d in Appendix 1 shows the estimated extent of the metals-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **300 m^2** has metals levels in soil above the applicable CCME criteria.

14. The extent of TPH and metals impacts in soil above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.12 Small Pond Bog

3.12.1 Site Description

The Small Pond Bog is located between Pit No. 3 and the Residential Subdivision, as shown on Drawing No. 121410103-EE-05a in Appendix 1. The site is a relatively flat marshy area that is believed to receive surface water runoff from various Former U.S. Military Sites located upgradient (i.e., Old Base 1, Main Base, Pallet Line, Pit No. 1, Pit No. 2, Pit No. 3 and Mid-Canada Line). There are two (2) drainage streams that flow into the Small Pond Bog, one originating from the Pit No. 3 direction, the other from the northeast. Photos taken of the site during investigations are presented in Appendix 13a.

3.12.2 Field Work

Field work at this site comprised the collection of four (4) surface soil samples (i.e., BS242 to BS244 and BS256), 11 freshwater sediment samples (i.e., SED-20 to SED-24 and SED-59 to SED-64) and one (1) benthic invertebrate sample (i.e., BENTHIC-5). Coordinates of each sample location are provided in Appendix 13b. A site location map (Drawing No. 121410103-EE-05a) showing the location of these as well as general site features is provided in Appendix 1.

3.12.3 Stratigraphy

No test pits were dug or monitor wells were drilled at the site during the Phase II/III ESA. Surface soil samples collected near the drainage stream near the subdivision generally consisted of light brown to dark brown rocky soil. The depth to bedrock throughout the site is unknown.

3.12.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, no potential waste sites were identified at the site. Buried debris was not encountered in any of the surface soil samples collected from the site, as identified in Table 2.3.

3.12.5 Groundwater Conditions

Groundwater seepage was not observed in any of the surface soil sample pits during sampling. The assumed direction of groundwater flow, based on site topography, is inferred to be to the southeast, towards the Residential Subdivision. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-05a in Appendix 1.

3.12.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. There was no visual evidence of free phase petroleum hydrocarbons in surface soil pits.

3.12.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil and sediment samples from the Small Pond Bog site are provided in Appendix 13c. The soil vapour concentrations measured ranged from 0.5 ppm in soil sample BS256 to 10.2 ppm in soil sample BS242. Soil vapour concentrations were not recorded for sediment samples SED-57 to SED-64. Petroleum hydrocarbon odours were detected in soil sample BS242.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. No soil vapour concentrations were recorded for the soil and sediment samples collected from the site exceeded 50 ppm; however the concentration of modified TPH in soil sample BS256 and sediment samples SED-20, SED-21, SED-24, SED-59 and SED-60 exceeded 1,000 mg/kg.

3.12.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Small Pond Bog site is presented in Table 3.12 below.

Table 3.12 Laboratory Analysis Schedule (Small Pond Bog)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	**Ground-water/ Surface water**	**Veg./ Berries**	**Small Mammals/ Rabbits/ Fish**	**Benthic Invert.**
<u>Small Pond Bog</u> Delineate TPH, PCBs and metals in sediment. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	SED-20 to SED-24 BENTHIC-5	TPH (5) PCBs (5) Metals (5) TOC & Grain Size (3)	-	-	-	Genus (1)
<u>Drainage Stream Northeast of Small Pond Bog</u> No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	BS242 to BS244, BS256 SED-61 to SED-63	<u>Soil</u>: TPH (3) PCBs (2) Metals (1) <u>Sed.</u>: TPH (3) PCBs (3) Metals (3)	-	-	-	-
<u>Drainage Stream from Pit No. 3</u> No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	SED-59, SED-60, SED-64	TPH (3) PCBs (3) Metals (3)	-	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 13.1 to 13.7 in Appendix 13c. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on three (3) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Table 13.1 in Appendix 13c. Modified TPH was detected in all three (3) soil samples, with concentrations ranging from 120 mg/kg in BS242 to 7,500 mg/kg in BS256. Concentrations of modified TPH exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg) in BS244 (340 mg/kg) and BS256 (7,500 mg/kg). Laboratory analytical results indicated that products impacting soil samples on this site resembled weathered fuel oil fractions or products in the fuel/lube oil range. Detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Soil

PCB analysis was conducted on two (2) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 13.2 in Appendix 13c. Concentrations of PCBs were not detected above the RDL (0.05 mg/kg)

Metals in Soil

Available metals analysis was conducted on one (1) surface soil sample collected from the site. Results of the laboratory analysis of soil sample for available metals are presented in Table 13.3 in Appendix 13c. Concentrations of various metals were detected in the soil sample. Selenium was not detected in soil sample BS256, however the RDL (2 mg/kg) was greater than the CCME residential/parkland guideline (1 mg/kg); therefore it is not possible to determine if the concentration of selenium exceeded the applicable guideline.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 10 freshwater sediment samples collected from the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Table 13.4 in Appendix 13c. Modified TPH was detected in nine (9) of the sediment samples at concentrations ranging from 80 mg/kg in SED-62 to 16,000 mg/kg in SED-20. The concentrations of modified TPH exceeded the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg) in sediment samples SED-20 (16,000 mg/kg), SED-211 (2,700 mg/kg), SED-24 (6,700 mg/kg), SED-59 (2,000 mg/kg) and SED-60 (1,600 mg/kg). Laboratory analytical results indicated the samples did not resemble petroleum products, samples contained one product in the fuel/lube oil range, or that products impacting the sediment samples resembled weathered fuel oil or lube oil fractions. BTEX parameters were not detected in soil samples collected from the site. There are no applicable guidelines for BTEX parameters in freshwater sediment.

PCBs in Sediment

PCB analysis was conducted on 11 sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 13.5 in Appendix 13c. PCBs were detected in two (2) sediment samples at concentrations of 0.68 mg/kg in sediment sample SED-20 and 64 mg/kg in sediment sample SED-64. The concentration of PCBs detected in sediment samples SED-20 and SED-64 exceeded the CCME freshwater ISQG of 0.0341 mg/kg and the CCME freshwater PEL of 0.277 mg/kg. Concentrations of PCBs were not detected above the RDL (0.05 mg/kg) in the remaining sediment samples collected from the site. The RDL is greater than the CCME freshwater ISQG for PCBs, therefore it is not possible to determine if the guideline was exceeded in these samples.

Metals in Sediment

Available metals analysis was conducted on all 11 sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 13.6 in Appendix 13c. Concentrations of various metals were detected in all sediment samples. The concentrations of copper (57 mg/kg), lead (42 mg/kg) and mercury (0.2 mg/kg) in sediment sample SED-64 exceeded their respective CCME freshwater ISQGs of 35.7 mg/kg, 35.0 mg/kg and 0.2 mg/kg. There were no exceedances of the CCME freshwater PELs.

TOC and Grain Size in Sediment

Total organic carbon (TOC) and grain size analysis were conducted on three (3) sediment samples collected from the site. Results of the laboratory analysis for TOC and grain size analysis are presented in Table 13.7 in Appendix 13c. Concentrations of TOC ranged from 8 g/kg in SED-22 to 110 g/kg in SED-20. Results of grain size analysis indicated that the sediment samples generally consisted of silty sand with some clay and gravel.

3.12.9 Conclusions

A Phase II/III ESA was completed at the Small Pond Bog, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of this assessment are summarised below.

1. The observed stratigraphy was generally similar at all surface soil sample locations, and consisted of light to dark brown rocky soil. Bedrock was not encountered in surface soil samples investigated at this site.
2. Groundwater was not encountered during sampling at the site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be southeast towards the Residential Subdivision.
3. This site was considered to have a residential/parkland site designation with non-potable surface water.
4. Buried debris was not encountered at any of the surface soil sampling locations.
5. There was olfactory evidence of petroleum hydrocarbon impacts in surface soil sample BS242. No free phase petroleum hydrocarbons were observed on soil, surface water or standing water throughout the site.

6. TPH concentrations exceeding the applicable Tier I RBSL for a residential site with non-potable water and coarse grained soil with fuel oil impacts (i.e., 140 mg/kg) were detected in two (2) soil samples analyzed (i.e., BS244 and BS256). TPH concentrations exceeding the applicable OMOE Guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg) were detected in five (5) sediment samples analyzed (i.e., SED-20, SED-21, SED-24, SED-59 and SED-60). BTEX parameters were not detected in the soil samples analyzed.
7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **BS244 and BS256** and remediation of site sediment would be required in the vicinity of samples **SED-20, SED-21, SED-24, SED-59 and SED-60** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
8. Drawing No. 121410103-EE-05b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, there is an estimated area of approximately **600 m^2** that has TPH levels in soil above 140 mg/kg and an estimated **1,500 m^2** that has TPH levels in sediment above 1,500 mg/kg.
9. PCB concentrations were not detected in soil samples analyzed. PCB concentrations exceeded the CCME ISQGs and PELs for freshwater sediment in sediment samples SED-20 and SED-64. The RDL for PCBs was greater than the CCME ISQG, therefore it was not possible to determine if the guideline was exceeded in the remaining sediment samples.
10. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site sediment would be required in the vicinity of **SED-20 and SED-64** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
11. Drawing No. 121410103-EE-05c in Appendix 1 shows the estimated extent of the PCB-impacted soil. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **450 m^2** has PCB levels in sediment above 0.0341 mg/kg.
12. Metals concentrations were below the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed. The elevated RDLs for selenium were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. The concentrations of copper, lead and manganese exceeded the CCME ISQG for marine sediment in one (1) sediment sample (i.e., SED-64).
13. Based on NLDEC policy directive PPD05-01, **metals** remediation of site sediment would be required in the vicinity of **SED-64** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site.

14. Drawing No. 121410103-EE-05d in Appendix 1 shows the estimated extent of the metal-impacted sediment. The actual impacted area may be smaller or larger than the estimated area. Based on available analytical and field data, an estimated area of approximately **300 m^2** has metals levels in sediment above the applicable CCME ISQGs.
15. The extent of TPH impacts in soil and TPH, PCB and metals impacts in sediment above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.13 POL Compound

3.13.1 Site Description

The POL Compound is located south of the main access road, immediately south of Pit No. 1/Helipad, as shown on Drawing No. 121410103-EE-05a in Appendix 1. Previous environmental reports revealed that the site was likely used as a former storage area for petroleum, oil and lubricants (POL). It is believed that waste materials at the site may have been disposed of by pushing materials into the gully.

Terrain at the site consists of a relatively flat area of exposed bedrock and soil, with a vegetated gully located further south. The site is located at a lower elevation than the other Former U.S. Military Site areas, allowing for water to pool at the site during rainfall events. Surface drainage (apparent groundwater flow direction) is expected to be south to southeast towards Old Dump Pond. Standing water and tar-like debris were observed at the site. Photos taken of the site during investigations are presented in Appendix 14a.

3.13.2 Field Work

Field work at this site comprised the excavation of three (3) test pits (i.e., TP140 to TP142), the installation of four (4) monitor wells (i.e., MW21 to MW24) and the collection of four (4) surface soil samples (i.e., BS39 to BS42) and four (4) groundwater samples (i.e., MW21 to MW24). Coordinates of each sample location are provided in Appendix 14b. A site location map (Drawing No. 121410103-EE-05a) showing the location of these as well as general site features is provided in Appendix 1.

3.13.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 14c.

Excavator refusal suggested probable bedrock at the base of all three (3) test pits at the site. The excavator refusal on presumed bedrock occurred at depths of 0.20 mbgs in TP141 and 0.30 mbgs in TP140 and TP142. Bedrock was encountered in all four (4) monitor wells at a depths ranging from 0.0 mbgs in MW22 and MW23 to of 0.10 mbgs in MW24.

Black and brown coarse sand (SW) was encountered at the surface of TP140 and extended to bedrock. Brown medium silty sand with some black tar-like coarse sand (SM) was encountered at the surface of TP141 and extended to bedrock. Dark brown to black organics and fine sand (OL) were encountered at the surface of TP142 and extended to bedrock. Dark brown sand (SP) and cobbles were encountered at the surface of MW21 and MW24, and extended to bedrock at depths of 0.08 mbgs and 0.10 mbgs, respectively.

3.13.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, one (1) potential waste site was identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of this potential waste site.

A tar deposit was observed at the site. In addition, buried debris was encountered in two (2) of the three (3) test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 14c and in three (3) of the four (4) surface soil samples, as identified in Table 2.3. Items encountered in test pits at the site consisted of the following:

- Metal
- Rebar
- Plates
- Bottles
- Cans
- Tar

3.13.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.23 mbgs in MW24 to 3.16 mbgs in MW22. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on July 27, 2009 in TP242 at a depth of 0.10 mbgs. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be south to southeast towards Old Dump Pond. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-05a in Appendix 1.

3.13.6 Free Phase Petroleum Hydrocarbons

A petroleum hydrocarbon sheen was observed on a fracture in MW22 during drilling. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.13.7 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the POL Compound site are provided on the Monitor Well Records in Appendix 14c and in Appendix 14d. The soil vapour concentrations measured ranged from 0.3 ppm in surface soil sample BS39 to 85 ppm in test pit sample TP141-BS1. Petroleum hydrocarbon odours were detected in test pit TP142 and in soil samples MW22-SS3, MW22-SS4 and MW24-SS1. An odour resembling asphalt was detected in TP141.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in two (2) soil samples collected at the site (i.e., TP141-BS1 and TP142-BS2). The two (2) soil samples that had soil vapour concentrations greater than 50 ppm had modified TPH concentrations in excess of 1,000 mg/kg. Soil samples BS42, MW21-SS1 and MW24-SS1 had soil vapour concentrations less than 50 ppm; however, TPH concentrations were greater than 1,000 mg/kg.

3.13.8 Laboratory Analysis and Results

A laboratory analysis schedule for the POL Compound site is presented in Table 3.13 below.

Table 3.13 Laboratory Analysis Schedule (POL Compound)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible petroleum hydrocarbons in soil. Possible petroleum hydrocarbons, PCBs or metals impacts in groundwater. Possible waste site in gully. Possible petroleum hydrocarbons, PCBs, VOCs and metals in soil and groundwater if waste site is confirmed.	TP140 to TP142 BS39 to BS42 MW21 to MW24	TPH (6) PCBs (6) PAHs (3) VOCs (1) Metals (3)	TPH (4) PCBs (4) Metals (4)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 14.1 to 14.10 in Appendix 14e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>Petroleum Hydrocarbons in Soil</u>

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on six (6) soil samples collected from the site, including three (3) test pit samples, one (1) surface soil sample and two (2) monitor well samples. TPH fractionation was conducted on one (1) test pit sample. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Tables 14.1 and 14.2 in Appendix 14e. Modified TPH was detected in all five (5) soil samples, at concentrations ranging from 1,300 mg/kg in MW21-SS1 to 25,000 mg/kg in TP141-BS1.

Concentrations of modified TPH exceeded the applicable Tier I RBSL for lube oil impacts (i.e., 690 mg/kg) in all six (6) soil samples (i.e., TP140-BS1, TP141-BS1, TP142-BS1, BS42, MW21-SS1 and MW24-SS1). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of fuel oil, weathered fuel oil and lube oil fractions. None of the detected concentrations of BTEX parameters in soils exceeded the applicable Tier I RBSLs.

PCBs in Soil

PCB analysis was conducted on six (6) soil samples collected from the site, including three (3) test pit samples, one (1) surface soil sample and two (2) monitor wells samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 14.3 in Appendix 14e. Detected concentrations of PCBs in TP141-BS1 (2.4 mg/kg) exceeded the CCME soil quality guideline for a residential/ parkland site of 1.3 mg/kg. The remaining detected concentrations of PCBs in soil were below the applicable CCME guideline.

PAHs in Soil

PAH analysis was conducted on three (3) soil samples collected from the site, including one (1) test pit sample and two (2) monitor well samples. Results of the laboratory analysis of these soil samples for PAHs are presented in Table 14.4 in Appendix 14e. Detectable concentrations of PAH parameters in soil samples collected from the site were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

VOCs in Soil

VOC analysis was conducted on one (1) soil sample collected from the site (i.e., MW24-SS1). Results of the laboratory analysis of this soil sample for VOCs are presented in Table 14.5 in Appendix 14e. With the exception of toluene, concentrations of VOC parameters were not detected in soil sample MW24-SS1. Concentrations of VOC parameters were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist.

Metals in Soil

Available metals analysis was conducted on three (3) soil samples collected from the site, including one (1) test pit sample and two (2) surface soil samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 14.6 in Appendix 14e. Concentrations of various metals were detected in all three (3) soil samples, several of which exceeded applicable CCME soil quality guidelines for a residential/parkland site. The concentrations of antimony, chromium, copper, lead, molybdenum, nickel, tin and zinc detected in BS39 and BS40 exceeded the applicable CCME residential/parkland guidelines. The concentration of arsenic in BS29 also exceeded the applicable CCME residential/parkland guideline. The elevated RDL for selenium for all three (3) soil samples (i.e., 2 mg/kg) was above the CCME residential/parkland guideline of 1 mg/kg, therefore it is not possible to determine if concentrations of selenium in soil exceeded the CCME guideline. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on four (4) groundwater samples collected from the site. TPH fraction was conducted on one (1) groundwater sample. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Tables 5.1.7 and 5.1.8 in Appendix 14e. Modified TPH was detected in three (3) groundwater samples (i.e., MW22, MW23 and MW24) at concentrations ranging from 0.6 mg/L in groundwater sample MW23 to 59 mg/L in MW22. The concentration of modified TPH in MW22 exceeded the applicable Tier I RBSL for lube oil impacts (i.e., 20 mg/L). Concentrations of modified TPH in the remaining groundwater samples were below the applicable Tier I RBSL. Laboratory analytical results indicated that products impacting groundwater samples on this site did not resemble petroleum products, or resembled weathered fuel oil, fuel oil or lube oil fractions, or had one product in the gas/fuel oil range. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on four (4) groundwater samples collected from the site. Results of laboratory analysis for these groundwater samples for PCBs are presented in Table 14.9 in Appendix 14e. The detected concentration of PCBs in MW22 (0.5 µg/L) exceeded the applicable OMOE non-potable groundwater guideline of 0.2 µg/L. PCBs were not detected in the remaining groundwater samples analyzed.

Metals in Groundwater

Available metals analysis was conducted on four (4) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for available metals are presented in Table 14.10 in Appendix 14e. Concentrations of various metals were detected in the groundwater samples. None of the detected concentrations of available metals exceeded the applicable OMOE non-potable groundwater guidelines, where such guidelines exist.

3.13.9 Conclusions

A Phase II/III ESA was completed at the POL Compound site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy in test pits at the site consisted of continuous layers coarse sand (SW), silty sand (SM) or dark brown to black organics (OL) overlying bedrock. Bedrock was encountered in all three (3) test pits investigated at this site and in all four (4) monitor wells at depths ranging from 0.0 mbgs in MW22 and MW23 to 0.30 mbgs in TP140 and TP142.
2. A tar deposit was observed at the site. In addition, various buried debris was observed within the overburden layer in two (2) of the three (3) test pits and within three (3) of the four (4) surface soil samples. Buried debris was generally found in test pits and surface soil samples located near the end of the road at the site and in the gully and consisted of metal, rebar, plates, bottles, cans and tar.

3. Groundwater was encountered at depths ranging from 0.10 mbgs to 3.16 mbgs in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be south to southeast, towards Old Dump Pond.
4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. There was olfactory evidence of petroleum hydrocarbon impacts on soil in TP142 and on soil samples MW22-SS3, MW22-SS4 and MW24-SS1. An odour resembling asphalt was detected in TP141. A petroleum hydrocarbon sheen was observed on a fracture in MW22 during drilling.
6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 690 mg/kg) were detected in six (6) soil samples (i.e., TP140-BS1, TP141-BS1, TP142-BS1, BS42, MW21-SS1 and MW24-SS1). Concentrations of BTEX parameters in soil samples were below the applicable Tier I RBSLs. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 20 mg/L) were also detected in one (1) groundwater sample (i.e., MW22). BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.
7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP140, TP141, TP142, BS42, MW21 and MW24** and petroleum hydrocarbon remediation of site groundwater would be required in the vicinity of **MW22** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
8. Drawing No. 121410103-EE-05b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil at the site. Drawing No. 121410103-EE-05e in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted groundwater at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **3,600 m^2** has TPH levels in soil above the Tier I RBSL (i.e., 690 mg/kg) and an estimated area of approximately **300 m^2** has TPH levels in groundwater above the Tier I RBSL (20 mg/L).
9. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in one (1) soil sample (i.e., TP141-BS1). Low levels of PCBs were also detected in four (4) other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCB concentrations exceeding the applicable OMOE standard (i.e., 0.2 µg/L) were detected in one (1) groundwater sample (i.e., MW22). PCBs were not detected in the other groundwater samples analyzed.
10. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of sample **TP141** and remediation of site groundwater would be required in the vicinity of **MW22** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial

approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

11. Drawing No. 121410103-EE-05c in Appendix 1 shows the estimated extent of the PCB-impacted soil and groundwater at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **200 m^2** has PCB levels in soil above 1.3 mg/kg and approximately **300 m^2** has PCB levels in groundwater above 0.2 µg/L.
12. PAH concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were not detected in soil samples analyzed.
13. VOC concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were not detected in soil samples analyzed.
14. Concentrations of antimony, arsenic, chromium, copper, lead, molybdenum, nickel, tin and/or zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in two (2) soil samples (i.e., BS39 and BS41). The elevated RDLs for selenium in soil were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of available metals were below the applicable OMOE groundwater standards in groundwater samples analyzed.
15. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **BS39 and BS41** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil would be governed by SSTLs determined for each contaminant. Drawing No. 121410103-EE-05d in Appendix 1 shows the estimated extent of the metals-impacted soil at the site.
16. Further field sampling and laboratory analysis would be required to more precisely determine the extent of above the generic guidelines at the site.
17. The extent of TPH, PCB and metals impacts on soil and the extent of TPH and PCB impacts on groundwater above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.14 Old Dump Pond

3.14.1 Site Description

Old Dump Pond is located downgradient of Reservoir Lake on the south side of the main access road, as shown on Drawing No. 121410103-EE-07a in Appendix 1. A new area of residential development is present on an elevated gravel pad approximately 200 m northeast of Old Dump Pond. The pond was historically used for storage of various metal waste and debris (i.e., wastes were stored in and around the pond).

The shore of the pond is heavily vegetated with some bedrock outcroppings. The road in the residential area is constructed out of gravel. Terrain in the vicinity of the site slopes towards the pond which discharges to the southeast into Hopedale Harbour via a stream. Surface drainage (apparent groundwater flow direction) near the site is expected to be towards the pond. Photos taken of the site during investigations are presented in Appendix 15a.

3.14.2 Field Work

Field work at this site comprised the excavation of nine (9) test pits (i.e., TP226 to TP234), the installation of six (6) monitor wells (i.e., MW31 to MW34, MW61 and MS62) and five (5) auger boreholes (i.e., AG-1 to AG-5), and the collection of five (5) surface soil samples (i.e., BS224 to BS228), 13 sediment samples (i.e., SED-25 to SED-37), six (6) groundwater samples (i.e., MW31 to MW34, MW61 and MS62), three (3) surface water samples (i.e., SW-1 to SW-3), four (4) fish (i.e., FISH-1 to FISH-4) and one (1) benthic invertebrate sample (i.e., BENTHIC-1). Coordinates of each sample location are provided in Appendix 15b. A site location map (Drawing No. 121410103-EE-07a) showing the location of these as well as general site features is provided in Appendix 1.

3.14.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 15c.

Excavator refusal suggested probable bedrock at the base of five (5) of the nine (9) test pits at the site and four (4) of the five (5) auger boreholes. The excavator refusal on presumed bedrock occurred at depths ranging from approximately 0.25 mbgs in TP229 to 2.40 mbgs in TP231. Bedrock was encountered in all of the monitor wells at depths ranging from 0.15 mbgs in MW34 to 2.13 mbgs in MW31, MW32, MW33 and MW62 and in four (4) of the auger boreholes at depths ranging from to 0.91 m in AG-5 1.98 m in AG-1.

Brown to black silty sand and gravel (GM) with occasional trace boulders and/or cobbles were encountered at or near the surface in TP226, TP228 to TP230, TP232 and ranged in thickness from 0.30 m in TP226 to 2.80 m in TP228. This layer extended to bedrock in test pits TP226 and TP229, and was underlain by a layer of black sand and gravel (GP) in TP232.

A layer of brown sand (SW) was encountered at or near the surface in TP234, MW31, MW32, MW33, MW34 and AG-1 to AG-3 and ranged in thickness from 0.61 m in MW31 to 2.3 m in TP234. This layer extended to bedrock in MW34. It was underlain by a clay or brown coarse sand and clay with occasional cobbles (CL) in MW31, MW32, MW33, AG-1, AG-2 and AG-3 that extended to bedrock at depths ranging from 1.67 mbgs in AG-2 to MW33 to 2.74 mbgs in MW31.

Brown coarse sand with trace cobbles and/or organics or was encountered at or near the surface in MW61, MW62, AG-4 and AG-5. This layer encountered bedrock at 0.46 mbgs in MW61, it encountered bedrock in AG-5 at 0.91 mbgs and it encountered a light pink/brown clay (CL) at 1.83 mbgs in MW62. The clay layer in MW62 extended to bedrock at 2.13 mbgs.

Brown silty sand (SM) was encountered at or near the surface in TP231 and TP233. This layer extended to the bottom of the test pit in TP233 (i.e., 2.80 mbgs) and it extended to a 2.1 m thick layer of black organics (OL) in TP231 (i.e., 0.30 mbgs).

Dark brown organics and light grey sand (OL) were encountered at or near the surface in TP227 and extended to bedrock (i.e., 0.30 mbgs).

3.14.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, no potential waste sites were identified at the site. However, buried debris was encountered in seven (7) of the nine (9) test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 15c, and in one (1) auger borehole. Debris was not encountered in any of the surface soil samples, as identified in Table 2.3. Buried debris at the site was generally found in test pits located near the residential area. Items encountered in test pits and the auger borehole at the site consisted of the following:

- Pieces of Steel
- Steel pipe
- Trace metal
- Rusted drums
- Bottles
- Siding
- WoodGroundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.37 mbgs in MW33 to 1.78 mbgs in MW61. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on August 3, 2009 in TP228 and TP231 to TP234 at depths ranging from 0.90 mbgs in TP231 to 2.80 mbgs in TP233. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution. Groundwater seepage was not encountered in surface soil samples on August 3, 2009.

Groundwater elevation data from a minimum of three (3) monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of shallow groundwater flow is inferred to be towards the pond. Deeper groundwater is expected to flow southeast towards Hopedale Harbour. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-07a in Appendix 1.

3.14.5 Free Phase Petroleum Hydrocarbons

Oil sheens were observed on groundwater encountered in TP231 and TP233 during test pit excavation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in the remaining test pits or surface soil pits.

3.14.6 Soil Vapour Concentrations

The soil vapour concentrations measured in soil and sediment samples from the Old Dump Pond site are provided on the Monitor Well Records in Appendix 15c and in Appendix 15d. The soil vapour concentrations measured ranged from 0.2 ppm in sediment sample SED-30 to 50.1 ppm in monitor well sample MW31-SS1. Petroleum hydrocarbon odours were noted in soil sample MW31-SS2.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations exceeded 50 ppm in one (1) soil sample collected from the site (i.e., MW31-SS1). TPH analysis was not conducted on samples collected from monitor wells at the site. Soil sample BS256 and sediment samples SED-20, SED-21 and SED-24 had soil vapour concentrations less than 50 ppm; however, modified TPH concentrations were greater than 1,000 mg/kg.

3.14.7 Laboratory Analysis and Results

A laboratory analysis schedule for the Old Dump Pond site is presented in Table 3.14 below.

Table 3.14 Laboratory Analysis Schedule (Old Dump Pond)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Old Dump Pond Delineate PCBs, metals, VOCs in sediment and VOCs and metals in surface water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	SED-25 to SED-34 SW-1 to SW-3, FISH-1 to FISH-4, BENTHIC-1	PCBs (10) VOCs (10) Metals (10) TOC & Grain size (3)	VOCs (3) Metals (3) Gen. Chem. (3)	-	Metals (3) PCBs (3) Lipids (3)	Genus (1)
Drainage Streams (2) from Old Dump Pond No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	SED-35 to SED-37	TPH (3) PCBs (3) VOCs (3) Metals (3)	-	-	-	-

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Area between subdivision and Old Dump Pond Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed.	TP226 to TP234 BS224 to BS228 MW31 to MW34, MW61, MW62 AG1 to AG5	TPH (18) PCBs (7) PAHs (1) VOCs (5) Metals (8)	TPH (5) PCBs (6) VOCs (1) Metals (4)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 15.1 to 15.18 in Appendix 15e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 18 soil samples collected from the site, including three (3) surface soil samples, six (6) test pit samples, six (6) monitor well samples and three (3) auger borehole samples. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Table 15.1 in Appendix 15e. Modified TPH was detected in 16 soil samples, at concentrations ranging from 30 mg/kg in AG3-FS2 to 34,000 mg/kg in MW61-SS1. Concentrations of modified TPH exceeded the applicable Tier I RBSL for lube oil impacts (i.e., 690 mg/kg) in TP230-BS2 (680 mg/kg), TP231-BS2 (1,300 mg/kg), TP233-BS2 (2,800 mg/kg), BS226 (2,000 mg/kg), BS228 (1,300 mg/kg), MW61-SS1 (3,400 mg/kg) and AG5-FS2 (1,800 mg/kg). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of weathered fuel oil and lube oil fractions. Detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Soil

PCB analysis was conducted on seven (7) soil samples collected from the site, including five (5) monitor well samples and two (2) auger borehole samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 15.2 in Appendix 15e. Detected concentrations of PCBs in MW32-SS2 (25 mg/kg), MW33-SS2 (4 mg/kg) and MW61-SS1 (29 mg/kg) exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

PAHs in Soil

PAH analysis was conducted on one (1) soil sample collected from the site. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 15.3 in Appendix 15e. PAH parameters were not detected above the RDL (0.005 mg/kg) in the soil sample collected from the site.

VOCs in Soil

VOC analysis was conducted on five (5) soil samples collected from the site, including two (2) monitor well samples and three (3) auger borehole samples. Results of the laboratory analysis of these soil samples for VOCs are presented in Table 15.4 in Appendix 15e. Concentrations of VOC parameters were not detected above the RDL in MW62-SS3, AG1-FS2, AG3-FS2 or AG-FS2. Concentrations of VOC parameters detected in MW61-SS1 were below the applicable CCME soil quality guidelines for a residential/parkland site, where such guidelines exist. The RDL for trichlorofluoromethane (30 mg/kg) was greater than the CCME soil quality guidelines for a residential/parkland site, therefore it is not possible to determine if the guideline was exceeded.

Metals in Soil

Available metals analysis was conducted on eight (8) soil samples collected from the site, including six (6) test pit samples and two (2) monitor well samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 15.5 in Appendix 15e. Concentrations of various metals were detected in all eight (8) soil samples, several of which exceeded applicable CCME criteria for metals in soil on a residential/parkland site in TP229-BS1, TP230-BS2, TP231-BS2 and TP233-BS2.

The concentrations of antimony, cadmium and chromium in soil samples TP229-BS1 and TP233-BS2 exceeded their respective CCME residential/parkland guidelines of 20 mg/kg, 10 mg/kg and 64 mg/kg. The concentrations of copper, lead, nickel, and tin in TP229-BS1, TP231-BS2, and TP233-BS2 exceeded their respective CCME residential/parkland guidelines of 63 mg/kg, 140 mg/kg, 50 mg/kg and 50 mg/kg. The concentrations of mercury and molybdenum in TP229-BS1 exceeded their respective CCME residential/parkland guidelines of 6.6 mg/kg and 10 mg/kg. The concentrations of zinc in TP229-BS1, TP230-BS2, TP231-BS2 and TP233-BS2 exceeded the applicable CCME residential/parkland guideline of 200 mg/kg. The concentration of selenium in TP229-BS2 exceeded the applicable CCME residential/parkland guideline of 1 mg/kg. Concentrations of selenium were not detected in the remaining samples collected from the site, however the elevated RDL (2 mg/kg) was greater than the CCME residential/parkland guideline; therefore it is not possible to determine if concentrations of selenium in these samples exceeded the guideline.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on three (3) freshwater sediment samples collected from the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Table 15.6 in Appendix 15e. Modified TPH was detected in two (2) of the sediment samples at concentrations of 95 mg/kg in SED-36 and 180 mg/kg in SED-35. The concentrations of TPH in sediment samples were below the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg). Laboratory analytical results indicated that the two (2) sediment samples contained one product in the fuel/lube oil range. BTEX parameters were not detected in soil samples collected from the site. There are no applicable guidelines for BTEX parameters in freshwater sediment.

PCBs in Sediment

PCB analysis was conducted on 13 sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 15.7 in Appendix 15e. PCBs were detected in 10 sediment samples at concentrations ranging from 0.18 mg/kg in SED-28 to 32 mg/kg in SED-34. The concentration of PCBs detected in sediment sample SED-28 exceeded the CCME freshwater ISQG of 0.0341 mg/kg. The concentrations of PCBs detected in sediment samples SED-25, SED-26, SED-27, SED-29, SED-30, SED-31, SED-32, SED-33 and SED-34 exceeded the CCME freshwater ISQG (0.0341 mg/kg) and the CCME freshwater PEL (0.277 mg/kg). PCBs were not detected above the RDL (0.05 mg/kg) in sediment samples SED-35, SED-36 and SED-37, however since the RDL is greater than the CCME freshwater ISQG, it is not possible to determine if the guideline was exceeded in these samples.

VOCs in Sediment

VOCs analysis was conducted on all 13 sediment sample collected from the site. Results of the laboratory analysis of sediment samples for VOCs are presented in Table 15.8 in Appendix 15e. Concentrations of VOC parameters were below the RDLs in all sediment samples analyzed, with the exception of toluene (160 µg/kg) in SED-34. There are no applicable CCME ISQGs or PELs for VOCs in freshwater sediment.

Metals in Sediment

Available metals analysis was conducted on all 13 sediment samples collected from the site. Results of the laboratory analysis of sediment samples for available metals are presented in Table 15.9 in Appendix 15e. Concentrations of various metals were detected in all sediment samples. The concentrations of cadmium and zinc in SED-25 to SED-27 and SED-29 to SED-34, copper and mercury in SED-27, SED-30, SED-31 and SED-34 and lead in sediment samples SED-27, SED-29 to SED-31 and SED-34 exceeded their respective CCME freshwater ISQGs. The concentrations of cadmium in SED-31 and SED-34, lead in SED-27 and SED-34, mercury in SED-34 and zinc in SED-27, SED-29 to SED-31, SED-33 and SED-34 exceeded their respective CCME freshwater PELs.

TOC and Grain Size in Sediment

Total organic carbon (TOC) and grain size analysis were conducted on three (3) sediment samples collected from the site. Results of the laboratory analysis for TOC and grain size analysis are presented in Table 15.10 in Appendix 15e. Concentrations of TOC ranged from 110 g/kg in SED-33 to 180 g/kg in SED-25 and SED-30. Results of grain size analysis indicated that the sediment samples generally consisted of silty sand with some clay and gravel.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on five (5) groundwater samples collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Table 15.6 in Appendix 15e. Modified TPH was detected in all five (5) groundwater samples (i.e., MW31, MW33, MW34, MW61 and MW61) at concentrations ranging from 0.2 mg/L in groundwater sample MW33 to 10 mg/L in MW61. Concentrations of modified TPH were below the applicable Tier I RBSL for lube oil impacts (i.e., 20 mg/L) in all groundwater samples. Laboratory analytical results indicated that products impacting groundwater samples on this site resembled weathered fuel oil, fuel oil or lube oil fractions, or had one product in the gas/fuel oil range. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on six (6) groundwater samples collected from the site. Results of laboratory analysis for these groundwater samples for PCBs are presented in Table 15.12 in Appendix 15e. Concentrations of PCBs in MW32 (1.6 µg/L), MW33 (4.1 µg/L) and MW34 (2.3 µg/L) exceeded the OMOE groundwater standard of 0.2 µg/L. Concentrations of PCBs in the remaining groundwater samples, including the field duplicate of MW34 (0.19 µg/L) were below the applicable OMOE groundwater standard.

VOCs in Groundwater

VOC analysis was conducted on one groundwater sample collected from the site (i.e., MW62). Results of the laboratory analysis of this groundwater sample for VOCs are presented in Table 15.13 in Appendix 15e. Concentrations of VOC parameters were below the applicable OMOE groundwater standards for non-potable groundwater, where such standards exist.

Metals in Groundwater

Available metals analysis was conducted on four (4) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for available metals are presented in Table 15.14 in Appendix 15e. Concentrations of various metals were detected in the groundwater samples. None of the detected concentrations of metals exceeded the applicable OMOE groundwater standards, where such guidelines exist.

VOCs in Surface Water

VOC analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of surface water samples for VOCs are presented in Table 15.15 in Appendix 15e. Concentrations of o-xylene in SW-3 (1 µg/L), p+m+xylenes in SW-1 to SW-3 (ranging from 2 µg/L to 3 µg/L) and toluene in SW-1 to SW-3 (ranging from 4 µg/L to 5 µg/L) were detected in surface water samples collected from the site. The remaining concentrations of VOC parameters were not detected in surface water samples collected from the site. Concentrations of VOC parameters were below the applicable CCME FWAL guidelines, where such guidelines exist.

Metals in Surface Water

Available metals analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for available metals are presented in Table 15.16 in Appendix 15e. Concentrations of various metals were detected in the surface water samples. The concentrations of aluminum (ranging from 155 µg/L to

176 µg/L), cadmium (ranging from <0.017 µg/L to 0.027 µg/L), copper (ranging from 2.5 µg/L to 3.0 µg/L), iron (ranging from 697 µg/L to 804 µg/L) and lead (ranging from 1.29 µg/L to 1.38 µg/L) detected in all three (3) surface water samples exceeded their respective CCME FWAL guidelines of 100 µg/L (based on pH > 6.5), 0.072 µg/L (based on a water hardness of 17 mg/kg), 2 µg/L (based on a water hardness of 17 mg/kg), 300 µg/L and 1 µg/L (based on a water hardness of 17 mg/kg).

General Chemistry in Surface Water

General chemistry analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for general chemistry parameters are presented in Table 15.17 in Appendix 15e. Concentrations of general chemistry parameters were below the applicable CCME FWAL guidelines.

PCBs in Fish

PCB analysis was conducted on three (3) fish samples caught at the site. The results of the laboratory analysis of fish samples for PCBs are presented in Table 15.18 in Appendix 15e. PCBs were detected in the three (3) fish samples analyzed (i.e., FISH-1, FISH-2 and FISH-4) with concentrations ranging from 4.8 mg/kg in FISH-4 to 5.9 mg/kg in FISH-2.

Metals in Fish

Available metals analysis was conducted on three (3) fish samples caught at the site. The results of the laboratory analysis of fish samples for metals are presented in Table 15.19 in Appendix 15e. Concentrations of various available metals were detected in all of the fish samples analyzed (i.e., FISH-1, FISH-2 and FISH-4).

3.14.8 Conclusions

A Phase II/III ESA was completed at the Old Dump Pond site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy in test pits at the site consisted of discontinuous layers silty sand and gravel (GM), silty sand (SM), brown sand (SW), black sand and gravel (GP), clay or brown coarse sand and clay (CL) or black organics (OL), all with varying percentages of organics, cobbles or boulders and overlying bedrock. Bedrock was encountered in all five (5) of the nine (9) test pits, four (4) of the five (5) auger boreholes and all six (6) monitor wells at depths ranging from 0.15 mbgs to 2.40 mbgs.
2. Various buried debris was observed within the overburden layer in seven (7) of the nine (9) test pits and within one (1) of the five (5) auger boreholes. No buried debris was encountered in surface soils samples. Buried debris at the site was generally found in test pits located near the residential area.
3. Groundwater was encountered at depths ranging from 0.37 mbgs to 2.80 mbgs in test pits and monitor wells completed at this site. Based on local topography and site observations, the direction of shallow groundwater flow at the site is inferred to be towards the pond.

4. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
5. There was olfactory evidence of petroleum hydrocarbon impacts on soil sample MW31-SS2. Oil sheens were observed on groundwater encountered in TP231 and TP233 during test pit excavation.
6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 690 mg/kg) were detected in seven (7) soil samples (i.e., TP230-BS2, TP231-BS2, TP233-BS2, BS226, BS228, MW61-SS1, and AG5-FS2). Concentrations of BTEX parameters in soil samples were below the applicable Tier I RBSLs. TPH concentrations were below the applicable OMOE guideline for total oil and grease in freshwater sediment in sediment samples analyzed. BTEX parameters were not detected in sediment samples analyzed. TPH concentrations were below the applicable Tier I RBSL (i.e., 20 mg/L) in groundwater samples analyzed. BTEX concentrations were below the applicable Tier I RBSLs in all groundwater samples analyzed.
7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP230, TP231, TP233, BS226, BS228, MW61, and AG5** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
8. Drawing No. 121410103-EE-07b in Appendix 1 shows the estimated extent of the petroleum-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately 800 m^2 has TPH levels in soil above the Tier I RBSL (690 mg/kg).
9. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in three (3) soil samples (i.e., MW32-SS2, MW33-SS2 and MW61-SS1). Low levels of PCBs were also detected in three (3) other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCB concentrations exceeding the applicable CCME ISQGs and PELs for freshwater sediment were detected in nine (9) sediment samples analyzed (i.e., SED-25, SED-26, SED-27, SED-29, SED-30, SED-31, SED-32, SED-33 and SED-34). The concentration of PCBs exceeded the CCME ISQGs for freshwater sediment in one (1) sediment sample analyzed (i.e., SED-28). The RDL for PCBs was greater than the CCME ISQG criteria, therefore it is not possible to determine if the criteria was exceeded in SED-35, SED-36 and SED-37 (i.e., sediments collected from the stream). PCB concentrations exceeding the applicable OMOE standard (i.e., 0.2 µg/L) were detected in three (3) groundwater samples (i.e., MW32, MW33 and MW34). PCBs were not detected in the other groundwater samples analyzed.
10. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of monitor wells **MW32, MW33 and MW61**, remediation of site sediment would be required in the vicinity of samples **SED-25 to SED-34** and remediation of site groundwater would be required in the vicinity of **MW32, MW33 and**

MW34 in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site.

11. Drawing No. 121410103-EE-07c in Appendix 1 shows the estimated extent of the PCB-impacted soil, sediment and groundwater at the site. Based on available analytical and field data, an estimated area of approximately **1,200 m^2** has PCB levels in soil above 1.3 mg/kg, the **entire pond** has PCB levels in sediment above 0.0341 mg/L and approximately **750 m^2** has PCB levels in groundwater above 0.2 µg/L.
12. PAHs were not detected in the soil sample analyzed. PAH analysis was not conducted on groundwater samples.
13. VOC concentrations did not exceed the applicable CCME criteria for soil on a residential/parkland site in soil samples analyzed. The RDL for trichlorofluoromethane was greater than the applicable CCME criteria, therefore it is not possible to determine if the criteria was exceeded in soil samples analyzed. With the exception of toluene in SED-34, VOCs were not detected in sediment samples analyzed. VOC concentrations were below the applicable OMOE groundwater standards in the groundwater sample analyzed. VOC concentrations were below the applicable CCME freshwater aquatic life guidelines in surface water samples analyzed.
14. Concentrations of antimony, cadmium, copper, lead, mercury, molybdenum, nickel, selenium, uranium and/or zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in three (3) soil samples (i.e., TP229-BS1, TP231-BS2 and TP233-BS2). The elevated RDLs for selenium in soil were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of cadmium, copper, lead, mercury and zinc exceed the CCME ISQGs and/or PELs for freshwater sediment in nine (9) sediment samples analyzed (i.e., SED-25, SED-26, SED-27, SED-29, SED-30, SED-21, SED-32, SED-33 and SED-34). Concentrations of available metals were below the applicable OMOE groundwater standards in groundwater samples analyzed. Concentrations of aluminum, cadmium, copper, iron and lead exceed the applicable CCME freshwater aquatic life guidelines in all three (3) surface water samples analyzed (i.e., SW-1, SW-2 and SW-3).
15. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **TP229, TP231 and TP233**, metals remediation of site sediment would be required in the vicinity **SED-25, SED-26, SED-27, SED-29, SED-30, SED-21, SED-32, SED-33 and SED-34** and metals remediation of **surface water in the pond** would be required in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil, sediment and surface water would be governed by SSTLs determined for each contaminant.
16. Drawing No. 121410103-EE-07d in Appendix 1 shows the estimated extent of the metals-impacted soil and sediment at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **700 m^2** has metals levels in soil above the applicable CCME criteria and the **entire pond** has metals levels in sediment above the applicable CCME ISQGs.

17. Concentrations or general chemistry parameters were below the applicable CCME freshwater aquatic life guidelines in surface water samples analyzed.
18. PCBs were detected in the three (3) fish samples analyzed at concentrations ranging from 4.8 mg/kg to 5.9 mg/kg. Concentrations of various available metals were detected in the three (3) fish samples analyzed.
19. The extent of TPH, PCB and metals impacts on soil and the extent of PCB impacts on groundwater above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.15 Pipeline

3.15.1 Site Description

During operation of the Former U.S. Military Site, fuel used at the site was received at the wharf and transferred upgradient via aboveground pipelines to two (2) large aboveground fuel storage tanks located at the Main Base site. The fuel tanks and pipelines have been removed, with the exception of some sections of the aboveground pipeline present near the wharf. The Pipeline site was identified as the corridor where the former pipeline crossed the site and is identified on Drawing No.’s 121410103-EE-07a and 121410103-EE-08a in Appendix 1. Photos taken of the site during investigations are presented in Appendix 16a.

The approach to the wharf consists of compacted sand along the road lined with minor vegetation. Surface drainage (apparent groundwater flow direction) is expected to be to the southeast and east towards Hopedale Harbour.

3.15.2 Field Work

Field work at this site comprised the installation of 10 monitor wells (i.e., MW53 to MW60, MW68 and MW69) and the collection of eight (8) surface soil samples (i.e., BS229 to BS236) and 10 groundwater samples (i.e., MW53 to MW60, MW68 and MW69). Coordinates of each sample location are provided in Appendix 16b. Site location maps (Drawing No. 121410103-EE-07a and Drawing No. 1214103-EE-08a) showing the location of these as well as general site features is provided in Appendix 1.

3.15.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well Records in Appendix 16c.

Bedrock was encountered in four (4) of the 10 monitor wells (i.e., MW58 to MW60 and MW68) at depths ranging from 0.00 mbgs in MW58 to 3.05 mbgs in MW53 and in four (4) of the eight (8) surface soil samples at depths ranging from 0.05 mbgs in BS232 to 0.10 mbgs in BS231. The depth to bedrock near the shore is expected to be shallow.

Brown to brownish grey sand with occasional cobbles, trace organics or fine gravel (SP, SW or GM) was encountered at or near the surface in MW53 to MW57, MW59, MW60 and MW69.

This layer of sand materials was underlain by a layer of light grey to pink clay (CL) in eight (8) of the monitor wells at depths ranging from 1.52 mbgs in MW60 and MW55 to 3.05 mbgs in MW53. Varying percentages of clay were observed in sand layer (SP, SW or GM), above the clay layer, typically between 1.22 and 1.83 mbgs. A layer of pink Styrofoam was encountered in MW53 at a depth of 2.44 mbgs, above the clay layer.

Light brown coarse sand and coarse gravel (GP) with some cobbles were encountered at or near the surface in MW68 and extended to a depth of 0.15 mbgs. This layer was underlain by a layer of boulders and cobbles, followed by a layer of light brown coarse sand with trace gravel (SM) to a depth of 1.82 mbgs. This layer was underlain by another layer of boulders and cobbles, followed by bedrock at a depth of 1.97 mbgs.

3.15.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, no potential waste sites were identified at the site. Buried debris was not encountered in any of the eight (8) surface soil samples dug at the site, as identified in Table 2.3.

3.15.5 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 3.05 mbgs in MW54, MW55 and MW56 to 4.67 mbgs in MW69. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Based on local topography and site observations the direction of groundwater flow is inferred to be southeast and east towards Hopedale Harbour. The assumed direction of groundwater flow is shown on Drawing No.'s 121410103-EE-07a and 121410103-EE-08a in Appendix 1.

3.15.6 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe.

3.15.7 Soil Vapour Concentrations

The soil vapour concentrations measured in the surface soil samples collected at the Pipeline site are provided on the in Appendix 16d. The soil vapour concentrations measured ranged from 0.9 ppm in BS229 to 46.6 ppm in BS230. Soil vapour concentrations were not recorded for monitor well samples collected from the Pipeline site. Petroleum hydrocarbon odours were detected in soil samples MW53-SS4 and MW53-SS5.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the surface soil sample collected from the site; however, concentrations of modified TPH in surface soil samples BS230 and BS234 exceeded

1,000 mg/kg. The concentrations of modified TPH also exceeded 1,000 mg/kg in MW53-SS4, MW68-SS3 and MW69-SS4.

3.15.8 Laboratory Analysis and Results

A laboratory analysis schedule for the Pipeline site is presented in Table 3.15 below.

Table 3.15 Laboratory Analysis Schedule (Pipeline)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Debris and physical hazards. No previous investigation conducted in the wharf and construction camp areas. Potential for petroleum hydrocarbons in soil near existing sections of pipeline and former pipeline location.	MW53 to MW60, MW68, MW69 BS229 to BS236	TPH (17) PCBs (8) VOCs (2) Metals (2)	TPH (10) PCBs (1) Metals (1)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 16.1 to 16.8 in Appendix 16e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 11 monitor well soil samples and six (6) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Table 16.1 in Appendix 16e. Modified TPH was detected in 14 of the soil samples analyzed, at concentrations ranging from 27 mg/kg in MW60-SS1 to 52,000 mg/kg in BS230. Concentrations of modified TPH exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140 mg/kg) in eight (8) soil samples (i.e., MW53-SS4, MW54-SS2, MW68-SS3, MW69-SS4, MW69-SS5, BS230, BS232 and BS234). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of fuel oil, weathered fuel oil and lube oil fractions. The concentrations of toluene and ethylbenzene detected in soil sample MW68-SS3 were below the applicable Tier I RBSLs. None of the remaining samples contained detectable concentrations of BTEX parameters.

PCBs in Soil

PCB analysis was conducted on five (5) monitor well soil samples and three (3) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 16.2 in Appendix 16e. The detected concentrations of PCBs in BS229 (13.0 mg/kg), BS230 (24 mg/kg) and BS231 (7.9 mg/kg) exceeded the applicable CCME guideline for a residential/parkland site in soil samples collected from the site. PCBs were detected in soil sample MW69-SS4 (0.2 mg/kg) below the CCME soil quality guideline for a residential/ parkland site of 1.3 mg/kg. PCBs were not detected in the remaining soil samples collected from the site.

VOCs in Soil

VOC analysis was conducted on two (2) monitor well soil samples collected from the site. Results of the laboratory analysis of these soil samples for VOCs is presented in Table 16.3 in Appendix 16e. Concentrations of VOC parameters were not detected in soil samples MW59-SS1 and MW69-SS4. The RDL for trichlorofluoromethane (30 mg/kg) was greater than the CCME soil quality guidelines for a residential/parkland site (10 mg/kg), therefore it is not possible to determine if the guideline was exceeded in soil samples collected from the site.

Metals in Soil

Available metals analysis was conducted on one (1) monitor well soil sample and one (1) surface soil collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 16.4 in Appendix 16e. Concentrations of various metals were detected in the soil samples. The concentrations of chromium (110 mg/kg), copper (70 mg/kg) and zinc (510 mg/kg) detected in soil sample BS230 exceeded their respective CCME guidelines for a residential/parkland site of 64 mg/kg, 63 mg/kg and 200 mg/kg, respectively.. The elevated RDL for selenium (i.e., 2 mg/kg) was greater than the CCME residential/parkland guideline of 1 mg/kg in both samples, therefore it is not possible to determine if the concentration of selenium exceeded the CCME guideline. None of the remaining concentrations of available metals exceeded the applicable CCME criteria for metals in soil on a residential/parkland site.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on 10 groundwater samples collected from the site. TPH fraction was conducted on one (1) groundwater sample. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Tables 7.3.5 and 7.3.6 in Appendix 16e. Modified TPH was detected in six (6) groundwater samples (i.e., MW53 to MW56, MW68 and MW69) at concentrations ranging from 0.2 mg/L in groundwater sample MW69 to 370 mg/L in MW53. The concentration of modified TPH in groundwater sample MW53 exceeded the applicable Tier I RBSL fuel oil impacts (i.e., 20 mg/L). Concentrations of modified TPH in the remaining groundwater samples were below the applicable Tier I RBSL. Laboratory analytical results indicated that products impacting groundwater samples on this site resembled a mixture of weathered fuel oil, fuel oil or lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on one (1) groundwater sample collected from the site. Results of laboratory analysis for this groundwater sample for PCBs are presented in Table 16.7 in Appendix 16e. PCBs were not detected above the RDL (i.e., 0.2 µg/L) in groundwater sample MW53.

Metals in Groundwater

Available metals analysis was conducted on one (1) groundwater sample collected from the site. Results of the laboratory analysis of this groundwater sample for available metals are presented in Table 16.8 in Appendix 16e. Concentrations of various metals were detected in the groundwater sample. None of the detected concentrations of available metals exceeded the applicable OMOE non-potable groundwater guidelines, where such guidelines exist.

3.15.9 Conclusions

A Phase II/III ESA was completed at the Pipeline site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. The observed stratigraphy in monitor wells at the site consisted of discontinuous layers of brown to brownish grey sand with occasional cobbles, trace organics or fine gravel (SP, SW or GM) overlying clay, boulders and cobbles or bedrock. Bedrock was encountered in four (4) of the 10 monitor wells at depths ranging from 0.00 mbgs (i.e., at surface) to 3.05 mbgs and in four (4) of eight (8) surface soils samples at depths ranging from 0.05 mbgs in BS232 to 0.10 mbgs in BS231.
2. Buried debris was not encountered at any of the surface soil sample locations.
3. Groundwater was depths ranged from 3.05 mbgs in MW54, MW55 and MW56 to 4.67 mbgs in MW69. Based on local topography and site observations, the direction of groundwater flow at the site is inferred to be to be southeast and to the east towards Hopedale Harbour.
4. There was olfactory evidence of petroleum hydrocarbon impacts on soil samples MW53-SS4 and MW53-SS5. No free liquid phase petroleum hydrocarbons were observed at the site.
5. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
6. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in eight (8) soil samples (i.e., MW53-SS4, MW54-SS2, MW68-SS3, MW69-SS4, MW69-SS5, BS230, BS232 and BS234). TPH concentrations exceeding the applicable Tier I RBSL (i.e., 20 mg/L) were also detected in one (1) groundwater sample (i.e., MW53). Concentrations of BTEX parameters in soil and groundwater samples analyzed were below the applicable Tier I RBSLs.
7. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of **MW53, MW54, MW68, MW69, BS230, BS232 and BS234** and petroleum hydrocarbon remediation of site groundwater would be required in the vicinity of **MW53** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

8. Drawing No. 121410103-EE-08b in Appendix 1 shows the estimated extent of the petroleum hydrocarbon-impacted soil and groundwater at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **1,700 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg) and an estimated area of approximately **300 m^2** has TPH levels in groundwater above the Tier I RBSL (20 mg/L).
9. PCB concentrations exceeded the applicable CCME criteria for soil on a residential/ parkland site (i.e., 1.3 mg/kg) in soil samples BS229, BS230 and BS231. PCB concentrations did not exceed the applicable OMOE standard (i.e., 0.2 µg/L) in the groundwater sample analyzed.
10. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of **BS229, BS230 and BS231** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
11. Drawing No. 121410103-EE-08c in Appendix 1 shows the estimated extent of the PCB-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **3,000 m^2** has PCB levels in soil above the CCME criteria.
12. VOC concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site were not detected in soil samples analyzed. The RDL for trichlorofluoromethane was greater than the applicable criteria, therefore it is not possible to determine if the criteria was exceeded in soil samples analyzed.
13. Concentrations of chromium, copper and zinc exceeded the applicable CCME criteria for soil on a residential/parkland site in soil sample BS230. The elevated RDLs for selenium in soil were greater than the CCME criteria, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of available metals were below the applicable OMOE groundwater standards in groundwater samples analyzed.
14. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of **BS230** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site. Adopting a risk-based remedial approach, remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
15. Drawing No. 121410103-EE-08b in Appendix 1 shows the estimated extent of the metals-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **300 m^2** has metals levels in soil above the CCME criteria.
16. The extent of TPH, PCB and metals impacts on soil and TPH impacts on groundwater above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.16 Wharf Area

3.16.1 Site Description

The wharf area is located south of the Former U.S. Military Site, at the beginning of the main access road on the west side of Hopedale Harbour, as shown on Drawing No. 121410103-EE-08a in Appendix 1. During operation of the Former U.S. Military Site, fuel was transferred from boats to the aboveground pipeline at this location. Access to the Former U.S. Military Site was largely via sea, so the wharf was likely used to load, unload and dock boats. The wharf is currently in use and various structures are present along the approach to the wharf.

The shoreline is lined with frequent bedrock outcrops and large boulders. Hopedale Harbour is a marine aquatic environment. Photos taken of the site during investigations are presented in Appendix 17a.

3.16.2 Field Work

Field work at this site comprised the collection of 17 sediment samples (i.e., SED-1 to SED-11 and SED-72 to SED-77). Coordinates of each sample location are provided in Appendix 17b. A site location map (Drawing No. 121410103-EE-08a) showing the location of these as well as general site features is provided in Appendix 1.

3.16.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.16.4 Soil Vapour Concentrations

The soil vapour concentrations measured in sediment samples from the Wharf Area are provided in Appendix 17c. The soil vapour concentrations measured ranged from 0.7 ppm in sediment sample SED-3 to 50 ppm in sediment sample SED-8. Petroleum hydrocarbon odours were detected in SED-5.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. The sediment sample that had a soil vapour concentration of 50 ppm (i.e., SED-3) and the sediment sample that had a petroleum hydrocarbon odour (i.e., SED-5) was not analyzed for TPH. Soil vapour concentrations were not recorded for sediment sample SED-70; however the concentration of modified TPH in this sample also exceeded 1,000 mg/kg.

3.16.5 Laboratory Analysis and Results

A laboratory analysis schedule for the Wharf Area site is presented in Table 3.11 below.

Table 3.16 Laboratory Analysis Schedule (Wharf Area)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Marine area near wharf and drainage outlets No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	SED-1 to SED-11, SED-72 to SED-77	TPH (13) PCBs (9) VOCs (1) Metals (9)	-	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 17.1 to 17.4 in Appendix 17d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 13 sediment samples collected from the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Tables 17.1 in Appendix 17d. Modified TPH was detected in all 13 sediment samples at concentrations ranging from 22 mg/kg in SED-4 to 1,200 mg/kg in SED-77. The concentrations of TPH in sediment samples were below the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg). Laboratory analytical results indicated that products impacting the sediment samples resembled a mixture of weathered fuel oil, fuel oil or lube oil fractions. BTEX parameters were not detected in soil samples collected from the site, with the exception of toluene in SED-76 (0.05 mg/kg). There are no applicable guidelines for BTEX parameters in sediment.

PCBs in Sediment

PCB analysis was conducted on nine (9) sediment samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 17.2 in Appendix 17d. The concentrations of PCBs detected in SED-1 (0.44 mg/kg), SED-72 (0.34 mg/kg), SED-73 (0.14 mg/kg), SED-74 (0.3 mg/kg), SED-75 (0.38 mg/kg), SED-76 (0.2 mg/kg) and SED-77 (0.46 mg/kg) exceeded the applicable CCME marine ISQG of 0.0215 mg/kg. The concentrations of PCBs detected in SED-1, SED-72, SED-74, SED-75, SED-76 and SED-77 also exceeded the CCME marine PEL of 0.189 mg/kg. The RDL for sediment sample SED-10 (0.1 mg/kg) was greater than the CCME marine ISQG, therefore it is not possible to determine if the guideline was exceeded in this sample.

VOCs in Sediment

VOCs analysis was conducted on one (1) sediment sample collected from the site. Results of the laboratory analysis of sediment samples for VOCs are presented in Table 17.3 in Appendix 17d. Concentrations of VOC parameters were not detected above the RDLs for any parameters analyzed. There are no applicable CCME ISQGs or PELs for VOCs in marine sediment.

Metals in Sediment

Available metals analysis was conducted on nine (9) sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 17.4 in Appendix 17d. Concentrations of various metals were detected in all sediment samples. None or the detected concentrations of available metals exceeded applicable CCME marine ISQGs or PELs.

3.16.6 Conclusions

A Phase II/III ESA was completed at the Wharf Area site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. There was olfactory evidence of petroleum hydrocarbon impacts on sediment sample SED-5. No free phase petroleum hydrocarbons were observed on soil, sediment, surface water or standing water throughout the site.
2. TPH concentrations were below the applicable OMOE guideline for oil and grease in freshwater sediment in all sediment samples analyzed. With the exception of toluene in SED-76 (0,05 mg/kg), BTEX parameters were not detected in the sediment samples analyzed.
3. PCBs were detected above the CCME ISQG (0.0215 mg/kg) in seven (7) sediment samples (i.e., SED-1, SED-72, SED-73, SED-74, SED-75, SED-76 and SED-77). PCBs were also detected above the CCME PEL (i.e., 0.189 mg/kg) in six (6) of these sediment samples. The RDL for PCBs in SED-10 (i.e., 0.1 mg/kg) was greater than the CCME ISQG, therefore it is not possible to determine if concentrations of PCBs exceeded the CCME ISQG in this sample.
4. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site sediment would be required in the vicinity of samples **SED-1, SED-72, SED-73, SED-74, SED-75, SED-76 and SED-77** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, PCB remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.
5. Drawing No. 121410103-EE-08c in Appendix 1 shows the estimated extent of the PCB-impacted sediment at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **1,500 m^2** of has PCB levels in sediment above 0.0215 mg/kg.
6. VOCs were not were detected in the sediment sample analyzed.
7. Concentrations of copper or lead exceeding the applicable CCME marine ISQGs were detected in three (3) sediment samples analyzed (i.e., SED-1, SED-7 and SED-76).
8. Based on NLDEC policy directive PPD05-01, **metals** remediation of site sediment would be required in the vicinity of samples **SED-1, SED-7 and SED-76** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the

site. Adopting a risk-based remedial approach, metals remediation of site sediment would be governed by SSTLs determined for each contaminant.

9. Drawing No. 121410103-EE-08d in Appendix 1 shows the estimated extent of the metals-impacted sediment at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **1,100 m^2** of has metals levels in sediment above 0.0215 mg/kg.

10. The extent of PCB and metals impacts on sediment above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.17 Old Dam

3.17.1 Site Description

The Old Dam is a concrete structure located northwest of the Town of Hopedale, as shown on Drawing No. 121410103-EE-10a in Appendix 1. The dam has a small stream passing through it that originates at the Mid-Canada Line site. Terrain in the vicinity of the Old Dam slopes to the southeast towards the Town of Hopedale. Vegetation at the site consists of patches of grasses and trees. Photos taken of the site during investigations are presented in Appendix 18a.

3.17.2 Field Work

Field work at this site comprised the collection of five (5) freshwater sediment samples (i.e., SED-49 to SED-53). Coordinates of each sample location are provided in Appendix 18b. A site location map (Drawing No. 121410103-EE-10a) showing the location of these as well as general site features is provided in Appendix 1.

3.17.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.17.4 Soil Vapour Concentrations

Soil vapour concentrations were not recorded for sediment samples collected from the Old Dam site. Appendix 18c indicates that no petroleum hydrocarbon odours were detected on the sediment samples collected at the site.

3.17.5 Laboratory Analysis and Results

A laboratory analysis schedule for the Old Dam site is presented in Table 3.17 below.

Table 3.17 Laboratory Analysis Schedule (Old Dam)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Drainage Stream at Old Dam area No previous investigation conducted. Potential for petroleum hydrocarbons, PCBs or metals in sediment.	SED-49 to SED-53	TPH (5) PCBs (5) Metals (5)	-	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 18.1 to 18.3 in Appendix 18d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on all five (5) freshwater sediment samples collected from the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Table 18.1 in Appendix 18d. Modified TPH was detected in four (4) of the sediment samples at concentrations ranging from 83 mg/kg in SED-52 to 1,000 mg/kg in SED-53. The concentrations of TPH in sediment samples were below the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg). Laboratory analytical results indicated that the four (4) sediment samples with detectable concentrations of modified TPH had one product in the fuel/lube oil range. BTEX parameters were not detected in sediment samples collected from the site. There are no applicable guidelines for BTEX parameters in freshwater sediment.

PCBs in Sediment

PCB analysis was conducted on all five (5) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 18.2 in Appendix 18d. PCBs were not detected above the RDL (0.05 mg/kg) in any of the sediment samples, however since the RDL is greater than the CCME freshwater ISQG (0.0341 mg/kg), it is not possible to determine if the guideline was exceeded. Non detectable concentrations of PCBs were below the CCME freshwater PEL (0.277 mg/kg).

Metals in Sediment

Available metals analysis was conducted on all five (5) sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 18.3 in Appendix 18d. Concentrations of various metals were detected in all sediment samples. The concentration of lead in sediment samples SED-25 to SED-27 and SED-29 to SED-34, copper and mercury in sediment samples SED-53 (77 mg/kg) exceeded the applicable CCME freshwater ISQG (35.0 mg/kg). The remaining concentrations of available metals were below the CCME freshwater ISQGs and PELs, where such guidelines exist.

3.17.6 Conclusions

A Phase II/III ESA was completed at the Old Dam site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on sediment at the site.
2. TPH concentrations did not exceed the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg) in sediment samples analyzed. With the exception of toluene in SED-49 (0.07 mg/kg), BTEX parameters were not detected in the sediment samples analyzed.
3. PCBs were not detected above the CCME PEL for freshwater sediment in sediment samples analyzed. The RDL for PCBs in all sediment samples was greater than the CCME ISQG for freshwater sediment, therefore it is not possible to determine if concentrations of PCBs exceeded the CCME ISQG in this sample.
4. A concentration of lead exceeding the applicable CCME ISQG for freshwater sediment was detected in one (1) sediment sample analyzed (i.e., SED-53).
5. Based on NLDEC policy directive PPD05-01, **metals** remediation of site sediment would be required in the vicinity of sample **SED-53** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for each contaminant.
6. Drawing No. 121410103-EE-10b in Appendix 1 shows the estimated extent of the metals-impacted sediment at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **300 m^2** of has metals levels in sediment the applicable CCME ISQGs.
7. The extent of metals impacts on sediment above the generic guidelines at the site have not been fully delineated. Samples were collected in “worst case” locations, and therefore, it is assumed that the maximum concentrations have been identified.

3.18 Reservoir

3.18.1 Site Description

The Reservoir site is located in a valley, approximately 300 m south of the BMEWS site. The site encompasses Reservoir Lake and is used as the primary source of potable water for the town of Hopedale. Reservoir Lake is a freshwater aquatic environment.

Terrain in the vicinity of the Reservoir site slopes steeply towards the lake. A small stream feeds into the lake from the north. It is assumed that surface run-off and apparent groundwater flow follow the general slope. The shore of the lake consists of bedrock outcroppings and lush vegetation. Visible substrate along the shore of the lake was generally coarse. Photos taken of the site during investigations are presented in Appendix 19a.

3.18.2 Field Work

Field work at this site comprised the collection of eight (8) freshwater sediment samples (i.e., SED-38 to SED-45), three (3) surface water samples (i.e., SW-4 to SW-6), one (1) fish sample (i.e., FISH-5) and one (1) benthic invertebrate sample (i.e., BENTHIC-2). Coordinates of each sample location are provided in Appendix 19b. A site location map (Drawing No. 121410103-EE-07a) showing the location of these as well as general site features is provided in Appendix 1.

3.18.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.18.4 Soil Vapour Concentrations

The soil vapour concentrations measured in sediment samples from Reservoir Lake are provided in Appendix 19c. Vapour concentrations measured ranged from 0.4 ppm in SED-39 to 1.1 ppm in SED-38 and SED-41. No petroleum hydrocarbon odours were detected on the sediment samples collected at the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. No soil vapour concentrations exceeded 50 ppm in sediment samples collected at the site.

3.18.5 Laboratory Analysis and Results (Reservoir)

A laboratory analysis schedule for the Reservoir site is presented in Table 3.18 below.

Table 3.18 Laboratory Analysis Schedule (Reservoir)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Delineate PCBs and metals in sediment and PCBs, metals and general chemistry in water. Test benthic invertebrates, grain size analysis and fish for risk assessment. Complete a habitat assessment for terrestrial, avian and aquatic ecological receptors.	SED-38 to SED-45, SW-4 to SW-6 FISH-5, BENTHIC-2	PCBs (8) Metals (8) TOC & Grain Size (3)	PCBs (3), Metals (3), RCAP-MS (3)	-	Metals (1) PCBs (1) Lipids (1)	Genus (1)

Results of laboratory analysis of soil obtained from this site are presented in Tables 19.1 to 19.6 in Appendix 19d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

PCBs in Sediment

PCB analysis was conducted on eight (8) sediment samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 19.1 in Appendix 19d. PCBs were not detected above the RDL (0.05 mg/kg) in any of the sediment samples. The RDL for PCBs in sediment is greater than the CCME freshwater ISQG (0.0341 mg/kg), therefore it is not possible to determine if the guideline was exceeded in samples collected from the site. Concentrations of PCBs were below the CCME freshwater PEL of 0.277 mg/kg.

Metals in Sediment

Available metals analysis was conducted on all eight (8) sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 19.2 in Appendix 19d. Concentrations of various metals were detected in all sediment samples. The concentrations of cadmium in SED-39 (0.6 mg/kg) equalled the applicable CCME freshwater ISQG of 0.6 mg/kg. The concentrations of chromium in SED-38 (40 mg/kg), SED-39 (44 mg/kg, 43 mg/kg in the lab-dup), SED-41 (58 mg/kg) and SED-43 (57 mg/kg) exceeded the applicable CCME freshwater ISQG of 37.3 mg/kg. The concentrations of copper in SED-39 (37 mg/kg in the lab-dup) and SED-43 (38 mg/kg) exceeded the applicable CCME freshwater ISQG of 35.7 mg/kg. The concentration of mercury in SED-39 (0.2 mg/kg, 0.2 mg/kg in the lab-dup) exceeded the applicable CCME freshwater ISQG of 0.17 mg/kg. The concentration of zinc in SED-41 (140 mg/kg) exceeded the applicable CCME freshwater ISQG of 123 mg/kg. None of the detected concentrations of available metals in sediment samples collected from the site exceeded the applicable CCME freshwater PELs.

TOC and Grain Size in Sediment

Total organic carbon (TOC) and grain size analysis were conducted on three (3) sediment samples collected from the site. Results of the laboratory analysis for TOC and grain size analysis are presented in Table 19.3 in Appendix 19d. Concentrations of TOC ranged from 1.8 g/kg in SED-44 to 130 g/kg in SED-39. Results of grain size analysis indicated that the sediment samples generally consisted of sand with some silt, clay and gravel.

PCBs in Surface Water

PCB analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of surface water samples for PCBs are presented in Table 19.4 in Appendix 19d. Concentrations of PCBs were below the RDL (0.05 mg/kg) in all surface water samples collected from the site (SW-4 to SW-6). There is no applicable Health Canada CDWQG for PCBs in surface water.

Metals in Surface Water

Available metals analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for available metals are presented in Table 19.5 in Appendix 19d. Concentrations of aluminum, iron and manganese were detected in the surface water samples. The detected concentrations of available metals were below the Health Canada CDWQG in all surface water samples collected from the site.

General Chemistry in Surface Water

General chemistry analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for general chemistry parameters are presented in Table 19.6 in Appendix 19d. The pH values in SW-1 (6.41), SW-2 (6.26) and SW-3 (6.39, 6.37 in the lab-dup) were outside the Health Canada CDWQG range of 6.5 to 8.5 (aesthetic objective). The turbidity value for SW-1 (1.1 NTU) was above the Health Canada CDWQG of 1.0 NTU (based on slow sand filtration). The remaining concentrations of general chemistry parameters were below the applicable Health Canada CDWQGs.

PCBs in Fish

PCB analysis was conducted on one (1) fish sample caught at the site. The results of the laboratory analysis of fish samples for PCBs are presented in Table 19.7 in Appendix 19d. PCBs were detected in the fish sample analyzed (i.e., FISH-5) at a concentration of 0.37 mg/kg.

Metals in Fish

Available metals analysis was conducted on one (1) fish sample caught at the site. The results of the laboratory analysis of fish samples for metals are presented in Table 19.8 in Appendix 19d. Concentrations of various available metals were detected in the fish sample analyzed (i.e., FISH-5).

3.18.6 Conclusions

A Phase II/III ESA was completed at Reservoir Lake, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. This site was considered to have freshwater sediment and potable surface water.
2. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on sediment collected from the site. No free phase petroleum hydrocarbons were observed on surface water within Reservoir Lake.
3. PCBs were not detected above the RDL (i.e., 0.05 mg/kg) in sediment collected from the site; therefore PCB concentrations were below the applicable CCME PEL for freshwater sediment (i.e., 0.277 mg/kg). It is not possible to determine if concentrations of PCBs exceeded the CCME ISQG for freshwater sediment (i.e., 0.0341 mg/kg). PCBs were not detected in the surface water samples analyzed.
4. Metals concentrations exceeding the applicable CCME criteria for freshwater sediment were detected in sediment samples SED-38, SED-39, SED-41 and SED-43 (i.e.,

cadmium, chromium, copper, mercury and/or zinc). Metals concentrations exceeding the applicable CDWQGs were not detected in surface water samples analyzed.

5. Based on NLDEC policy directive PPD05-01, **metals** remediation of site sediment would be required in the vicinity of samples **SED-38, SED-39, SED-41 and SED-43** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for each contaminant.
6. Drawing No. 121410103-EE-6b in Appendix 1 shows the estimated extent of the metals-impacted sediment at the site. The actual impacted area may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **1,200 m^2** of has metals levels in sediment the applicable CCME ISQGs.
7. Levels of pH in all three surface water samples collected from the site and turbidity in surface sample SW-4 and were outside the CDWQG objectives. The objective for pH is aesthetic.
8. PCBs were detected in the fish sample analyzed at a concentration of 0.37 mg/kg. Concentrations of various available metals were detected in the fish sample analyzed.
9. The extent of metals impacts in sediment above the generic guidelines at the site have not been fully delineated. Samples were collected throughout the lake, and therefore, it is assumed that the maximum concentrations have been identified.

3.19 Second Reservoir

3.19.1 Site Description

The Second Reservoir is located in a valley, approximately 600 m west of Reservoir Lake. The Second Reservoir is used as a back-up source of potable water for the Town of Hopedale. There is a waterline connecting the Second Reservoir to Reservoir Lake; however, the Second Reservoir appears to lie west of any significant activities or infrastructure on the Former U.S. Military Site. A strong bedrock ridge lies between the Second Reservoir, a small pond and a large forested bog complex and the known areas of contamination on the Former U.S. Military Site. The Second Reservoir lies within a drainage system that discharges between the town wharf and the airport. The lower part of this watershed is presently under development for residential purposes.

Terrain in the vicinity of the site slopes moderately towards the Second Reservoir. It is assumed that surface run-off and apparent groundwater flow follow the general slope. The shore of the reservoir consists of gravel, boulders and lush vegetation. Photos taken of the site during investigations are presented in Appendix 20a.

3.19.2 Field Work

Field work at this site comprised the collection of five (5) freshwater sediment samples (i.e., SED-54 to SED-58), three (3) surface water samples (i.e., SW-7 to SW-9) and one (1) benthic invertebrate sample (i.e., BENTHIC-3). Coordinates of each sample location are provided in Appendix 20b. A site location map (Drawing No. 121410103-EE-011a) showing the location of these as well as general site features is provided in Appendix 1.

3.19.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.19.4 Soil Vapour Concentrations

Soil vapour concentrations were not measured in sediment samples collected from the Second Reservoir. Appendix 20c indicates that no petroleum hydrocarbon odours were detected on the sediment samples collected at the site.

3.19.5 Laboratory Analysis and Results

A laboratory analysis schedule for the Second Reservoir site is presented in Table 3.15 below.

Table 3.19 Laboratory Analysis Schedule (Second Reservoir)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
No previous investigation conducted. Possible PCBs and metals in sediment and surface water. Test benthic invertebrates, grain size analysis and fish for risk assessment.	SED-54 to SED-58 SW-7 to SW-9 BENTHIC-3	PCBs (5) Metals (5) TOC & Grain Size (5)	PCBs (3) Metals (3) Gen. Chem. (3)	-	-	Genus (1)

Results of laboratory analysis of soil obtained from this site are presented in Tables 20.1 to 20.6 in Appendix 20d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>PCBs in Sediment</u>

PCB analysis was conducted on all five (5) sediment samples collected from the site. Results of the laboratory analysis of soil samples for PCBs are presented in Table 20.1 in Appendix 1b. PCBs were not detected above the RDL (0.05 mg/kg) in any of the sediment samples. The RDL for PCBs in sediment is greater than the CCME freshwater ISQG (0.0341 mg/kg), therefore it is not possible to determine if the guideline was exceeded in samples collected from the site. Concentrations of PCBs were below the CCME freshwater PEL of 0.277 mg/kg.

<u>Metals in Sediment</u>

Available metals analysis was conducted on all five (5) sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in

Table 20.2 in Appendix 20d. Concentrations of various metals were detected in all sediment samples. The concentrations of cadmium in sediment samples SED-55 (1.3 mg/kg) and SED-57 (0.7 mg/kg) exceeded the applicable CCME freshwater ISQG of 0.6 mg/kg. The concentrations of copper in sediment samples SED-55 (38 mg/kg) and SED-57 (36 m/gkg) exceeded the applicable CCME freshwater ISQG of 35.7 mg/kg. The concentrations of zinc in sediment samples SED-55 (160 mg/kg) and SED-57 (160 mg/kg) exceeded the applicable CCME freshwater ISQG of 123 mg/kg. None of the concentrations of available metals detected in sediment samples collected from the site exceeded the applicable CCME freshwater PELs.

TOC and Grain Size in Sediment

Total organic carbon (TOC) and grain size analysis were conducted on five (5) sediment samples collected from the site. Results of the laboratory analysis for TOC and grain size analysis are presented in Table 20.3 in Appendix 20d. Concentrations of TOC ranged from 5 g/kg in SED-58 to 160 g/kg in SED-55 and SED-57. Results of grain size analysis indicated that the sediment samples generally consisted of sand with some gravel.

PCBs in Surface Water

PCB analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of surface water samples for PCBs are presented in Table 20.4 in Appendix 20d. Concentrations of PCBs were below the RDL (0.05 mg/kg) in all surface water samples collected from the site (SW-7 to SW-9). There is no applicable CCME FWAL guideline for PCBs in surface water.

Metals in Surface Water

Available metals analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for available metals are presented in Table 20.5 in Appendix 20d. Concentrations of aluminum, lead and manganese were detected in the surface water samples. The detected concentrations of available metals were below the CCME FWAL guidelines in all surface water samples collected from the site.

General Chemistry in Surface Water

General chemistry analysis was conducted on three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for general chemistry parameters are presented in Table 20.6 in Appendix 20d. The pH values in surface water samples SW-7 Lab-Dup (6.43), SW-8 (6.45) and SW-9 (6.36) were outside the CCME FWAL range of 6.5 to 9.0. The remaining concentrations of general chemistry parameters were below the applicable CCME FWAL guidelines.

3.19.6 Conclusions

A Phase II/III ESA was completed at the Second Reservoir, located near the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. This site was considered to have freshwater sediment and potable surface water.

2. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on sediment collected from the site. No free phase petroleum hydrocarbons were observed on surface water within the Second Reservoir.
3. PCBs were not detected above the RDL (i.e., 0.05 mg/kg) in sediment collected from the site; therefore PCB concentrations were below the applicable CCME PEL for freshwater sediment (i.e., 0.277 mg/kg). It is not possible to determine if concentrations of PCBs exceeded the CCME ISQG for freshwater sediment (i.e., 0.0341 mg/kg). PCBs were not detected in the surface water samples analyzed.
4. Levels of pH in three surface water samples collected from the site (i.e., SW-7 Lab-Dup, SW-8 and SW-9) were outside the CDWQG objectives. The objective for pH is aesthetic.
5. Metals concentrations exceeding the applicable CCME criteria for freshwater sediment were detected in sediment samples SED-55 and SED-57 (i.e., cadmium, copper, and zinc). Metals concentrations exceeding the applicable CDWQGs were not detected in surface water samples analyzed.
6. Based on NLDEC policy directive PPD05-01, **metals** remediation of site sediment would be required in the vicinity of samples **SED-55 and SED-57** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil and groundwater would be governed by SSTLs determined for each contaminant.
7. Drawing No. 121410103-EE-11b in Appendix 1 shows the estimated extent of the metals-impacted sediment at the site. The actual impacted area may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **1,300 m^2** of has metals levels in sediment the applicable CCME ISQGs.
8. The extent of metals impacts in sediment above the generic guidelines at the site have not been fully delineated. Samples were collected at various locations throughout the lake, and therefore, it is assumed that the maximum concentrations have been identified.

3.20 Residential Subdivision

3.20.1 Site Description

The Residential Subdivision site is located approximately 500 m west of the main area of the Town of Hopedale, as shown in Drawing 121410103-EE-07 in Appendix 1. The subdivision site is bounded by undeveloped vacant land to the north, south, and east, and by the former military base access road and Old Dump Pond to the west. The ground cover of the adjacent properties is mainly exposed bedrock with scattered grasses, shrubs, and small trees. A small pond and boggy area (i.e., Small Pond Bog site) are present to the northwest of the subdivision. The outlet stream from the Small Pond Bog passes along the north side of the subdivision area and then runs through the east side of the subdivision in a north to south direction. The stream discharges to Hopedale Harbour, which is located approximately 200 m south of the subdivision site. A previously identified landfill area is present adjacent to the small stream on the northeastern portion of the residential subdivision site. Two (2) large aboveground fuel storage tanks were also located approximately 600 m north of the wharf, in an area that is now surrounded by the residential subdivision; these tanks were removed in 2001. Photos taken of the site during investigations are presented in Appendix 21a.

Terrain in the vicinity of the site slopes moderately to the south towards Hopedale Harbour.

3.20.2 Field Work

Field work at this site comprised the excavation of 15 test pits (i.e., TP235 to TP249), the installation of 18 monitor wells (i.e., MW35 to MW52), and the collection of 36 surface soil samples (i.e., BS188 to BS223), four (4) freshwater sediment samples (i.e., SED-65 to SED-68), 17 groundwater samples and six (6) surface water samples (i.e., SW-13 to SW-18). Coordinates of each sample location are provided in Appendix 21b. A site location map (Drawing No. 121410103-EE-07a) showing the location of these as well as general site features is provided in Appendix 7a.

3.20.3 Stratigraphy

The stratigraphic information recorded during the Phase II/III ESA investigation is presented on the Monitor Well and Test Pit Records in Appendix 21c.

The stratigraphy was quite variable across the site. Bedrock was encountered in four (4) of the 15 test pits at depths ranging from 0.10 mbgs in TP235 to 1.50 mbgs in TP246.

Larger substrate, including cobbles and boulders with some occasional sand and gravel (GP) were encountered at or near the surface in TP245, TP246 and ranged in thickness from 1.50 m in TP24 to 2.00 m in TP245. Brown to grey gravel and sand with some boulders (GP) were encountered at or near the surface in TP248 and extended to a depth of 1.30 mbgs.

Brown to black or grey silty sand and gravel with occasional trace boulders and cobbles (GM) were encountered at or near the surface in TP235 and TP239 to TP243 (top), and ranged in thickness from 0.10 m in TP235 and TP239 to 0.40 m in TP240. This layer extended to bedrock in test pits TP239 and TP241, and was underlain by a layer of dark brown organics (GP) in TP243.

Brown organics (OL) mixed with occasional light grey sand or gravel, brown silty sand or gravel were encountered at or near the surface in TP236 to TP238, TP244 and below a layer of silty sand and gravel (GM) in TP243 and ranged in thickness from 0.10 m in TP237 to 0.80 m in TP239. Reddish brown organics and topsoil were encountered at or near the surface in TP249. The layer of organics was underlain by grey clay (CL) in TP244 and TP249 a depths of 0.6 mbgs and 0.8 mbgs, respectively

Brown to reddish brown fine silty sand and clay was encountered at or near the surface in TP247 and extended to a depth of 0.50 mbgs.

3.20.4 Debris and Physical Hazards

During the initial site inspection conducted in October 2008, three (3) potential waste sites were identified at the site. Test pits and surface soil samples were excavated to investigate the size and contents of these potential waste sites.

Buried debris was encountered in three (3) of the 15 test pits, as identified in Table 2.2 and documented on the Test Pit Records in Appendix 21c. Debris was not encountered in any of the surface soil samples, as indicated in Table 2.3. Buried debris at the site was found in a test pit located in the northern portion of the subdivision (i.e., TP238) and in two (2) test pits located near the brook (i.e., TP247 and TP248). Items encountered in test pits at the site consisted of the following:

- Trace metal
- Steel bar
- Old track
- Rusted drums
- Pole

3.20.5 Stream and Debris Cleanup

During the Stage 1 field event, a total of three (3) tandem dump truck loads of debris were removed from the Residential Subdivision site, including debris removed from the stream northeast of the Residential Subdivision and buried debris encountered in test pits. The debris was transported to a lay-down area at the Pit No. 1/Helipad site where PCB swab analysis was conducted. Results of the PCB swab analysis are provided in Section 3.20.9. During the Stage 2 field event, the debris was transported to the Hopedale landfill.

3.20.6 Groundwater Conditions

Groundwater levels were measured in the monitor wells on October 15, 2009, and ranged from 0.15 mbgs in MW51 to 3.48 mbgs in MW41. Groundwater levels at these monitor wells are expected to vary seasonally and in response to individual precipitation events.

Groundwater seepage was observed during the excavation of test pits on August 4, 2009 in TP248 at 0.0 mbgs. Test pits are not normally left open long enough for groundwater levels to stabilize, therefore groundwater level estimates at these locations have to be considered with caution. Water was also encountered in surface soil sample BS203 on August 2, 2009.

Groundwater elevation data from a minimum of three monitor wells is required to determine the direction of groundwater flow. Monitor well elevations were not recorded as part of the current field program, therefore groundwater elevations cannot be determined. However, based on local topography and site observations the direction of groundwater flow is inferred to be to the south towards Hopedale Harbour. The assumed direction of groundwater flow is shown on Drawing No. 121410103-EE-07a in Appendix 1.

3.20.7 Free Phase Petroleum Hydrocarbons

Oil was observed at the surface of some standing water near BS203 during the investigation. No product was detected on groundwater in the monitor wells with the product interface probe. There was no visual evidence of free phase petroleum hydrocarbons in test pits or surface soil pits.

3.20.8 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Residential Subdivision are provided on the Monitor Well Records in Appendix 21c and in Appendix 21d. The soil vapour concentrations measured ranged from 0.5 ppm in soil samples BS207 and BS209 to 5.5 ppm in soil sample TP249-BS2. Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site. Soil vapour concentrations were not recorded for the soil samples collected from monitor wells at the site or the sediment samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations did not exceed 50 ppm in any of the soil samples collected from the site. Soil samples TP236, TP247-BS1, TP248-BS1, TP249-BS2, BS211 and BS218 had soil vapour concentrations less than 50 ppm; however, modified TPH concentrations were greater than 1,000 mg/kg. Soil vapour concentrations were not recorded for samples MW48-SS3; however the modified TPH concentration was greater than 1,000 mg/kg in this sample.

3.20.9 Laboratory Analysis and Results

A laboratory analysis schedule for the Residential Subdivision site is presented in Table 3.20 below.

Table 3.20 Laboratory Analysis Schedule (Residential Subdivision)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment/ Swab/ Tar	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Residential Subdivision Possible petroleum hydrocarbons, PCBs, PAHs, metals and VOCs in soil and groundwater. PCB impacted soil - delineation needed. Two former waste disposal areas and an additional possible waste site – further investigations needed.	TP235 to TP249 BS188 to BS223 MW35 to MW52 PCB SWAB-2 to PCB SWAB-6 Tar-1	Soil: TPH (36) PCBs (15) PAHs (2) VOCs (1) Metals (29) Swab: PCBs (5) Tar: Free Product ID (1) PCBs (1)	TPH (17) PCBs (7) PAHs (5) Metals (4)	-	-	-

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment/ Swab/ Tar	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Possible petroleum hydrocarbons in the vicinity of the remediated area.						
Stream that passes through Residential Subdivision Possible petroleum hydrocarbons, PCBs, metals, PAHs and VOCs in sediment and surface water.	SED-65 to SED-68 SW-13 to SW-18	TPH (4) PCBs (4) PAHs (4) VOCs (4) Metals (4)	TPH (7) PCBs (7) PAHs (7) VOCs (7) Metals (7)	-	-	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 21.1 to 21.20 in Appendix 21e. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Petroleum Hydrocarbons in Soil

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on 35 soil samples collected from the site, including 10 surface soil samples, 11 test pit samples and 14 monitor well samples. Results of the laboratory analysis of soil samples for petroleum hydrocarbons are presented in Table 21.1 in Appendix 21e. Modified TPH was detected in 30 soil samples, at concentrations ranging from 27 mg/kg in TP239 to 5,400 mg/kg in TP248-BS1. Concentrations of modified TPH exceeded the applicable Tier I RBSL for fuel oil impacts (i.e., 140/690 mg/kg) in 17 soil samples (i.e., TP235-B1, TP236, TP238-BS2, TP241-BS1, TP243-BS1, TP244-BS1, TP247-BS1, TP248-BS1, TP249-BS2, BS203, BS211, BS218, MW39-SS1, MW40-SS1, MW46-SS1, MW48-SS3 and MW52-SS3). Laboratory analytical results indicated that products impacting soil samples on this site resembled a mixture of fuel oil, weathered fuel oil and lube oil fractions.

With the exception of soil sample MW40-SS1, BTEX parameters were not detected in soil samples collected at the site. Concentrations of BTEX parameters in soil sample MW40-SS1 were below the applicable Tier I RBSLs.

PCBs in Soil

PCB analysis was conducted on 15 soil samples collected from the site, including one (1) surface soil samples, six (6) test pit samples and eight (8) monitor well samples. Results of the laboratory analysis of soil samples for PCBs are presented in Table 21.2 in Appendix 21e. Detected concentrations of PCBs in soil samples TP238-BS2 (2.6 mg/kg), TP248-BS1 (2.6 mg/kg) and TP249-BS2 (1.7 mg/kg) exceeded the CCME soil quality guideline for a residential/parkland site of 1.3 mg/kg.

PAHs in Soil

PAH analysis was conducted on two (2) soil samples collected from the site. Results of the laboratory analysis of this soil sample for PAHs are presented in Table 21.3 in Appendix 21e. PAH parameters were not detected in the soil samples analyzed.

VOCs in Soil

VOC analysis was conducted on one (1) monitor well soil sample collected from the site. Results of the laboratory analysis of these soil samples for VOCs are presented in Table 21.4 in Appendix 21e. Concentrations of VOC parameters were not detected above the RDL in sample MW49-SS2. The RDL for trichlorofluoromethane (30 mg/kg) was greater than the CCME soil quality guidelines for a residential/parkland site, therefore it is not possible to determine if the guideline was exceeded.

Metals in Soil

Available metals analysis was conducted on 23 soil samples collected from the site, including six (6) surface soil samples, 12 test pit samples and five (5) monitor well samples. Results of the laboratory analysis of soil samples for available metals are presented in Table 21.5 in Appendix 21e. Concentrations of various metals were detected in all 23 soil samples. The concentrations of lead detected in soil sample TP247-BS1 (170 mg/kg) exceeded the applicable CCME residential/parkland guideline of 140 mg/kg. The concentrations of tin and zinc detected in soil sample MW37-SS3 (80 mg/kg and 300 mg/kg, respectively) exceeded their respective CCME residential/parkland guidelines of 50 mg/kg and 200 mg/kg. The elevated RDL for selenium (2 mg/kg) was above the applicable CCME residential/parkland guideline of 1 mg/kg, therefore it is not possible to determine if concentrations of selenium in soil exceeded the CCME guideline. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Petroleum Hydrocarbons in Sediment

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on all four (4) freshwater sediment samples collected from the stream at the site. Results of the laboratory analysis of sediment samples for petroleum hydrocarbons are presented in Table 21.6 in Appendix 21e. Modified TPH was detected in all four (4) of the sediment samples at concentrations ranging from 82 mg/kg in SED-67 to 110 mg/kg in SED-68. The concentrations of modified TPH in sediment samples were below the applicable OMOE guideline for total oil and grease in freshwater sediment (i.e., 1,500 mg/kg). Laboratory analytical results indicated that petroleum products impacting the sediment samples resembled a mixture of fuel oil, weathered fuel oil and lube oil fractions. BTEX parameters were not detected in soil samples collected from the site. There are no applicable guidelines for BTEX parameters in freshwater sediment.

PCBs in Sediment

PCB analysis was conducted on all four (4) sediment samples collected from the stream at the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 21.7 in Appendix 21e. Concentrations of PCBs detected in sediment samples SED-68

(0.48 mg/kg) and SED-69 (0.40 mg/kg) exceeded the CCME freshwater ISQG of 0.0341 mg/kg and the CCME freshwater PEL of 0.277 mg/kg. PCBs were not detected above the RDL (0.05 mg/kg) in sediment samples SED-65 and SED-66, however since the RDL is greater than the CCME freshwater ISQG, it is not possible to determine if the guideline was exceeded in these samples.

PAHs in Sediment

PAH analysis was conducted on all four (4) sediment samples collected from the stream at the site. Results of the laboratory analysis of sediment samples for PAHs are presented in Table 21.8 in Appendix 21e. Concentrations of PAH parameters were below the RDLs in all sediment samples analyzed. The RDLs for acenaphthene, acenaphthylene and dibenz(a,h)anthracene (0.01 mg/kg) are greater than the applicable CCME freshwater ISQGs, therefore it is not possible to determine if the concentrations of these parameters exceeded the applicable ISQGs at the site.

VOCs in Sediment

VOCs analysis was conducted on all four (4) sediment samples collected from the stream at the site. Results of the laboratory analysis of sediment samples for VOCs are presented in Table 21.9 in Appendix 21e. Concentrations of VOC parameters were below the RDLs in all sediment samples analyzed. There are no applicable CCME ISQGs or PELs for VOCs in freshwater sediment.

Metals in Sediment

Available metals analysis was conducted on all four (4) sediment samples collected from the stream at site. Results of the laboratory analysis of sediment samples for available metals are presented in Table 21.10 in Appendix 21e. Concentrations of various metals were detected in all sediment samples. The concentrations of available metals detected in sediment samples collected from the site were below the applicable CCME freshwater ISQGs and PELs.

Petroleum Hydrocarbons in Groundwater

Petroleum hydrocarbon analysis was conducted on 17 groundwater samples collected from the site. Results of the laboratory analysis for petroleum hydrocarbon indicator compounds (TPH and BTEX) are presented in Table 21.11 in Appendix 21e. Modified TPH was detected in nine (9) groundwater samples at concentrations ranging from 0.1 mg/L in groundwater samples MW40, MW44 (including Field-Dup), MW46, MW47 (Field-Dup only) and MW51 to 1.7 mg/L in MW49. Concentrations of modified TPH were below the applicable Tier I RBSL for fuel oil impacts (i.e., 20 mg/L) in all groundwater samples. Laboratory analytical results indicated that products impacting groundwater samples on this site resembled a mixture of weathered fuel oil and lube oil fractions. Furthermore, detected concentrations of BTEX parameters were below the applicable Tier I RBSLs.

PCBs in Groundwater

PCB analysis was conducted on seven (7) groundwater samples collected from the site. Results of laboratory analysis for these groundwater samples for PCBs are presented in Table 21.12 in Appendix 21e. PCBs were detected in the groundwater sample MW47. The concentration of PCBs in MW47 (0.32 µg/L) exceeded the applicable OMOE groundwater standard of 0.2 µg/L. Note that the concentrations of PCBs in MW47 Lab-Dup and MW47 Field-Dup did not exceed the guideline. PCBs were not detected above the RDL (0.05 µg/L) in the remaining groundwater samples.

PAHs in Groundwater

PAH analysis was conducted on five (5) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for PAHs are presented in Table 21.13 in Appendix 21e. Concentrations of some PAH parameters detected in the groundwater samples. None of detected concentrations of PAHs exceeded the applicable OMOE groundwater standards, where such standards exist.

Metals in Groundwater

Available metals analysis was conducted on four (4) groundwater samples collected from the site. Results of the laboratory analysis of these groundwater samples for available metals are presented in Table 21.14 in Appendix 21e. Concentrations of various metals were detected in the groundwater samples. None of detected concentrations of available metals exceeded the applicable OMOE groundwater standards, where such standards exist.

Petroleum Hydrocarbons in Surface Water

Petroleum hydrocarbon analysis (TPH/BTEX) was conducted on all six (6) surface water samples collected from the stream at the site. Results of the laboratory analysis of surface water samples for petroleum hydrocarbons are presented in Table 21.15 in Appendix 21e. Modified TPH, benzene and ethylbenzene were not detected in any of the surface water samples. Toluene and xylenes were detection in various surface water samples collected from the stream at the site, however concentrations were below the applicable CCME FWAL guidelines.

PCBs in Surface Water

PCB analysis was conducted on all six (6) surface water samples collected from the stream at the site. Results of the laboratory analysis of surface water samples for PCBs are presented in Table 21.16 in Appendix 21e. Concentrations of PCBs were below the RDL (0.05 µg/L) in all surface water samples collected from the site (SW-13 to SW-18). There are no applicable CCME FWAL guidelines for PCBs in surface water.

PAHs in Surface Water

PAH analysis was conducted on all six (6) surface water samples collected from the stream at the site. Results of the laboratory analysis of surface water samples for PAHs are presented in

Table 21.17 in Appendix 21e. Concentrations of PAH parameters were not detected above the RDLs in all surface water samples collected from the site (SW-13 to SW-18).

VOCs in Surface Water

VOC analysis was conducted on all six (6) surface water samples collected from the stream at the site. Results of the laboratory analysis of surface water samples for VOCs are presented in Table 21.18 in Appendix 21e. With the exception of chloroform in SW-16 and toluene in all surface water samples, concentrations of VOC parameters were not detected above the RDLs in all surface water samples collected from the site (SW-13 to SW-18). The detected concentrations of VOC parameters were below the applicable CCME FWAL guidelines.

Metals in Surface Water

Available metals analysis was conducted on all six (6) surface water samples collected from the stream at the site. Results of the laboratory analysis of these surface water samples for available metals are presented in Table 21.19 in Appendix 21e. Concentrations of aluminum in all surface water samples (ranging from 107 µg/L in SW-14 to 131 µg/L in SW-13) exceeded the applicable Health Canada CDWQG of 100 µg/L (based on pH > 6.5). Concentrations of cadmium in all surface water samples, with the exception of SW-14, exceeded the applicable CCME FWAL guideline of 0.017 µg/L. Concentrations of copper in surface water samples SW-16 to SW-18 (ranging from 2.1 µg/L in SW-17 to 6.2 µg/L in SW-16) exceeded the applicable CCME FWAL guideline of 2 to 4 µg/L (dependant on hardness). Concentrations of iron in SW-17 (469 µg/L) and SW-18 (415 µg/L and 431 in the Lab-Dup) exceeded the applicable CCME FWAL guideline of 300 µg/L. The concentration of zinc in SW-15 (35.8 µg/L) exceeded the applicable CCME FWAL guideline of 30 µg/L.

PCB Swab Analysis

PCB swab analysis was conducted on five (5) swab samples collected from debris removed from the site (i.e., PCB SWAB-2 to PCB SWAB-6). The results of the laboratory analysis of the swab samples are presented in Table 21.20 in Appendix 21e. Laboratory analysis of the swab samples indicated that PCBs were not present on the debris removed from the site, therefore debris was disposed of at the Hopedale landfill.

Free Product Identification

Free product identification analysis was conducted on one (1) tar sample collected from the site. The results of the laboratory free product identification analysis conducted on the sample are presented in Table 21.21 in Appendix 21e. Laboratory analytical results indicate that no product could be identified within the sample within the analysis ranges.

PCBs in Tar

PCB analysis was conducted on one (1) tar sample collected from the site. The results of the laboratory analysis of tar for PCBs are presented in Table 21.22 in Appendix 21e. PCBs were not detected in the tar sample.

3.20.10 Conclusions

A Phase II/III ESA was completed at the Residential Subdivision site, located within the Former U.S. Military Site in Hopedale, NL. The conclusions of these assessments are summarised below.

1. A total of three (3) tandem dump truck loads of debris were removed from the stream northeast of the subdivision and transported to the Hopedale landfill.
2. The observed stratigraphy in test pits at the site was quite variable and consisted of discontinuous layers brown organics (OL), silty sand and clay (SC), silty sand and gravel (GM), gravel and sand with some boulders (GP), silty sand and gravel with occasional trace boulders and cobbles (GM) or cobbles and boulders overlying clay or bedrock. Bedrock was encountered in all four (4) of the 15 test pits, at depths ranging from 0.10 mbgs to 1.50 mbgs.
3. Various buried debris was observed within the overburden layer in three (3) of the 15 test pits. No buried debris was encountered in surface soils samples. Buried debris at the site was found in a test pit located in the northern portion of the subdivision (i.e., TP238) and in two (2) test pits located near the brook (i.e., TP247 and TP248).
4. Groundwater was encountered at depths ranging from 0.0 mbgs to 3.48 mbgs in test pits, monitor wells and surface soil samples completed at this site. Based on local topography and site observations, the direction of shallow groundwater flow at the site is inferred to be to the south towards Hopedale Harbour.
5. This site was considered to have a residential/parkland site designation with non-potable groundwater and coarse-grained soil.
6. Oil was observed at the surface of some standing water near BS203 during sample collection.
7. TPH concentrations exceeding the applicable Tier I RBSL (i.e., 140 mg/kg) were detected in 17 soil samples (i.e., TP235-B1, TP236, TP238-BS2, TP241-BS1, TP243-BS1, TP244-BS1, TP247-BS1, TP248-BS1, TP249-BS2, BS203, BS211, BS218, MW39-SS1, MW40-SS1, MW46-SS1, MW48-SS3 and MW52-SS3). Concentrations of BTEX parameters in soil samples were below the applicable Tier I RBSLs. TPH concentrations were below the applicable OMOE guideline for total oil and grease in freshwater sediment in sediment samples analyzed. BTEX parameters were not detected in sediment samples analyzed. TPH concentrations were below the applicable Tier I RBSL (i.e., 20 mg/L) in groundwater samples analyzed. BTEX parameters were not detected in groundwater samples analyzed. TPH was not detected in the surface water samples analyzed. Concentrations of BTEX parameters were below the applicable CCME freshwater aquatic life guidelines in surface water samples analyzed.
8. Based on NLDEC policy directive PPD05-01, **petroleum hydrocarbon** remediation of site soil would be required in the vicinity of samples **TP235, TP236, TP238, TP241, TP243, TP244, TP247, TP248, TP249, BS203, BS211, BS218, MW39, MW40, MW46, MW48 and MW52** in accordance with provincial regulations, unless a Tier II risk assessment is conducted to determine a risk-based remedial approach for the site.

Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

9. Drawing No. 121410103-EE-07b in Appendix 1 shows the estimated extent of the petroleum-impacted soil at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated combined area of approximately **11,000 m^2** has TPH levels in soil above the Tier I RBSL (140 mg/kg).

10. PCB concentrations exceeding the applicable CCME criteria for soil on a residential/parkland site (i.e., 1.3 mg/kg) were detected in three (3) soil samples (i.e., TP238-BS2, TP248-BS1 and TP249-BS2). Low levels of PCBs were also detected in two (2) other soil samples analyzed at this site; however these did not exceed applicable CCME criteria. PCB concentrations exceeding the applicable CCME ISQGs and PELs for freshwater sediment were detected in two (2) sediment samples analyzed (i.e., SED-67 and SED-68). The RDL for PCBs was greater than the CCME ISQG criteria, therefore it is not possible to determine if the criteria was exceeded in SED-65 and SED-66. PCB concentrations exceeding the applicable OMOE standard (i.e., 0.2 µg/L) were detected in one (1) groundwater samples (i.e., MW47). Low levels of PCBs were also detected in two (2) other groundwater samples analyzed at this site; however these did not exceed applicable CCME criteria. PCBs were not detected in the other groundwater samples analyzed.

11. Based on NLDEC policy directive PPD05-01, **PCB** remediation of site soil would be required in the vicinity of test pits **TP238, TP248 and TP249**, remediation of site sediment would be required in the vicinity of samples **SED-67 and SED-68** and remediation of site groundwater would be required in the vicinity of **MW47** in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, petroleum hydrocarbon remediation of site soil would be governed by SSTLs determined for this contaminant based on actual site conditions.

12. Drawing No. 121410103-EE-07c in Appendix 1 shows the estimated extent of the PCB-impacted soil, sediment and groundwater at the site. The actual impacted areas may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **700 m^2** has PCB levels in soil above 1.3 mg/kg, approximately **700 m^2** has PCB levels in sediment above 0.0341 mg/L and approximately **300 m^2** has PCB levels in groundwater above 0.2 µg/L.

13. Concentrations of PAHs were below the applicable CCME criteria for soil on a residential/parkland site. Concentrations of PAHs were not detected in sediment samples analyzed. The RDLs for acenaphthene, acenaphthylene and dibenz(a,h)anthracene were greater than the applicable CCME freshwater ISQGs, therefore it is not possible to determine if the concentrations of these parameters exceeded the applicable criteria in sediment samples analyzed. Concentrations of PAHs were below the applicable OMOE standards in groundwater samples analyzed. PAHs were not detected in surface water samples analyzed.

14. VOC concentrations were not detected in the soil sample analyzed. The RDL for trichlorofluoromethane was greater than the applicable CCME criteria, therefore it is not possible to determine if the criteria was exceeded in the soil sample analyzed. VOC concentrations were not detected in the sediment sample analyzed. VOC concentrations were below the applicable CCME freshwater aquatic life guidelines in surface water samples analyzed.
15. Concentrations of lead, or tin and zinc exceeding the applicable CCME criteria for soil on a residential/parkland site were detected in two (2) soil samples (i.e., TP247-BS1 and MW37-SS3). The elevated RDLs for selenium in soil were greater than the CCME guideline, therefore it is not possible to determine if concentrations of selenium in soil exceeded the criteria at the site. Concentrations of available metals were below exceed the CCME ISQGs and PELs for freshwater sediment in sediment samples analyzed. Concentrations of available metals were below the applicable OMOE groundwater standards in groundwater samples analyzed. Concentrations of aluminum, cadmium, copper, iron and/or zinc exceed the applicable CCME freshwater aquatic life guidelines in all eight (8) surface water samples analyzed (i.e., SW-13, SW-14, SW-15, SW-16, SW-17 and SW-18).
16. Based on NLDEC policy directive PPD05-01, **metals** remediation of site soil would be required in the vicinity of samples **TP247 and MW37**, metals remediation of site surface water would be required in the vicinity **SW-13, SW-14, SW-15, SW-16, SW-17 and SW-18** would be required in accordance with provincial regulations, unless a risk-based remedial approach is followed for the site. Adopting a risk-based remedial approach, metals remediation of site soil, sediment and surface water would be governed by SSTLs determined for each contaminant.
17. Drawing No. 121410103-EE-07d in Appendix 7a shows the estimated extent of the metals-impacted soil at the site. The actual impacted area may be smaller or larger than the estimated areas. Based on available analytical and field data, an estimated area of approximately **700 m^2** has metals levels above the applicable CCME criteria.
18. The tar sample (i.e., Tar-1) did not resemble petroleum products and did not contain detectable concentrations of PCBs.
19. The extent of TPH, PCB and metals impacts on soil, the extent of PCB impacts in sediment, and the extent of TPH impacts on groundwater above the generic guidelines at the site have not been fully delineated. Samples were collected at various locations throughout the lake, and therefore, it is assumed that the maximum concentrations have been identified.

3.21 Big Lake

3.21.1 Site Description

The Big Lake, located approximately 650 m northwest of the BMEWS site, was selected as a background sampling area. Terrain in the vicinity of the site slopes moderately towards the lake. The shore of the lake is made up of low vegetation, trees and bedrock outcrops. Photos taken of the site during investigations are presented in Appendix 22a.

Once background sampling in the lake was completed, it was discovered that the lake has previously been used for airplane landing. Also, several 45-litre drums were observed floating in the lake and along the shore. These possible sources of impacts should be taken into consideration when applying values to the risk assessments.

3.21.2 Field Work

Field work at this site comprised the collection of three (3) freshwater sediment samples (i.e., SED-69 to SED-71), three (3) surface water samples (i.e., SW-10 to SW-12), five (5) fish (i.e., FISH-7 to FISH-11) and one (1) benthic invertebrate sample (i.e., BENTHIC-4). Coordinates of each sample location are provided in Appendix 22b. A site location map (Drawing No. 121410103-EE-09a) showing the location of these as well as general site features is provided in Appendix 1.

3.21.3 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation.

3.21.4 Soil Vapour Concentrations

Soil vapour concentrations were not measured in sediment samples collected from Big Lake, as noted in Appendix 22c.

3.21.5 Laboratory Analysis and Results

A laboratory analysis schedule for the Big Lake site is presented in Table 3.21 below.

Table 3.21 Laboratory Analysis Schedule (Big Lake)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Background PCBs, metals concentrations in sediment, surface water, fish and benthic invertebrates for use in risk assessments.	SED-69 to SED-71 SW-10 to SW-12 FISH-7 to FISH-11 BENTHIC-4	PCBs (3) Metals (3) TOC & Grain Size (3)	PCBs (1) Metals (3) Gen. Chem. (3)	-	Metals (5) PCBs (5) Lipids (5)	Genus (1)

Results of laboratory analysis of soil obtained from this site are presented in Tables 22.1 to 22.6 in Appendix 22d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

<u>**PCBs in Sediment**</u>

PCB analysis was conducted on all three (3) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for PCBs are presented in Table 22.1 in Appendix 22d. Concentrations of PCBs were not detected above the RDL in any of the sediment samples collected from the site. The RDL (0.05 mg/kg) is greater than the CCME freshwater ISQG for PCBs (0.0341 mg/kg), therefore it is not possible to determine if the guideline was exceeded in these samples.

Metals in Sediment

Available metals analysis was conducted on all three (3) sediment samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 22.2 in Appendix 22d. Concentrations of various metals were detected in all sediment samples. The concentration of chromium in sediment sample SED-71 (39 mg/kg) exceeded the CCME freshwater ISQG of 37.5 mg/kg. None of the remaining concentrations of available metals in sediment collected from the site exceeded the CCME freshwater ISQGs or PELs.

TOC and Grain Size in Sediment

Total organic carbon (TOC) and grain size analysis were conducted on all three (3) sediment samples collected from the site. Results of the laboratory analysis for TOC and grain size analysis are presented in Table 22.3 in Appendix 22d. Concentrations of TOC ranged from 5.1 g/kg in SED-70 to 110 g/kg in SED-71. Results of grain size analysis indicated that the sediment samples generally consisted of sand with minor silt and gravel.

PCBs in Surface Water

PCB analysis was conducted on one (1) surface water samples collected from the site. Results of the laboratory analysis of surface water samples for PCBs are presented in Table 22.4 in Appendix 22d. Concentrations of PCBs were below the RDL (0.05 µg/L) in the surface water sample analyzed (SW-11). There is no applicable CCME FWAL guideline for PCBs in surface water.

Metals in Surface Water

Available metals analysis was conducted on all three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for available metals are presented in Table 22.5 in Appendix 22d. Concentrations of aluminum in surface water samples SW-10 (123 µg/L) and SW-11 (110 µg/L) exceeded the CCME FWAL guideline of 100 µg/L (based on pH > 6.5). The concentration of lead in surface water sample SW-11 (1.19 µg/L) exceeded the CCME FWAL guideline of 1 µg/L. The RDLs (0.017) for cadmium in the three (3) surface water samples exceeded the applicable CCME FWAL guideline of 0.0014 µg/L (based on a water hardness of 6 mg/kg as $CaCO_3$), therefore it is not possible to determine of the non-detectable concentrations of cadmium exceed the guideline.

General Chemistry in Surface Water

General chemistry analysis was conducted on all three (3) surface water samples collected from the site. Results of the laboratory analysis of these surface water samples for general chemistry parameters are presented in Table 22.6 in Appendix 22d. Concentrations of general chemistry parameters were below the applicable CCME FWAL guidelines.

PCBs in Fish

PCB analysis was conducted on two (2) fish samples caught at the site. The results of the laboratory analysis of fish samples for PCBs are presented in Table 22.7 in Appendix 22d. PCBs were detected in the one (1) of the fish samples analyzed (i.e., FISH-10 and FISH-10 Lab-Dup) at a concentration of 0.06 mg/kg.

Metals in Fish

Available metals analysis was conducted on two (2) fish samples caught at the site. The results of the laboratory analysis of fish samples for metals are presented in Table 22.8 in Appendix 22d. Concentrations of various available metals were detected in all of the fish samples analyzed (i.e., FISH-10 and FISH-11).

3.21.6 Conclusions

Background sampling was conducted at the Big Lake site for use in the risk assessments. The conclusions of this sampling program are summarised below.

1. COCs are not expected to migrate from the Former U.S. Military Site to the site, however former airplane landing on the lake and barrels dumped into the lake may have caused impacts.
2. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil, sediment or surface water at the site.
3. PCBs were not detected in any of the sediment samples analyzed. The RDLs for PCBs were greater than the CCME ISQG for freshwater sediments in all samples analyzed, therefore it is not possible to determine if there were exceedances of CCME ISQGs for PCBs in sediment.
4. PCBs were not detected in surface water.
5. The concentrations of chromium in one (1) sediment sample (i.e., SED-71) exceeded the applicable CCME ISQG for freshwater sediment.
6. The concentrations of aluminum in two (2) surface water samples (i.e., SW-10 and SW-11) and the concentration of lead in one (1) surface water sample (i.e., SW-10) exceeded the applicable CCME freshwater aquatic life guidelines. The RDL for cadmium was greater than the CCME criteria in all of the surface water samples analyzed, therefore it is not possible to determine if concentrations of cadmium in surface water exceeded the applicable criteria.
7. The concentrations or general chemistry parameters in surface water were below the applicable CCME freshwater aquatic life guidelines.
8. PCBs were detected in the one (1) of the two (2) fish samples analyzed at a concentration of 0.06 mg/kg.
9. Concentrations of various available metals were detected in the fish samples analyzed.

3.22 Clean Background Area

3.22.1 Site Description

An area of native/virgin ground within similar regional geological soil conditions as the Former U.S. Military Site, located approximately 500 m west of the Wharf Area was selected as the background sampling area. An elevated drainage divide is located between the Former U.S. Military Site and the Clean Background Area, therefore impacted groundwater and surface water at the Former U.S. Military Site are not expected to migrate to the Clean Background Area. Photos taken of the site during investigations are presented in Appendix 23a.

3.22.2 Field Work

Field work at this site comprised the collection of seven (7) surface soil samples (i.e., BS249 to BS255), three (3) freshwater sediment samples (i.e., SED-46 to SED-48), seven (7) vegetation samples (i.e., VEG-47 to VEG-53), seven (7) berry samples (i.e., BERRY-11 to BERRY-17), two (2) small mammal samples (i.e., SM-43 to SM-44) and one fish sample (i.e., FISH-6). Coordinates of each sample location are provided in Appendix 23b. A site location map (Drawing No. 121410103-EE-12a) showing the location of these as well as general site features are provided in Appendix 1.

3.22.3 Stratigraphy

No test pits were dug or monitor wells were drilled at the site during the investigation. Surface soil composition was not recorded during the field investigations. The depth to bedrock at the site is unknown.

3.22.4 Free Phase Petroleum Hydrocarbons

Free liquid phase petroleum hydrocarbons were not observed at the site during the investigation. There was no visual evidence of free phase petroleum hydrocarbons in surface soil pits.

3.22.5 Soil Vapour Concentrations

The soil vapour concentrations measured in soil samples from the Clean Background Area are provided in Appendix 23c. The soil vapour concentrations were recorded for two (2) of the soil samples collected from the site; BS254 (0.7 ppm) and BS255 (0.8 ppm). Petroleum hydrocarbon odours were not detected in any of the soil samples collected from the site. Soil vapour concentrations were not recorded for the soil or sediment samples collected from the site.

Soil vapour concentrations vary with both fuel type and age, and it should be noted that the readings are intended to provide only a qualitative indication of volatile hydrocarbon levels and are not directly equivalent to soil analytical results. Soil vapour concentrations that exceed 50 ppm may indicate the presence of hydrocarbon or VOC impacts in soil. Soil vapour concentrations recorded for the site did not exceed 50 ppm. Petroleum hydrocarbon analysis was not conducted on samples collected from the site.

3.22.6 Laboratory Analysis and Results

A laboratory analysis schedule for the Clean Background Area site is presented in Table 3.22 below.

Table 3.22 Laboratory Analysis Schedule (Clean Background Area)

Issues	Sample Locations	Sample Matrix				
		Soil/ Sediment	Ground-water/ Surface water	Veg./ Berries	Small Mammals/ Rabbits/ Fish	Benthic Invert.
Background metals concentrations in soil, vegetation, berries, small mammals, rabbits and fish for use in risk assessments.	BS249 to BS255 SED-46 to SED-48 VEG-47 to VEG-53 BERRY-11 to BERRY-17 SM-43 to SM-44 FISH-6	Soil: Metals (7) Sed.: Metals (3)	-	Veg.: Metals (7) Berries: Metals (7)	Small mammals: PCBs (2) Metals (2) Fish: Metals (1) PCBs (1) Lipids (1)	-

Results of laboratory analysis of soil obtained from this site are presented in Tables 23.1 to 23.4 in Appendix 23d. Corresponding analytical reports from Maxxam Analytics are presented in Appendix 24.

Metals in Soil

Available metals analysis was conducted on seven (7) surface soil samples collected from the site. Results of the laboratory analysis of soil samples for available metals are presented in Table 23.1 in Appendix 23d. Concentrations of various metals were detected in all seven (7) soil samples. The concentration of copper in soil sample BS255 (85 mg/kg) exceeded the applicable CCME residential/parkland guideline of 63 mg/kg. The concentrations uranium detected in soil sample BS253 (80 mg/kg) exceeded the CCME residential/parkland guideline of 26 mg/kg. The elevated RDLs for selenium (2 and 5 mg/kg) were above the applicable CCME residential/parkland guideline of 1 mg/kg, therefore it is not possible to determine if concentrations of selenium in soil exceeded the CCME guideline. None of the other detected concentrations of available metals in soils exceeded the applicable CCME residential/parkland criteria.

Metals in Sediment

Available metals analysis was conducted on all three (3) sediment samples collected from the site. Results of the laboratory analysis of sediment samples for available metals are presented in Table 23.2 in Appendix 23d. Concentrations of various metals were detected in all sediment samples. The concentrations of available metals detected in sediment samples collected from the site were below the applicable CCME freshwater ISQGs and PELs.

Metals in Berries

Available metals analysis was conducted on seven (7) berry samples collected from the site. Results of the laboratory analysis of these berry samples for available metals are presented in Table 23.3 in Appendix 23d. Various metals (i.e., aluminum, copper, manganese and strontium) were detected in berry samples; however, there are no federal or provincial guidelines for available metals concentrations in berry samples.

Metals in Vegetation

Available metals analysis was conducted on seven (7) vegetation samples collected from the site. Results of the laboratory analysis of these vegetation samples for available metals are presented in Table 23.4 in Appendix 23d. Various metals (i.e., aluminum, barium, boron, chromium, copper, lead, manganese, molybdenum, nickel, strontium, uranium and zinc) were detected in vegetation samples; however, there are no federal or provincial guidelines for available metals concentrations in vegetation samples.

Metals in Small Mammals

Available metals analysis was conducted on the two (2) small mammals caught at the site. The results of the laboratory analysis of small mammals for metals are presented in Table 23.5 in Appendix 2e. Concentrations of various available metals were detected in both of the small mammal samples analyzed. There are presently no provincial or federal criteria for available metal levels in small mammals.

PCBs in Small Mammals

PCB analysis was conducted on the two (2) small mammals caught at the site. The results of the laboratory analysis of small mammals for PCBs are presented in Table 23.6 in Appendix 23d. PCBs were not detected in either of the small mammal samples analyzed. There are presently no provincial or federal criteria for PCB levels in small mammals, but any detected level is considered undesirable.

PCBs in Fish

PCB analysis was conducted on one (1) fish sample caught at the site. The results of the laboratory analysis of fish samples for PCBs are presented in Table 23.7 in Appendix 23d. PCBs were not detected in the fish sample analyzed (i.e., FISH-6).

Metals in Fish

Available metals analysis was conducted on one (1) fish sample caught at the site. The results of the laboratory analysis of fish samples for metals are presented in Table 23.8 in Appendix 23d. Concentrations of various available metals were detected in the fish sample analyzed (i.e., FISH-6).

3.22.7 Conclusions

Background sampling was conducted at the Clean Background Area for use in the risk assessments. The conclusions of this sampling program are summarised below.

1. An elevated drainage divide is located between the Former U.S. Military Site and the Clean Background Area, therefore COCs are not expected to migrate from the Former U.S. Military Site to the Clean Background Area.
2. There was no visual or olfactory evidence of petroleum hydrocarbon impacts on soil, sediment or surface water at the site.
3. The concentrations of copper in one (1) soil sample (i.e., BS255) and soil in one (1) soil sample (i.e., BS253) exceeded the applicable CCME criteria for soil on a residential/parkland site. The elevated RDL for selenium exceeded the applicable CCME criteria for soil on a residential/parkland site, therefore it is not possible to determine if concentrations of selenium in soil exceeded the applicable criteria. Drawing No. 121410103-EE-12b in Appendix 1 shows the estimated extent of the metals-impacted soil at the site.
4. Concentrations of available metals were below the applicable CCME marine ISQGs and PELS for freshwater sediment in all sediment samples analyzed.
5. Concentrations of aluminum, copper, manganese and/or strontium were detected in selected berry samples analyzed.
6. Concentrations of aluminum, barium, boron, chromium, copper, lead, manganese, molybdenum, nickel, strontium, uranium and/or zinc were detected in selected vegetation samples.
7. Concentrations of aluminum, barium, copper, iron, lead, manganese and/or zinc were detected in selected small mammal samples.
8. PCBs were not detected in the small mammal samples analyzed.
9. PCBs were not detected in the fish sample analyzed.
10. Concentrations of various available metals were detected in the fish sample analyzed.

4.0 HUMAN HEALTH RISK ASSESSMENT APPROACH

4.1 Methodology

The approach for the human health risk assessment is consistent with guidance issued by Health Canada (2009a) and CCME (2006), and involves the following components:

- Hazard Identification - Identification of the environmental hazards that may pose a health risk (*e.g.*, chemicals).
- Receptor Identification - Identification of the human organisms that may be exposed to the above hazard(s).

- Exposure Assessment - Qualitative or quantitative evaluation of the likelihood or degree to which the receptors will be exposed to the hazard.
- Risk Characterization - Qualitative or quantitative assessment of the potential health risk of each hazard to each receptor, based on the degree of exposure.
- Target Level Determination - The determination of site-specific concentrations or Site-Specific Target Levels (SSTLs) at the site below which no adverse effects would be expected.
- Uncertainty Assessment - A qualitative or quantitative assessment of the uncertainty associated with the risk estimation.
- Recommendations – A list of recommendations required to further understand the potential risk posed by hazards at the site.

4.1.1 Data Sources

The data for soil, groundwater, surface water, sediment and biota selected for use in the risk assessments were compiled from the Phase III Environmental Site Assessment completed herein as well as the following:

- Phase II ESA, New Subdivision, Hopedale, NL. Stantec Project No. 1044856 (2009); and
- Human Health Risk Assessment of the Former Hopedale Military Site, Hopedale, NL Environmental Sciences Group (ESG), Royal Military College (RMC), (2009).

4.2 Areas Assessed for Human Health Risk Assessment

Based on a review of site conditions and land uses, residents of Hopedale would be expected to spend a majority of their time in the Town of Hopedale. This “Residential Area” includes the Subdivision, the Wharf, Old Dump Pond, the Pipeline, and Small Pond Bog. Residents of Hopedale would be expected to visit the “Former Radar Site” occasionally for recreational purposes (*e.g.*, berry picking, hunting, walking). This is consistent with land uses identified in the community survey conducted by ESG (2009). The Former Radar Site includes BMEWS, Valley Drainage Ponds, Old Base1, Main Base, Sewage Outfall, Roadway, Mid Canada Line, Pit No. 1, Pit No. 2, Pit No. 3, POL Compound, and the Pallet Line. The Residential Area and the Former Radar Site are shown on Drawing No. 121410103-EE-26a, Appendix 26.

For the purposes of the human health risk assessment, the Residential Area and the Former Radar Site were assessed separately based on the expected human exposure time (*i.e.*, human receptors would be expected to spend less time on the Former Radar Site than in the Residential Area) and activities (*e.g.*, hunting is expected to be limited to the Former Radar Site).

4.3 Screening Framework

An initial generic assessment of the potential for adverse effects associated with site-originated chemicals was conducted within the Phase III ESA (Section 3.0). This assessment compared the detected concentrations from each environmental medium in each area to established generic environmental guidelines (*i.e.*, "screening values") that are designed for the protection of human and ecological receptors. Generic guidelines have been developed by various jurisdictions (including CCME) as conservative benchmarks for screening purposes. If soil concentrations are below these guidelines then the potential for adverse human health and ecological effects is negligible.

For the human health risk assessment, a second screening was completed using human health based guidelines (discussed below) to determine the contaminants of concern (COCs) specifically for human health. Groundwater is not used as a source of potable water at either the Residential Area or the Former Radar Site; therefore, guidelines for non-potable groundwater conditions were used for screening purposes. Because no buildings exist at the Former Radar Site, guidelines based on vapour intrusion to indoor air were excluded for screening purposes. Although residential buildings are present at the Residential Area, most houses are constructed with an earthen floor in the basement or crawl space. Screening guidelines based on vapour intrusion (*e.g.,* Atlantic PIRI Tier I RBSL and Tier II PSSL Tables for the indoor air exposure pathway) do not apply to buildings without a concrete floor due to the increased vapour infiltration in the absence of a concrete barrier. Therefore, screening guidelines based on vapour intrusion were not applied to the Residential Area. As a result, the screening guidelines used for soil are based on surface soil ingestion/dermal contact. Recommendations will be provided for additional work to assess the indoor air inhalation exposure pathway for volatile COCs at the Residential Area. As per CCME (2006) guidance, soil samples from grade to 1.5 m below ground surface were considered surface soil.

4.3.1 Soil

For the human health risk assessment, the following guidelines (in order of preference) were used for the screening of chemicals in soil for inclusion in the human health risk assessment (HHRA).

- Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines for Residential/Parkland land use for protection of human health (1999, and subsequent updates). Pathway-specific information from the individual fact sheets was reviewed to confirm human health guidelines.
- Atlantic RBCA Tier I Risk Based Screening Levels (RBSLs) and Pathway Specific Screening Levels (PSSLs) for a residential site with non-potable groundwater and coarse-grained soil (2003).
- Alberta Environment (AENV) Tier I and II Soil Remediation Guidelines for Residential/Parkland land use (2009).
- Ontario Ministry of Environment (OMOE) guidelines for soil for Residential/Parkland land use (2004).
- United States Environmental Protection Agency (US EPA) (Oak Ridge National Laboratory) Regional Screening Levels for Chemical Contaminants at Superfund Sites (September 2008) for soil at residential sites. As per current Health Canada guidance, screening level concentrations have been multiplied by 0.2.

In order to conduct the human health risk assessment, a framework was developed. The following steps were taken to identify the COCs in soil at the sites.

1. ***Is the maximum concentration greater than the applicable guideline?***

   Maximum concentrations were compared to selected guidelines. If the concentration of a chemical exceeds the guideline, then it is carried forward in the risk assessment. Where an applicable guideline did not exist and a substance was detected in measurable concentrations, the substance was carried forward to the next step in the screening framework.

2. ***Are the on-site concentrations comparable to background concentrations?***

   It is important that current soil conditions at the site are compared to natural background conditions. This prevents recommendations for remediation of soil that is reflecting natural conditions in the area. Background soil concentrations were based on samples collected from an area located southwest of the Town of Hopedale (Drawing No. 121410103-EE-01b, Appendix 1).

   If the maximum concentration for a chemical was considered comparable to background soil concentrations, the chemical was not carried forward in the risk assessment. Where no background soil concentration could be established, the substance was carried forward to the next step in the screening framework.

3. ***Is the substance a major mineral forming element of low inherent toxicity or is the substance a nutrient and of low inherent toxicity?***

   Several elements can be classified as major mineral forming elements of low inherent toxicity or essential nutrients of low inherent toxicity. In the same way that it is important that site soil conditions are compared to naturally occurring background soil conditions, it is important to determine whether all parameters analyzed and/or detected are present as a result of site activities and if they are generally considered hazardous or toxic to humans or wildlife. The following elements are generally ubiquitous in the environment and are generally not considered hazardous to humans or wildlife, although they are commonly analyzed within standard analytical chemistry or trace metal packages:

   - Aluminum, iron, calcium, magnesium, manganese, sodium, potassium, chloride, nitrate, nitrite, phosphorus, silica, and sulfate.

   The following elements, for which limited toxicity information exits, are typically associated with seawater spray and could be expected to be present at the site due to its proximity to the ocean, and not as a result of historical site activities:

   - Boron, bismuth, lithium, rubidium, and strontium.

   Therefore, the above-mentioned elements of low inherent toxicity, even if detected, were not carried forward in the human health risk assessment.

4. ***Is the exposure point concentration greater than the applicable screening guideline?***

   The exposure point concentration (EPC) is an estimate of a reasonable upper limit value for the average chemical concentration in the medium, determined for each exposure unit (USEPA, 1989). Details of how EPCs were determined are provided in Section 5.1.1. If the exposure point concentration did not exceed the applicable screening guideline the chemical was not carried forward in the risk assessment. Where an applicable guideline did not exist and a substance was detected in measurable concentrations, the substance was carried forward to the next step in the screening framework.

5. ***Conduct quantitative risk assessment.***

   COCs whose concentrations exceed the applicable guidelines, are considered higher than the naturally occurring background concentrations, and are not considered a major mineral forming element of low inherent toxicity or a nutrient of low inherent toxicity, were carried forward into the risk assessment process.

4.3.2 Groundwater, Sediment, Surface Water, and Biota

No Newfoundland and Labrador guidelines exist for human health that would be directly applicable to metals and PAHs in groundwater at the site (*i.e*., non-potable). Further, no CCME human health guidelines exist for these chemicals in groundwater. The only pathway for human health exposure to chemicals in groundwater is through the inhalation of volatiles from groundwater (*i.e*., petroleum hydrocarbons). No exposure pathway exists for human exposure to metals in groundwater as they are not considered volatile. PAHs are also relatively non-volatile with the exception of some lighter compounds that volatize from water or soil (CCME, 2008). Of the PAHs considered in this assessment, the lighter PAHs are the non-carcinogenic PAHs (*e.g*., naphthalene, phenanthrene). Based on information provided in Atlantic RBCA Reference Documentation for Petroleum Impacted Site, the TPH mixture consists of thirteen fractions and that PAHs are found in many petroleum mixtures. The hydrocarbon fractions address the non-carcinogenic compounds in the TPH mixture. As such, the non-carcinogenic PAHs are addressed for inhalation exposure pathways with the TPH fractions in this assessment. Therefore, metals and PAHs in groundwater were not carried forward in the human health risk assessment.

No known guidelines exist for human health that would be directly applicable to sediment and surface water (*i.e*., non-potable) at the site. Because of the lack of guidelines, if a chemical was carried forward in soil, it was also carried forward for surface water and sediment.

Analytical data exists for various biota from the site including berries, vegetation, fish, small mammals, and Arctic hare. No known guidelines exist for chemicals in biota for human health screening. Therefore, for the human health risk assessment, if a chemical was carried forward in soil, it was also carried forward in biota.

5.0 QUALITATIVE HUMAN HEALTH RISK ASSESSMENT

5.1 Hazard Identification

5.1.1 EPC Calculations

The ESA process results in positively biased data, because the majority of samples are collected at locations where contamination is expected, or to delineate known areas of contamination. As a result, relatively few samples are usually taken from areas of the site where human impacts have been minor or negligible, and the data will tend to overstate or over-represent the true presence and concentration of COCs in soil and other media. In addition to this inherent source of conservatism, an additional layer of conservatism is introduced through statistical analysis of the data. The primary purpose of the statistical analysis is to determine representative EPCs for estimating potential risks associated with COCs in the various media. The EPC is an estimate of a reasonable upper limit value for the average chemical concentration in the medium, determined for each exposure unit (USEPA, 1989). The appropriate upper confidence limit (UCL) provides reasonable confidence that the true site average will not be underestimated (USEPA, 1992).

In order not to underestimate exposure, where the number of samples was less than 10, the maximum value would be selected as the EPC. Where the number of samples exceeded ten, Pro UCL, Version 4.0 (USEPA, 2007) was used to determine representative exposure point concentrations (EPCs). ProUCL calculates the appropriate upper confidence limit (UCL) given the specific distribution of the site specific analytical results data.

Note that where the minimum concentration was reported as being non-detectable, a value of ½ of the laboratory detection limit was used in calculations. In the case of laboratory and field duplicate samples, the sample with the highest concentration was used in the calculation of the EPC. This prevents the potential for one soil sample to unduly skew the EPC.

5.1.2 Summary of Chemicals of Concern

As mentioned previously, no applicable human health guidelines exist for chemicals in sediment, surface water, and biota. Therefore, if a chemical were carried forward in soil, it was also carried forward in sediment, surface water and biota. As a result, screening of chemicals for human health was essentially based on concentrations in soil. Screening of chemicals in soil for the human health risk assessment is presented in Tables 26-1 and 26-2, Appendix 26. Based on the screening process outlined in Section 4.3, the following substances were identified as being of potential concern in soil at the Former Radar Site:

- TPH (fuel oil);
- TPH (lube oil);
- PCBs; and,
- Lead.

Based on the screening process outlined in Section 4.3, the following substances were identified as being of potential concern in soil at the Residential Area:

- TPH (fuel oil);
- PCBs;
- Antimony; and,
- Lead.

All other substances analyzed in soil were either not of toxicological concern, or were non-detectable in all samples, or in the event that they were detected, the maximum value or EPC was below the selected guideline or benchmark value.

The EPC calculated for PCBs at the Residential Area (22 mg/kg) is equal to the screening guideline (AENV, 2009). PCBs were carried forward for the Residential Area because the screening level AENV guideline for PCBs in soil is based on a toxicity reference value (TRV) of 0.001 mg/kg-day (Health Canada, 2004b) and not the TRV of 0.00013 mg/kg-day (Health Canada, 2009b). It was considered conservative to carry forward PCBs for the Residential Area given the more recent Health Canada guidance recommends a lower TRV for PCBs.

Concentrations of several metals including copper, mercury, molybdenum, and nickel were elevated in one test pit (TP229) from the Old Dump Pond area but were not elevated in any other samples from the Residential Area. In addition, concentrations of antimony and lead were particularly elevated in this test pit. During excavation of the test pit, metal debris was noted to be present. This test pit is considered an anomaly for several metals and the results may skew the EPCs for metals such as antimony and lead. Therefore, the analytical results from this test pit were not included in the risk assessment screening for COCs. Instead, recommendations will be made later in this report to remove the soil and associated debris from this area. The results from this test pit are not considered further in the human health risk assessment.

TPH at the Residential Area mainly resembled a mixture of fuel oil and lube oil. As per guidance provided by Atlantic PIRI (2003), impacts will be assessed for the more restrictive product type (*i.e.*, fuel oil). At the Former Radar Site, there was a distinct area of petroleum hydrocarbons impacts that resembled lube oil at the POL Compound. Therefore, TPH (fuel oil) and TPH (lube oil) were assessed separately for the Former Radar Site.

5.2 Exposure Point Concentrations – Soil, Game and Berries

The maximum concentration of antimony in soil at the Residential Area exceeded the screening guideline and was hence carried forward in the human health risk assessment. Antimony was detected in two soil samples of twenty-six soil samples analyzed and two sediment samples of twenty-eight sediment samples analyzed. Because of the large number of non-detectable concentrations, statistics were not used to determine an EPC for antimony in soil and sediment. Therefore, the maximum concentrations of antimony in soil and sediment were used as EPCs at the Residential Area.

To determine representative concentrations of chemicals in wild game meat that may be consumed from the site, Arctic hare were collected. During the Phase III ESA, one Arctic hare was collected and analysed for PCBs. During previous investigations by ESG, five hares were collected and analyzed for PCBs. The analytical results of the hare reported by ESG (2009) as well as the current Phase III ESA are summarized in Table 5.1.

Table 5.1 Summary of PCB Concentrations in Arctic Hare collected from the Former Radar Site

Hare Sample	Tissue Analyzed	Aroclor 1254 (ng/g)	Aroclor 1260 (ng/g)	Total PCBs (ng/g)[1]	Lipid (%)
Exposure Hare #1 (ESG, 2009)	Liver	1.86	214.00	215.86	3.31
Exposure Hare #2 (ESG, 2009)	Muscle	<0.31	2.80	2.8	2.90
	Liver	<0.41	4.93	4.93	4.26
Background Hare #3 (ESG, 2009)	Muscle	3.28	143.00	4.93	35.80
Background Hare #4 (ESG, 2009)	Muscle	<0.57	9.93	146.46	5.12
Background Hare #5 (ESG, 2009)	Muscle	<0.29	13.40	9.93	2.40
Rabbit-1 (current investigaton)	Muscle	-	-	90	1.3
	Liver	-	-	160	2.3

1. ESG (2009) report total PCBs as total congeners

Because of the limited amount of data available for Arctic hare at the site, the maximum concentrations in liver and muscle (*i.e.*, 215.86 ng/g for liver and 146.46 ng/g for muscle) were used to determine a representative EPC for wild game meat at the Former Radar Site. As per ESG (2009), it was assumed that residents of Hopedale would consume both liver and muscle, with hare liver representing 15% and hare muscle representing 85% of the total amount of country food consumed in one day (Scheffel *et al*., 1982). This resulted in an EPC of 157 ng/g wet weight or 0.157 mg/kg wet weight for total PCBs in wild game meat. This is the same EPC used by ESG (2009).

Arctic hare were not analyzed for metals during current or previous investigations. Therefore, the concentrations of lead in other small mammals collected from the site during the current site investigation (*i.e.*, vole, squirrels) were used to calculate an EPC for wild game ingestion. This is very conservative because the small mammals collected from the site would have a smaller home range than Arctic hare and thus would be more highly exposed resulting in higher body burdens.

To determine the concentrations of PCBs in berries that would be consumed from the site, berries were collected from the site and analysed for PCBs and metals. PCBs were not detected in berries collected in 2009 at an RDL of 0.05 mg/kg. Therefore, the EPC for berries calculated by ESG (2009) was used for the human health risk assessment (0.003 mg/kg). ESG (2009) based this calculation on twenty-three berry samples collected from various areas of the site. ESG (2009) divided the site into four zones as well as one background zone. The maximum berry concentration from each zone were used to determine the PCB dose based on harvesting frequency for each zone (%). Lead was not detected in berry samples from the site at an RDL of 0.05 mg/kg. Therefore, lead was assessed at half the RDL (*i.e.*, 0.025 mg/kg) in berries.

It should be noted that TPH was not carried forward in berries and small game from the site because TPH is not considered to bioaccumulate.

The EPCs used in this human health risk assessment are summarized in Table 5.2.

Table 5.2 EPCs used in the Human Health Risk Assessment

Chemical	Former Radar Site			Residential Area	
	Soil (mg/kg)	Game (mg/kg)	Berries (mg/kg)	Soil (mg/kg)	Sediment (mg/kg)
TPH (fuel oil)	17211	-	-	6279	6484
TPH (lube oil)	8787	-	-	-	-
PCBs	29	0.157	0.003	22	14
Antimony	-	-	-	42	6
Lead	372	0.71	<0.5	156	39

5.3 Receptor Identification

Existing and intended land use is an important factor in evaluating the potential exposures and estimating risk. The exposure assessment has been performed considering that there will be no significant development at the site that would increase exposure times, the Former Radar Site will continue to be used on an occasional basis only and that groundwater from the area will not be used as a drinking water source.

Evaluation of the potential for exposure of human receptors to COCs identified at the site requires an understanding of the receptors' characteristics and sensitivities, the method of exposure, and the duration over which the exposure is likely to occur. The potential human receptors, or people who may be most affected by the COCs were selected based on site-specific assumptions for the area.

The Former Radar Site is no longer used as a commercial property. Based on a community survey conducted in 2008 (ESG, 2009), local residents indicated that they would use the property for walking, berry picking, ski-dooing, fishing, hunting, and other recreational purposes. It is therefore possible that a toddler may be present at the site on an occasional basis. Therefore, in evaluating non-carcinogenic risks, the most sensitive receptor is considered to be a toddler (*i.e.*, toddler occasionally visiting the site for recreational purposes).

In evaluating the carcinogenic risk, a composite receptor was selected in order to assess long term exposure to chemicals in soil. The composite receptor consists of an infant, toddler, child, teen and adult with total exposure duration of 80 years (Health Canada, 2009a). The receptors are characterized as having no extreme sensitivities.

The applicable receptor for the Residential Area of Hopedale is also a toddler for the assessment of non-carcinogenic risks and a composite receptor for assessment of carcinogenic risks, as discussed above for the Former Radar Site.

In summary, the following receptor categories have been considered in this assessment:

- Former Radar Site: recreational site user (toddler for non-carcinogenic compounds and composite receptor for all life stages for carcinogenic compounds).
- Residential Area: resident (toddler for non-carcinogenic compounds and composite receptor for all life stages for carcinogenic compounds).

5.4 Exposure Pathway Assessment

The exposure assessment evaluated 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 (*i.e.*, ingestion, dermal contact, and inhalation).

5.4.1 Fate and Transport Properties of Identified Hazards

The relative mobility of a hazard is typically determined through review of the physical properties of the hazard. The fate and transport properties of the identified hazards are summarized in Table 5.3.

Table 5.3 Summary of Fate and Transport Properties of Identified Hazards

Potential Hazards	Solubility	Volatility	Sorption Potential	Reactivity/ Biodegradability	Conditions for Persistence	Fate Assessment
TPH	moderate to high	low to moderate	moderate to high	low to moderate	anaerobic	Low to moderate mobility,
PCBs	low	low	high	low	high	largely immobile
Metals	low to moderate	low	moderate	low	any	immobile, persistent

5.4.2 Potential Transport Pathways

The principal pathways through which environmental hazards can typically contact a receptor include:

- direct contact (with soil, sediment, dust, liquid phase product, or water);
- transport of liquid phase product;
- transport in groundwater;
- transport in surface water;
- air borne transport (as dust); and,
- transport as a vapour.

5.4.3 Potential Exposure Mechanisms

The mechanisms by which receptors typically become exposed to hazards include:

- inhalation;
- ingestion;
- dermal contact; and,
- uptake by plants.

5.4.4 Identification of Operable Exposure Pathways

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 or sediments;
- inhalation/ingestion/dermal contact with dust;
- ingestion of vegetation or garden produce grown in impacted soil or irrigated with impacted groundwater;
- ingestion of wild game;
- ingestion of fish;
- ingestion/dermal contact with surface water;
- ingestion/dermal contact with groundwater; and,
- inhalation of vapours.

The likelihood that the on-site receptors may be exposed to the identified hazards through the various exposure scenarios was identified by using a qualitative method. The likelihood of exposure is considered and evaluated in terms of the series of definitions presented in Table 5.4.

Table 5.4 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 for the Former Radar Site and the Residential Area are summarized in Table 5.5 and 5.6, which includes the qualitative evaluation of each pathway and a justification for the likelihood of exposure assigned. 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 5.5 Potential Exposure Scenarios – Human Receptors – Former Radar Site

Exposure Pathway Description	Likelihood of Exposure	Carried Forward for Quantitative Analysis?	Justification
Ingestion of soil Dermal contact with soil Ingestion of dust Dermal contact with dust	Possible	Yes	Human receptors may be exposed to impacted soil through the soil ingestion/dermal contact/dust inhalation exposure pathways.
Ingestion of sediment Dermal contact with sediment	Unlikely	No	Water bodies at the site would not be expected to be used regularly by human receptors. In the community survey (ESG, 2009), no use of water bodies on the site was identified.
Ingestion of vegetation/garden produce grown in impacted soil	Possible	Yes	Based on the community survey (ESG, 2009), residents pick berries grown at the site for human consumption.
Ingestion of wild game Ingestion of fish	Possible	Yes	Based on the community survey (ESG, 2009), residents hunt game at the site and fish in ponds at the site. It was reported by residents that fishing would only occur at Big Lake.
Dermal Contact with surface water Ingestion of surface water	Unlikely	No	Water bodies at the site would not be expected to be used regularly by human receptors. In the community survey (ESG, 2009), no use of water bodies on the site was identified. The source of drinking water (*i.e.*, Reservoir and second Reservoir) was sampled and chemical concentrations were below the CDWQG. Drinking water is therefore not assessed further.
Ingestion of groundwater Dermal contact with groundwater	Unlikely	No	Groundwater at the site is not used for any purpose by human receptors.
Inhalation of vapours (outdoors)	Possible	No	Although petroleum hydrocarbons are volatile, there is a high potential for dilution in outdoor. Atlantic PIRI (2003) noted that the PSSLs for outdoor air for petroleum hydrocarbons are > RES, requiring only free product remediation.
Inhalation of vapours (indoors)	Very Unlikely	No	There are no buildings on the site.

Table 5.6 Potential Exposure Scenarios – Human Receptors – Residential Area

Exposure Pathway Description	Likelihood of Exposure	Carried Forward for Quantitative Analysis?	Justification
Ingestion of soil Dermal contact with soil Ingestion of dust Dermal contact with dust	Possible	Yes	Human receptors may be exposed to impacted soil through the soil ingestion/dermal contact/dust inhalation exposure pathways.
Ingestion of sediment Dermal contact with sediment	Possible	Yes	Because of the proximity of Old Dump Pond, Small Pond Bog and the stream to the community, exposure to impacted sediment is considered possible.
Ingestion of vegetation/garden produce grown in impacted soil	Unlikely	No	It is unlikely that berries from the Residential Area of Hopedale would grow or be consumed in significant amounts. No home gardens were observed in the Hopedale area during site visits. Recommendations on home gardens will be provided later in this report.
Ingestion of wild game Ingestion of fish	Unlikely	Yes	It is unlikely that game would be hunted within the Residential Area of Hopedale. Fish in Old Dump Pond consist of sticklebacks which would not be used for human consumption. Local residents reported that fishing would not occur in old Dump Pond or Small Pond Bog.
Dermal Contact with surface water Ingestion of surface water	Unlikely	No	Because of the proximity of Old Dump Pond, Small Pond Bog and the Subdivision Stream to the community, it is considered possible that residents would come into contact with surface water. The water bodies will unlikely be used for swimming however, and dermal contact with and ingestion of surface water is therefore considered negligible.
Ingestion of groundwater Dermal contact with groundwater	Unlikely	No	Groundwater at the site is not used for any purpose by human receptors.
Inhalation of vapours (outdoors)	Possible	No	Although petroleum hydrocarbons are volatile, there is a high potential for dilution in outdoor. Atlantic PIRI (2003) noted that the PSSLs for outdoor air for petroleum hydrocarbons is > RES, requiring only free product remediation.
Inhalation of vapours (indoors)	Possible	No	Several buildings in the subdivision area of Hopedale are in the vicinity of petroleum hydrocarbon impacts. It is possible that residents may be exposed through inhalation of vapours in indoor air; however, due to the presence of earthen floors and crawl spaces, this pathway was not assessed quantitatively. Further assessment of this exposure pathway is required.

5.5 Conceptual Site Model

Based on the qualitative risk evaluation, the conceptual model developed for evaluating the quantitative exposure of the human receptor identified the following possible exposure pathways.

Former Radar Site:

- Recreational visitors to the Former Radar Site may be exposed to the impacted soil through ingestion, dermal contact, and dust inhalation at the property.
- Residents of Hopedale living near the Former Radar Site may be exposed to impacts in fish and small game that may be hunted at the site.
- Residents of Hopedale living near the Former Radar Site may be exposed to impacts in berries that may be picked form the site for human consumption.
- Recreational visitors to the Former Radar Site may be exposed to impacts in soil and groundwater through inhalation of outdoor air.

Residential Area:

- Residents at the Residential Area may be exposed to the impacted soil through ingestion, dermal contact, and dust inhalation.
- Residents at the Residential Area may be exposed to the impacted sediment through ingestion and dermal contact with impacted sediment in Small Pond Bog, Old Dump Pond and the stream.
- Residents at the Residential Area may be exposed to impacts in soil and groundwater through inhalation of outdoor air.
- Residents at the Residential Area may be exposed to impacts in soil and groundwater through inhalation of indoor air.

While outdoor air inhalation and indoor air inhalation were identified as exposure pathways in the conceptual model, the pathways were not assessed further in the human health risk assessment. The only chemicals that are of concern for the outdoor air and indoor air inhalation exposure pathways are petroleum hydrocarbons. Outdoor air pathway specific criteria are not calculated because the criteria (Atlantic PIRI, 2003) are greater than the residual saturation limit of TPH in soil (*i.e.*, ">Res") and greater than the solubility in groundwater (*i.e.*, ">Sol") thus requiring only free product remediation. This means that in the absence of free phase petroleum hydrocarbons at the site, TPH concentrations in soil would be below the Tier II PSSL for this exposure pathway. Therefore, the outdoor air exposure pathway is not considered further in this human health risk assessment.

The inhalation of indoor air was considered an operable exposure pathway for residential receptors living in the Residential Area of Hopedale where petroleum hydrocarbons were identified in soil and groundwater. Most houses in the Residential Area are constructed with an earthen floor in the basement or crawl space. The Tier I RBSL and Tier II PSSL Tables do not apply to buildings without a concrete floor due to the increased vapour infiltration in the absence of a concrete barrier. The Atlantic RBCA Version 2.1 software is not applicable for homes with earthen floors (Atlantic PIRI, 2003). Therefore, the indoor air inhalation exposure pathway cannot not be assessed with the information available. Recommendations will be provided for additional work to assess this exposure pathway.

The ingestion of fish from Big Lake was identified as a potential exposure pathway for the Hopedale Radar Site. Concentrations of PCBs were non-detectable and 0.06 mg/kg in two brook trout collected from Big Lake. Additional samples would be required to determine if PCBs are present in the fish from Big Lake.

5.5.1 Receptor Characteristics and Exposure Time

Based on the community survey (ESG, 2009), it is assumed that a recreational site user could potentially be on the Former Radar Site for 6 hours per day, 3 days/week, for 52 weeks/year. It should be noted that for the soil ingestion/dermal contact/inhalation exposure pathway, an exposure time of 26 weeks per year with no snow cover was assumed based on Environment Canada climate data for nearby areas. It is assumed that receptors would not be exposed to the surface soil impacts while it is snow covered or frozen. For the dermal contact and ingestion exposure pathway, it is assumed that the receptors will receive their entire daily exposure during the 3 hours that they are outside (*i.e.*, event driven exposure).

It was assumed that wild game and berries from the Former Radar Site may be ingested 365 days per year. The wild game ingestion rate from Health Canada (2009a) was applied. Health Canada (1994) indicates a strawberry ingestion rate for toddlers of 3.01 g/day and a blueberry ingestion rate of 0.67 g/day resulting in a berry consumption rate of 3.68 g/day. Residents from Hopedale, however, would be expected to consume more berries than the typical Canadian. Health Canada (2009a) provides an ingestion rate of 67 g/day for vegetables other than root vegetables. For the purposes of this human health risk assessment, it was conservatively assumed that residents of Hopedale would supplement their diet with the same amount of berries as other Canadians would supplement their diet with vegetables other than root vegetables.

It is assumed that a Residential Area user will be present at the Residential Area for 24 hours/day, 7 days per week, for 52 weeks per year. Again, it should be noted that for the soil ingestion/dermal contact/inhalation exposure pathway, an exposure time of 26 weeks per year with no snow cover was assumed based on Environment Canada climate data for nearby areas.

It is assumed that a Residential Area user would potentially be exposed to impacts in sediment in old Dump Pond, Small Pond Bog or the Subdivision Stream once a day, seven days a week, for twelve weeks of the year (*i.e.*, weeks with warm temperatures).

Receptor characteristics, exposure frequencies and ingestion/inhalation rates are presented in Tables 5.7 and 5.8.

Table 5.7 Summary of Receptor Characteristics

Characteristic		Toddler	Source
Averaging Times and Constant Values			
Atn	Averaging time, non-cancer (days)	1,643	Equal to exposure duration
ED	Exposure duration (years)	4.5	Health Canada, 2009a
EF	Exposure frequency (days/year)	Game Ingestion: 365 Berry Ingestion: 365 Soil Exposure – Radar Site: 78 Soil Exposure – Residential Area: 182 Sediment Exposure - Residential Area: 84	Estimates based on community survey results and meteorological data
ET ing	Exposure Time, ingestion (hrs/day)	24	Assumes ingestion is event driven

Characteristic		Toddler	Source
ET inh	Exposure Time, inhalation (hrs/day)	Radar Site: 6 Residential Area: 24	Estimate of daily exposure on site.
BW	Body Weight (kg)	16.5	Health Canada, 2009a
Ingestion of Surface Soil/Sediment			
IR s	Incidental ingestion rate (mg/day)	80	Health Canada, 2009a
Dermal Contact with Surface Soil/Sediment			
SA	Exposed surface area – Hands (cm^2)	430	Health Canada, 2009a
	Exposed surface area – Rest of Body (cm^2)	2,580	Health Canada, 2009a
AF	Soil adherence factor - Hands (mg/cm^2)	0.1	Health Canada, 2009a
	Soil adherence factor – Rest of Body (mg/cm^2)	0.01	Health Canada, 2009a
Inhalation of Dust/Vapours			
IR air	Inhalation rate (m^3/day)	8.3	Health Canada, 2009a
Ingestion of Wild Game			
GIR	Wild game ingestion rate (kg/day)	0.085	Health Canada, 2009a
F_{site}	Fraction of wild game from the site	0.3	Assumed (30%) ESG, 2009
$P_{smallgame}$	Percentage of game harvest	0.08	Usher, 1982
Ingestion of Berries			
BIR	Berry ingestion rate (kg/day)	0.067	Richardson, 1997
F_{site}	Fraction of berries from the site	1	Assumed (100%)

Table 5.8 Age-Specific Receptor Characteristics: Carcinogens Only

Parameter		Age Group				
		0 – 0.5 yrs	>0.5 – 4 yrs	5-11 yrs	12-19 yrs	20-80 yrs
ED	Exposure Duration (y)	0.5	4.5	7	8	60
BW	Body Weight (kg)	8.2	16.5	32.9	59.7	70.7
IRs	Soil Ingestion Rate (mg/d)	20	80	20	20	20
IRa	Inhalation Rate (m^3/d)	2.2	8.3	14.5	15.6	16.6
BIR	Berry Ingestion Rate (mg/d)	0.072	0.067	0.098	0.12	0.137
GIR	Game Ingestion Rate (mg/d)	0	0.085	0.125	0.175	0.270
AF	Adherance Factor - Hands	0.1	0.1	0.1	0.1	0.1
	Adherence Factor – Rest of Body	0.01	0.01	0.01	0.01	0.01
SA	Skin Surface Area (cm^2) - Hands	320	430	590	800	890
	Skin Surface Area (cm^2) – Rest of Body	1,460	2,580	4,550	2,230	2,500
Sources : Health Canada (2009a) Berry Ingestion rate is based on other vegetable ingestion rate from Richardson (1997)						

The important characteristics of the receptors (including body weight, exposure duration, etc.) considered in the risk analysis are also presented in the input and output tables in Appendix 26.

6.0 QUANTITATIVE HUMAN HEALTH RISK ASSESSMENT

6.1 Modelling Tools

6.1.1 Petroleum Hydrocarbons

The quantitative risk assessment and the derivation of SSTLs for petroleum hydrocarbons (TPH, BTEX) as described above was made with the aid of Groundwater Services, Inc. (GSI) RBCA Toolkit for Atlantic Canada, Version 2.1. The spreadsheet model is based on the exposure and mass transport equations presented in the appendix of the ASTM PS-104 “Standard Provisional Guide for Risk-Based Corrective Action” (ASTM 2002). Under the RBCA process, using these standard equations for derivation of site-specific risks and clean-up targets, is considered a “Tier II” assessment. See Appendix 26 for detailed equations and source information.

The Atlantic RBCA Spreadsheet model, Version 2.1, has incorporated a methodology for assessing total petroleum hydrocarbons as thirteen separate fractions. This approach was developed by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG, 1997a; 1997b; 1998).

The RBCA model was used for the modeling of two exposure pathways: 1) dermal contact/ingestion of soil, and 2) dermal contact/ingestion of sediment. The quantitative analysis of these pathways uses conservative assumptions and relatively simple exposure models and is considered likely to overestimate exposure risks as compared to using detailed models based upon more site-specific data and less conservative assumptions. The input parameters used for the risk calculations are provided in Appendix 26. The Tier II risk assessment for the site was conducted for petroleum hydrocarbons using the exposure point concentration calculated for soil on the site (refer to Table 5.2). This is a conservative assumption because calculations are performed assuming that this concentration is found throughout the identified area.

The soil exposure pathway of the GSI RBCA Toolkit is a direct pathway that uses equations to evaluate such variables as average daily soil ingestion rate, skin surface area and sorption of contaminants to skin. It is a direct exposure route, therefore, no predictive chemical fate and transport modelling is required. To conservatively evaluate human health risks, it is further assumed that the impacts are located uniformly across the site and that there is no biodegradation or other loss mechanism.

6.2 Pro-Rating of Results

The RBCA toolkit requires TPH fractionation in order to assess the potential risks to receptors from exposure to TPH. In order to conservatively assess the potential risks, the fractionated TPH results were pro-rated based on the percentage of each fraction identified in the fractionated result with these percentages utilized in deriving “fractioned” results from the EPC. Pro-rating is a method of estimating the individual fractions from a non-fractionated sample (*i.e.*, EPC) based on a comparison to a fractionated sample. The procedure includes calculating the mass fraction of each known fraction as a percentage of the total TPH concentration. Estimated fraction concentrations can then be calculated by pro-rating these to the TPH concentration of the non-fractionated sample (*i.e.*, multiplying the TPH value of the non-fractionated sample (EPC) by the mass fraction of the fractionated sample). The potential risks to human receptors were then determined from these pro-rated fractions

The maximum concentration of TPH (fuel oil) identified in surface soil from the Former Radar Site was at BMEWS (BS20 – 94,000 mg/kg). Therefore, TPH fractionation from a sample from BMEWS (TP117-BS2) was used for pro-rating of TPH (fuel oil) EPC at the Former Radar Site. The maximum concentration of TPH (lube oil) identified in surface soil from the Former Radar Site was at the POL Compound (TP14-BS1 – 25,000 mg/kg). Therefore, TPH fractionation from a sample from the POL Compound (TP141-BS1) was used for pro-rating of TPH (lube oil) EPC at the Former Radar Site. No samples from the Residential Area were analyzed for TPH fractionation. Therefore, the fractionated sample from BMEWS (BS20) was used for pro-rating of soil and sediment TPH EPCs at the Residential Area. Pro-rating tables are presented in Appendix 26.

Although the concentrations of toluene, ethylbenzene and xylenes did not exceed screening guidelines, the concentrations were added into the TPH fractionation results (i.e., total TPH is required) as per Atlantic PIRI (2003). The RBCA model is inherently conservative and using default values will largely over-estimate the risk associated with the remaining concentrations of petroleum hydrocarbons at the site.

6.2.1 Metals and PCBs

A risk assessment spreadsheet was used to develop site specific target levels (SSTLs) and to calculate the human health risk associated with metals and PCBs impacts identified at the site. Where necessary, SSTLs were derived in accordance with the methods presented in "A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines", CCME 2006. The specific methods employed to develop the SSTLs are consistent with CCME and Health Canada protocols as referenced above, and with standard human health risk assessment methodologies. The equations used in the assessment of metals impacts are shown on the spreadsheets in Appendix 26.

6.3 Toxicity Assessment

The potential hazards associated with exposures to non-carcinogenic (threshold) substances are assessed based on the assumption that there is a dose (or concentration) of the chemical of concern that does not produce any adverse effect. A Tolerable Daily Intake (TDI) is an estimate of a chemical intake that is unlikely to cause an increased incidence of deleterious health effects during a lifetime of exposure. TDIs are specifically developed to be protective for chronic exposure to a chemical.

For contaminants for which the critical effect is assumed to have no threshold (*i.e.*, carcinogens), it is assumed that there is some probability of harm to human health at any level of exposure (CCME, 2006). There is a linear dose-response relationship that converts estimated daily intakes averaged over a lifetime of exposure directly to an incremental risk of an individual developing cancer. For the purposes of deriving site-specific soil quality guidelines, Health Canada considers that a single increased case of cancer in an exposed population of 100,000 merits action (Health Canada, 2004a). As such, a target risk (TR) of one in one hundred thousand or 10^{-5} is used in this risk assessment for carcinogenic effects.

6.3.1 Toxicity Reference Values

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 Atlantic PIRI, Health Canada, the United States Environmental Protection Agency (US EPA), and the World Health Organization (WHO). Preference has been given to Health Canada values and where these are not established, values from the US EPA'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 Tables 6.1 and 6.2.

Table 6.1 Selected Toxicity Values for Non-Carcinogens

Metal		Route of Exposure	Tolerable Daily Intake (mg/kg-day)	Toxicological Basis	Source Agency
Antimony		Ingestion	0.0004	Longevity, blood glucose, and cholesterol	USEPA IRIS
		Inhalation	0.0004		
Lead		Ingestion	0.00185	No increase in body burden in infants	OMOE, 2004 as recommended by Health Canada, 2009c
		Inhalation	0.00185		
PCBs		Ingestion	0.00013	Not given	Health Canada, 2009b
		Inhalation	0.00013		
TPH	Aliphatics $>C_6$-C_8	Ingestion	5	Not given	Atlantic PIRI, 2003
	Aliphatics $>C_8$-C_{10}	Ingestion	0.1		
	Aliphatics $>C_{10}$-C_{12}	Ingestion	0.1		
	Aliphatics $>C_{12}$-C_{16}	Ingestion	0.1		
	Aliphatics $>C1_6$-C_{21}	Ingestion	2		
	Aliphatics $>C_{21}$-C_{34}	Ingestion	2		
	Aromatics$>C_7$-C_8	Ingestion	0.2		
	Aromatics$>C_8$-C_{10}	Ingestion	0.04		
	Aromatics$>C_{10}$-C_{12}	Ingestion	0.04		
	Aromatics$>C_{12}$-C_{16}	Ingestion	0.04		
	Aromatics$>C_{16}$-C_{21}	Ingestion	0.03		
	Aromatics$>C_{21}$-C_{35}	Ingestion	0.03		

As indicated in Tables 6.2 and 6.3, PCBs were assessed as both non-carcinogens and carcinogens as part of this human health risk assessment. In their most recent assessment of PCBs, Health Canada (2009a) indentified PCBs as having inadequate data for evaluation of carcinogenicity to humans, and has therefore only provided a non-carcinogenic TRV. Health Canada is considered the most appropriate regulatory agency for this human health risk assessment. However, as the US EPA has provided a carcinogenic slope factor for PCBs, this toxicological information was also considered in the assessment.

Table 6.2 Toxicity Values for Carcinogens

Substance	Route of Exposure	Exposure Limit $(mg/kg\text{-}d)^{-1}$	Toxicological Basis	Source Agency
PCBs	Ingestion	2	Not given	USEPA IRIS
	Inhalation	2		

6.3.2 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". 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 TRV. These factors were 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) metal is absorbed into the bloodstream compared to the absorption in the TRV study. Table 6.3 provides the bioavailability factors used in this assessment.

Table 6.3 Bioavailability Factors

Bioavailability Factor (or Relative Absorption Factor)	Oral	Dermal	Inhalation
Antimony	1	0.1[1]	1
Lead	0.6[1]	0.006[1]	1
TPH (all fractions)	1	0.5[2]	1
PCBs	1	0.14[1]	1

1. Health Canada, 2009b
2. Atlantic PIRI, 2003

6.4 Risk Characterization

6.4.1 Approach and Methodology – Non Carcinogens

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

The potential health effects associated with non-carcinogenic chemicals are assessed differently than those for carcinogenic chemicals. Non-carcinogenic chemicals are generally considered to act through a threshold mechanism where it is assumed that there is a dose (or concentration) that does not produce any adverse effect. As the dose or concentration increases to the point where the body can no longer process or excrete the chemical, an adverse effect may occur. This point is termed the threshold and is different for every chemical.

We have employed the Health Canada Preliminary Quantitative Risk Assessment (PQRA) methodology (Health Canada, 2004a) to derive the SSTLs. This methodology was issued by Health Canada in conjunction with approved TRVs and is intended for application in risk assessments on Federal sites. This methodology modifies the CCME approach by eliminating the use of the EDI and calculates a Hazard Quotient (HQ) as follows:

$$HQ = \frac{\text{Estimated Exposure (mg/kg-day)}}{\text{TDI (mg/kg-day)}}$$

Because the background exposure is not taken into account (as is the case with the generic CCME guidelines), a target hazard quotient of 0.2 (20%) is used for metals and PCBs. This permits 80% (0.8) of allowable exposure to come from non-site related sources (*e.g.*, dietary intake). Other aspects of the risk characterization process are conducted in the same manner (*i.e*. using the same calculations) as with the CCME approach. As per Atlantic PIRI (2003), a target hazard quotient of 1.0 was used for petroleum hydrocarbons.

The following is a simplified version of the equation used to calculate the soil SSTLs.

$$SSTL = \frac{TDI \times BW \times SAF}{CDI}$$

Where:
SAF = Soil Allocation Factor = Target Hazard Quotient
BW = Body Weight
TDI = Tolerable Daily Intake
CDI = Chronic Daily Intake (sum of all intake pathways)

Details of the equations and parameter values used in the analysis are provided in the spreadsheets in Appendix 26.

6.4.2 Carcinogens

In determining the incremental increase in lifetime cancer risk associated with exposure to carcinogenic metals and carcinogenic PAHs, the estimated dose is compared to the established cancer slope factors as shown in the simplified equation below:

$$ILCR = LADD \times CSF$$

Where:
ILCR = Incremental Lifetime Cancer Risk
LADD = Lifetime Averaged Daily Dose (mg/kg-day) = Daily Intake/Body Weight
CSF = Cancer Slope Factor ($[\text{mg/kg-day}]^{-1}$

The ILCR estimates the incremental probability that a person will develop cancer as a result of a lifetime of exposure to the site. This incremental lifetime cancer risk is over and above the probability of developing cancer due to ambient exposures. The characterization of potential ILCR was undertaken using a target risk benchmark established by Health Canada of 1 in

100,000 (theoretically one additional cancer per 100,000 population). Calculation of the LADD is based on methods presented by US EPA (1989), CCME (2006), Health Canada (2009a), and OMOE (1996). Details of the equations and parameter values used in the analysis are provided in the spreadsheets in Appendix 26. In the case of carcinogenic PAHs, the ILCR associated with the benzo(a)pyrene TPE was benchmarked against the 1 in 100,000 risk level.

In general, exposure pathways and intake values for carcinogens were consistent with those used for the development of the non-carcinogenic SSTL for human health, but were averaged over a lifetime of exposure rather than being specific to one age group.

6.5 Human Health Risk Assessment Results – Metals and PAHs

6.5.1 Baseline Risks

The cumulative hazard indices and carcinogenic risks for the exposure scenarios assessed are shown in Table 6.4. The hazard index values for the soil ingestion, inhalation, and dermal contact pathway for PCBs at the Former Radar Site and for PCBs and antimony at the Residential Area exceed the target maximum hazard index value of 0.2. The calculated total carcinogenic risks for the wild game exposure pathway for PCBs exceed the target risk of 1 x 10^{-5}. The hazard index and carcinogenic risk values for all other chemicals for all other pathways were below their targets.

Table 6.4 Cumulative Pathway Hazard Indices and Target Risks – Metals and PAHs

COC	Exposure Pathway	Hazard Index	Target Hazard Index	Total Carcinogenic Risk	Target Risk (Carcinogens)
Antimony	Residential Area – Soil Exposure	**0.28**	0.2	NA	NA
	Residential Area – Sediment Exposure	0.018	0.2	NA	NA
Lead	Residential Area – Soil Exposure	0.13	0.2	NA	NA
	Residential Area – Sediment Exposure	0.014	0.2	NA	NA
	Former Radar Site – Soil Exposure	0.13	0.2	NA	NA
	Former Radar Site – Game Ingestion	0.05	0.2	NA	NA
	Former Radar Site – Berry Ingestion	0.03	0.2	NA	NA
PCBs	Residential Area – Soil Exposure	**0.47**	0.2	**2.0E-05**	1.0E-05
	Residential Area – Sediment Exposure	0.13	0.2	5.5E-06	1.0E-05
	Former Radar Site – Soil Exposure	**0.26**	0.2	**1.1E-05**	1.0E-05
	Former Radar Site – Game Ingestion	0.15	0.2	**2.9E-05**	1.0E-05
	Former Radar Site – Berry Ingestion	0.094	0.2	**1.3E-05**	1.0E-05

COC	Exposure Pathway	Hazard Index	Target Hazard Index	Total Carcinogenic Risk	Target Risk (Carcinogens)
TPH (Fuel Oil)	Residential Area – Soil Exposure	0.55	1	NA	NA
	Residential Area – Sediment Exposure	0.25	1	NA	NA
	Former Radar Site – Soil Exposure	0.64	1	NA	NA
TPH (Lube Oil)	Former Radar Site – Soil Exposure	0.27	1	NA	NA
Note: BOLD indicates risk estimate is higher than target.					

6.5.2 SSTLs for Remediation

Based on the results of cumulative pathway hazard indices and carcinogenic risks, soil SSTLs were calculated for each of the COC identified as representing a potential health risk to help direct the remedial actions. An SSTL of 30 mg/kg was calculated for antimony at the Residential Area based on the soil ingestion/dermal contact/dust inhalation exposure pathways. Concentrations of antimony exceeding the SSTL were identified at Old Dump Pond (Drawing No. 121410103-EE-28b).

An SSTL of 9 mg/kg was calculated for PCBs at the Residential Area based on non-carcinogenic exposure via the soil ingestion/dermal contact/dust inhalation exposure pathways. Concentrations of PCBs in soil exceeding the SSTL were identified at the following areas of the Residential Area: Old Dump Pond (Drawing No. 121410103-EE-28b) and the Wharf Area (Drawing No. 121410103-EE-28a).

An SSTL of 22 mg/kg was calculated for PCBs at the Former Radar Site based on non-carcinogenic exposure via the soil ingestion/dermal contact/dust inhalation exposure pathways. It is recommended that this SSTL be applied to the Former Radar Site for human health based remediation of soil. Concentrations of PCBs in soil exceeding the proposed SSTL (22 mg/kg) were identified at the following areas of the Former Hopedale Radar Site: BMEWS (Drawing No. 121410103-EE-28c) and Old Base1 and Main Base (Drawing No. 121410103-EE-28d).

It is recognized that the wild game ingestion exposure pathway and the berry ingestion exposure pathway resulted in carcinogenic risks that were 2.9 and 1.3, respectively, times the target risk (1.0E-05). The concentrations of PCBs in wild game and berries are assumed to be directly related to PCB concentrations in soil (i.e., the contamination in the soil is the source of the observed concentrations of PCBs in the berries and the wild game). If soil with PCB concentrations higher than 22 mg/kg is removed, the EPC for the Former Radar Site would decrease from 29 mg/kg to 4.3 mg/kg (*i.e.*, a reduction by a factor of 6.7). The subsequent reduction in the EPC by a factor of 6.7 is expected to be sufficient to decrease the associated carcinogenic risks due to wild game and berry ingestion to a value below the target risk.

7.0 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.

7.1 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 US EPA 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 is 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 result 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.

7.2 Modeling Assumptions

Table 7.1 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.

Table 7.1 Evaluation of Assumptions in the Risk Analysis

Risk Analysis Study Factor/Assumption	Justification	Analysis Likely to Over/Under Estimate Risk?	Acceptable Assumption ?
Hazard Screening/ Identification			
Measured concentrations are representative.	Used maximum concentrations or statistical data for EPC: conservative measure.	Over-Estimate	Yes
Receptor Characteristics			
The most sensitive receptors for the Residential Area and the Former Radar Site were assumed to be a toddler (non-carcinogens) and an age-adjusted lifetime receptor (carcinogens).	Although it is unlikely that a toddler would spend a significant amount of time at the Former Radar Site, the site is publicly accessible. Therefore, a toddler and age-adjusted lifetime receptor were carried forward as the most sensitive receptor as it is reasonable that nearby residents would visit the site.	Neutral	Yes
For the exposure scenario of soil ingestion/dermal contact and inhalation, an occasional visitor to the Former Radar Site was assumed to be present on the property 78 days/year for the exposure duration. Residential receptors at the Residential Area are assumed to be present 365 days/year. Residents are assumed to be in contact with sediment from the water bodies 7 days a week for 12 weeks of the year. Residents were also assumed to potentially eat wild game and berries form the site 365 days/year.	The exposure times represent a reasonable estimate of average annual exposure based on current and potential future site use.	Neutral	Yes
The “other vegetable” ingestion rate from Health Canada (2009a) was used to represent berry ingestion for Hopedale.	The berry ingestion rate from Health Canada (1994) was not considered representative for the Town of Hopedale because residents would be expected to consume more berries than the typical Canadian. Therefore, it was assumed that residents of Hopedale would supplement their diet with the same amount of berries as other Canadians would supplement their diet with other vegetables	Over-estimate	Yes
Risk Characterization			
PCBs were assessed as carcinogens (*i.e.*, age-adjusted lifetime exposure) and as non-carcinogens (*i.e.*, toddler)	Health Canada does not consider PCBs to be carcinogenic; however, other regulatory agencies (*e.g.*, USEPA) consider PCBs carcinogenic. Both endpoints are considered to be conservative.	Neutral	Yes
Exposure was modelled for soil ingestion/dermal contact and dust inhalation, wild game and berry ingestion, sediment ingestion/dermal contact.	Other exposures are expected to produce negligible risks. The indoor air exposure pathway will be considered in future work at the Residential Area.	Neutral	Yes

Note: Over-estimation of risk indicates that the assumption was conservative, and could possibly overestimate the risks at the site (*i.e*. higher than actual). Underestimating the risk indicates that the assumptions made could slightly underestimate the level of risk at the site. Based on the assessment conducted on the site, the assumptions are acceptable.

7.3 Summary of 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 Human Health Risk Assessment, 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.

8.0 ECOLOGICAL RISK ASSESSMENT

Ecological Risk Assessment (ERA) is the formal process that has been developed for the purpose of assessing and quantifying risks to ecological receptors from exposure to one or more stressors. The framework within which ERA is performed was largely developed in the United States, under the US Environmental Protection Agency (US EPA, 1992) and later expanded (US EPA, 1998). In Canada, the Canadian Council of Ministers of the Environment (CCME, 1996a and 1997) has developed a similar protocol, and variants of these protocols are presently in use in several provinces.

Ecological Risk Assessment is defined (US EPA, 1992) as the process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. In terms of this ERA, ecological effects refer to toxicologically-induced changes in the health of ecological receptors exposed to stressors, specifically chemicals of concern (COC), present at the site. Ecological Risk Assessment is a process for organizing and analyzing data, information, assumptions, and uncertainties to evaluate the likelihood of adverse ecological effects. Ecological risk assessment provides risk managers with an approach for considering available scientific information along with the other factors (*e.g.*, social, legal, political, economic) when selecting a course of action.

An ERA includes three primary activities: problem formulation, analysis (composed of an exposure and toxicity assessment) and risk characterization. Within problem formulation, important steps include identifying goals and assessment endpoints, preparing the conceptual model, and developing an analysis plan. The analysis phase involves evaluating exposure to stressors and the relationship between stressor levels and ecological effects. In risk characterization, key elements are estimating risk through integration of exposure and stressor response profiles, describing risk by discussing lines of evidence, and determining ecological adversity.

8.1 Levels of ERA Process

The ERA process is iterative and tiered. A relatively simple process may be all that is required to achieve an adequate foundation for a management decision. Alternatively, remaining uncertainties may require that the process be repeated at increasing levels of detail before decision-making can occur. Initial tiers in an ERA are typically based on conservative assumptions such as maximum exposure or ecological sensitivity. When a lower tier cannot sufficiently define risk to support a management decision, a higher assessment tier that may require either additional data, or applying a more refined analysis technique, may be needed. Higher tiers provide more ecologically realistic assessments while making less conservative assumptions about exposure and effects.

The three tiers of ERA that are typically followed include:

- Screening Level ERA;
- Preliminary Quantitative ERA; and
- Detailed Quantitative ERA.

Each level in this tiered approach to ERA has the same structure and builds upon the data, information, knowledge and decisions from the preceding level. Thus, each level is progressively more complex. At the same time, each level becomes more focused on specific issues or concerns, as the available information is reviewed, and data gaps are addressed. The ERA process does not necessarily involve all three tiers; rather, the process stops at a point when sufficient information has been assembled to support the decision-making or management process (CCME, 1996a). A Screening Level ERA was deemed acceptable to support the decision-making or management process for the site.

8.2 Objectives and Overview

This ERA has been conducted according to principles laid out in Canadian and U.S. federal and state guidance documents (CCME 1996a, 1997, US EPA 1992, Ohio EPA 2008). The objectives of the ERA are to:

- Qualitatively characterize the potential ecological receptors that have been observed or could be present in terrestrial or aquatic habitats on or adjacent to the site;
- Assess potential exposures of ecological receptors to COCs in various environmental media within terrestrial or aquatic habitat under current conditions;
- Characterize the risks associated with exposures of ecological receptors to COCs in various environmental media under current conditions; and
- If unacceptable risk is identified, determine acceptable concentrations of COCs (site-specific target levels, or SSTLs) that would allow re-establishment of the habitat and would not pose on-going risks.

This ERA uses a general framework similar in concept to the approach used for the human health risk assessment, but is distinctive in its emphasis in three areas:

- The ecological risk assessment generally considers effects at the population level rather than at the individual level, with the notable exception being species protected under federal or provincial legislation (e.g., Species at Risk Act)
- There is no single set of ecological values or resources to be protected that can be generally applied to every site; and
- If appropriate, the ecological risk assessment can consider non-chemical, as well as chemical, stressors, however, only chemical stressors have been evaluated herein.

8.3 Approach and Methodology

The ecological risk assessment consists of three main steps:

1. **Problem Formulation** - This is a review of available physical, chemical and biological data for the site and receptor habitats that may be affected by releases of chemicals to environmental media. This step i) identifies potential ecological receptors (*i.e.,* biological communities, populations, individuals, or habitats potentially at risk); ii) identifies chemicals of concern and other stressors for ecological receptors; iii) identifies potential exposure pathways; and iv) identifies appropriate assessment and measurement endpoints for the ecological risk assessment. Each of these elements is integrated into a conceptual model.
2. **Analysis (Exposure and Toxicity Assessments)** - This step involves estimation of the level of exposure of the ecological receptors to the COC, and identification of the biological exposure-response standards based on the concentrations of these chemicals in various environmental media.
3. **Risk Characterization** - This is a description of the nature and magnitude of potential environmental risks, derived by comparing exposure estimates for various media, exposure-response standards for the ecological receptors, and results of the site-specific surveys and bioassays. This step also includes a discussion of the uncertainties in the analysis, an evaluation of the necessity for remedial action, and estimates of maximum chemical concentrations consistent with an acceptable level of risk (*i.e.*, SSTLs).

Following this, a discussion of the uncertainties inherent to ERA, and conclusions and recommendations stemming from the assessment are discussed. The ERA framework is conceptually illustrated in Figure 8.1 below.

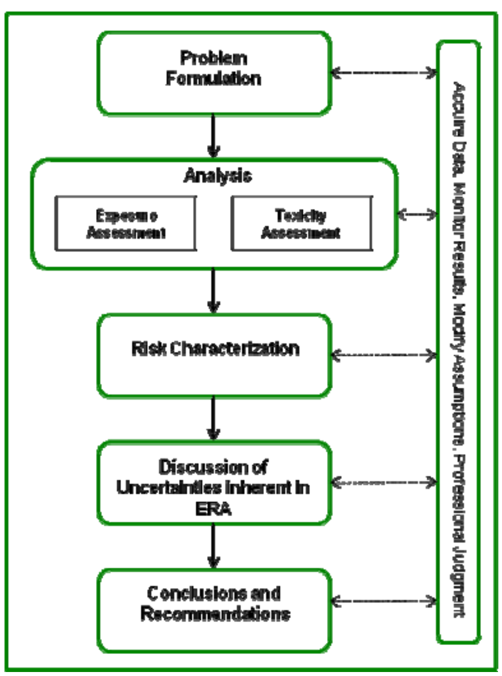


Figure 8.1 ERA Framework

The organization of this document is consistent with these elements of an ERA.

8.4 Study Area

The study area is defined as that area including and surrounding the investigated sections at the Hopedale radar site. In an overall sense, this area incorporates the predominantly natural areas between the Town of Hopedale and the high ground where the radar installations and other infrastructure were located, but also includes the Town of Hopedale, Hopedale Harbour, the access road from Hopedale to the site, as well as a number of investigated areas along the access road.

The habitat present at the former radar site is a patchwork of microhabitats including rock outcrops, natural and anthropogenic barren areas (roadways, building foundations, and exposed areas with thin soils), sloping ground with variable ground cover (mainly stunted black spruce, alders and other deciduous shrubs), areas of bog and marsh and watercourses.

8.5 Site Description

The Hopedale site falls within the Coastal Barrens ecoregion in Newfoundland and Labrador. This ecoregion is composed of a coastal strip with islands, exposed headlands, and protected inlets, from Napaktok Bay south to the Strait of Belle Isle (Meade, 1990; Government of Newfoundland, 2010). The region has a low subarctic climate with short, moist, cool summers and long, cold winters. The mean annual temperature is around 3.5°C and the annual precipitation in the region ranges from 600 mm in the north to over 1000 mm in the south.

The area surrounding the Hopedale radar site provides habitat that is typical of the Labrador Coastal Barrens. Bedrock is granite and gneiss, and is largely exposed. Soils are thin on the hills, with accumulations of rock, gravel, sand and organic matter in low lying areas. Trees at the Hopedale site are sparse and stunted but include white and black spruce (*Picea glauca* and *P. mariana*) as well as tamarack (*Larix laricina*). Shrubs are predominant, and include abundant alder (*Alnus viridis*) as well as willows (*Salix* spp.) and dwarf birch (*Betula* sp.). Smaller shrubs include Labrador tea (*Ledum sp.*) and blueberry (*Vaccinium* sp.). Ground vegetation includes bakeapple (*Rubus chamaemorus*), partridgeberry (*Vaccinium vitis-idaea*), Canada dogwood (*Cornus sp*.), grasses, sedges, saxifrages and willow herb. Cotton grass (*Eriophorum sp*.) is abundant in boggy areas. Lichens and mosses are important components of the ground cover in some areas with thin soils.

There are few overt signs of stressed vegetation around the site that could be attributable to chemical stressors. The local environment, however, is harsh and there are large areas of bare rock, or rock covered with little more than lichens. Soil development has taken place in rock fractures and where slopes are sufficiently shallow to allow the accumulation of sand and gravel that will subsequently provide rooting habitat and hold organic matter to form soils. The current condition of the site appears to show considerably more vegetation, particularly shrubs, than historical photographs from the 1950s. The increase in vegetation is likely attributable to the distribution of sand and gravel around the site as a result of road building and the placement of pads for various infrastructure.

Avian species observed during site visits include American robin (*Turdus migratorius*) and American Crow (*Corvus brachyrhynchos)*. Ravens (*Corvus sp.*) were not seen but are likely found in the area. Merlin (*Falco columbarius)* and Short-eared owl (*Asio flammeus*) are also likely present at the site. Herring gulls (*Larus argentatus*) are common in the region and were observed near the stream outlet foraging. Spruce grouse (*Falcipennis Canadensis*) were reported by local residents to be present at the site but none were observed. White Crowned Sparrows (*Zonotrichia leucophrys*) were particularly abundant in the lower portions of the site.

Local residents indicated that common mammals in the area include black bear (*Ursus Americanus*), red fox (*Vulpes vulpes*), Arctic fox (*Alopex lagopus*), Arctic hare (*Lepus arcticus)*, snowshoe hare (*Lepus americanus*), weasels (mostly ermine (*Mustela erminea*)); mink (*Mustela vison*) are rare locally, but more common farther inland, lemmings, voles (*e.g.,* red backed vole (*Clethrionomys rutilus)* and shrews (*e.g*., masked shrew (*Sorex cinereus*). Caribou (*Rangifer tarandus tarandus)* also pass through occasionally, but are not regularly present. Squirrels (*e.g.,* red squirrel (*Sciurus vulgaris*)) and hare were observed at the site during field visits.

Freshwater aquatic habitat in the immediate vicinity of the site is limited to small bog ponds and small, generally shallow lakes. Eight potential freshwater habitats and one marine habitat have been identified for assessment in this ecological risk assessment. The freshwater habitats include: 1) Subdivision Stream, 2) Old Dump Pond, 3) Small Pond Bog, 4) Old Dam, 5) Valley Drainage Ponds, 6) Reservoir, 7) Second Reservoir, and 8) Big Lake. The one marine aquatic habitat, the Wharf Area, includes the coastline and Hopedale Harbour. Aquatic habitats are shown on Drawing No. 121410103-EE-27a, Appendix 27.

Sticklebacks (*Gasterosteus aculeatus)* are likely to be present in most if not all of the freshwater ponds. The distribution of larger fish (such as brook trout (*Salvelinus fontinalis)* or landlocked Arctic char (*Salvelinus alpinus*)) is limited to the larger and deeper lakes. Big Lake, located northwest of the BMEWS site, was reported to contain brook trout and landlocked Arctic char. Brook trout were collected from this lake. Despite significant fishing effort, only sticklebacks were collected from Old Dump Pond, Reservoir, and Second Reservoir. Most people reported that fish (Atlantic salmon (*Salmo salar*), Arctic char, sea-run brook trout, and in former times when they were more abundant, cod (*Gadus sp*.) and tomcod *(Microgadus tomcod*) are generally caught in the marine environment using gill nets, or occasionally on rod and line for sport.

8.6 Receptor Identification

Potential receptor habitats and receptors were identified from observations made during site visits and through a desktop review of the site and similar sites. In addition, photography from the site was studied to further delineate the habitat present, both in terms of the types present, and the quantities present, in the vicinity of the potentially affected areas. This information was used to identify suitable ecological receptors, referred to as valued ecosystem components (VECs), for the ERA that are likely to be exposed to stressors present at the site.

The Hopedale radar site is located on a broad, high peninsula located north of the Town of Hopedale. Terrestrial habitats present at the site include disturbed areas near former building locations, roads, and dump sites, exposed high ground (coinciding in some areas with disturbed areas, due to the need to site the former radar installations on or near local high points of land), exposed bedrock, and steeply sloping ground leading down to the ocean. Freshwater habitats include riparian areas associated with small stream channels and wetlands, marsh and bog, and streams. The marine habitat includes the shoreline and Hopedale Harbour.

A broad range of ecological receptors, including freshwater and marine aquatic receptors (fish and benthic invertebrates), terrestrial mammals that have been identified as potentially present at the site have been assessed in this ERA.

Freshwater fish and benthic invertebrates were assessed as a community rather than as individual species. Toxicity benchmarks for these organisms are commonly derived based on COC media concentrations and the adverse effects thresholds for organisms that reside/rely on those media. Additionally, these benchmarks are typically generated using toxicity data for not one, but several species that rely on that medium, and are intended to represent a COC concentration that will be protective of most, if not all species associated with that medium.

The following mammalian species were identified as ecological receptors for quantitative risk evaluation in the ERA:

- masked shrew (*Sorex cinereus*);
- meadow vole (Microtus pennsylvanicus);
- Arctic hare (*Lepus arcticus*); and
- red fox (Vulpes vulpes).

Large wildlife receptors, such as caribou, were also considered but not included as VECs. These animals, although they may occasionally wander onto the site, have very large ranges, and would have very little overall exposure to COCs on site, in comparison with other herbivore VECs (such as the Arctic hare and meadow vole) that have been modelled. Therefore, the present study is designed to provide an accurate picture of current conditions and potential risks, and considers a broad range of ecological habitats and potential receptors.

The following avian species were identified as ecological receptors for quantitative risk evaluation in the ERA:

- Herring gull (*Larus argentatus);*
- American robin (*Turdus migratorius*);
- Short-eared owl (*Asio flammeus*); and
- Common merganser (*Mergus merganser*).

Freshwater streams do not provide productive or significant habitat for fish and most of the ponds on the site also have low productivity. Larger fish such as char and trout are expected to be present only in Big Lake. Sticklebacks were collected from Old Dump Pond and the Reservoir. Some piscivorous birds may feed on sticklebacks. Therefore, it was considered necessary to model the exposure of fish-eating birds to COCs on site. A merganser was modelled to represent freshwater fish-eating birds from the site.

8.6.1 Rare, Threatened, or Endangered Species and Species of Special Concern

The Short-eared owl (*Asio flammeus*) in Newfoundland and Labrador has been reported in tundra, coastal barren, sand dune, field and bog habitats. This species is designated as a "Vulnerable" species in Newfoundland and Labrador under the provincial *Endangered Species Act* (NL ESA E-10.1, 2001). It was also assessed as a species of "Special Concern" in Canada (Committee on the Status of Endangered Wildlife in Canada (COSEWIC), April 1994), and is listed as a species of "Special Concern" under the federal *Species at Risk Act* (*SARA*, Schedule 3). The Short-eared owl is not protected under the Canada-U.S. Migratory Birds Convention, and is listed as an "Appendix 2" species under the Convention on International Trade of Endangered Species (CITES). There has been a long term decrease in this species in Canada but the population is not small enough to be considered threatened. The populations are still stable in the Atlantic Provinces (Government of Newfoundland and Labrador, 2010). Because the Short-eared owl may make occasional use of the Hopedale radar site, this species was considered a representative bird in this ecological risk assessment as is being treated as a sensitive species (see below on how toxicity values are adjusted for sensitive species).

The Harlequin Duck (*Histrionicus histrionicus*) is a small, subarctic sea duck that is listed as "Special Concern" by COSEWIC, as "Special Concern" under Schedule 1 of *SARA,* and as "Vulnerable" under the *Provincial Endangered Species Act*. Satellite telemetry and banding information have indicated that the migration patterns of Harlequin Ducks are variable but many of them spend the winter on the east and south coasts of Newfoundland, in southeastern Nova Scotia, in southern New Brunswick, in Maine, and at a few locations south of Cape Cod (Government of Canada, 2010). Breeding habitat includes fast flowing rivers that may vary in width across the species range. In Labrador, these ducks may breed in narrow, warmer, less acidic rivers (Rodway, 1998). It is estimated that there are two hundred ducks that winter off the coast of Newfoundland and Labrador. There is very limited Harlequin duck habitat (*i.e.*, rivers) on the Hopedale radar site. Therefore, it is considered unlikely that this species would spend substantial time on the site.

The Ivory Gull (*Pagophila eburnea*) has also been observed along the coast of Newfoundland and Labrador and is listed as "Endangered" by COSEWIC, as "Endangered" under Schedule 1 of *SARA,* and as "Vulnerable" by the provincial *Endangered Species Act*. The Ivory Gull breeds in high Arctic coastal areas and winters primarily in the Arctic Seas. They are generally associated with pack ice found north of Newfoundland. The small number of Ivory gulls in Canada are most likely part of a large Holarctic population. In Canada, the numbers of Ivory gull have been stable (Government of Newfoundland and Labrador, 2010). The Ivory Gull was not assessed, although more resident gull species (*i.e.*, Herring gull) will be assessed and will be considered representative of exposure that might be experienced by the Ivory Gull.

The Peregrine falcon (*Falco peregrinus anatum*) nests along the coast of Labrador from Table Bay to Cape Chidley and along a number of major rivers that offer suitable habitat. The tundra Peregrine falcon (*Falco peregrinus tundrius*) is similar to *anatum* and ranges throughout the northern tundra as far south as the treeline. There are about 60 to 70 known nesting sites in Labrador for both species. There is a nationally upward trend for both species but a general decrease in the numbers of the *anatum* species in Labrador (Government of Newfoundland and Labrador, 2010). Both species are listed as "Threatened" by the provincial *Endangered Species*

Act and as a species of “Special Concern” by COSEWIC. The subspecies *anatum* is listed as “Threatened” under Schedule 1 of *SARA* and the subspecies *tundrius* is listed as “Special Concern” under Schedule 3 of *SARA*. The peregrine falcon was not modelled as part of this ecological risk assessment but other predatory bird species (*i.e.*, Short-eared owl) were assessed and are considered representative of exposure that might be experienced by the Peregrine falcon.

The polar bear (*Ursus maritimus*) may be found on ice-covered areas from Labrador to Alaska. They are a sensitive species due to their low densities, low reproductive rates and low recovery rates. The polar bear is currently listed as “Vulnerable” by the provincial *Endangered Species Act* and as a species of “Special Concern” by COSEWIC and as “Special Concern” under the federal *Species at Risk Act* (*SARA*) (no schedule). The population in Canada is considered stable (Government of Newfoundland and Labrador, 2010). Polar bear were reported by local residents to be very rare in Hopedale. Therefore, exposure to the site would be considered minimal. Polar bears were not modelled in this ecological risk assessment.

The eastern population of wolverine (*Gulo gulo*) is thought to extend from Northern Quebec into most of Labrador. It is probable that it has been extirpated from most of its historical range in Eastern Canada. This species is designated as an “Endangered” species in Newfoundland and Labrador under the provinces *Endangered Species Act* (NL ESA E-10.1, 2001). The species is also listed as “Endangered” by COSEWIC and “Endangered” under Schedule 1 of *SARA*. It is unlikely that wolverine would spend substantial time in the Hopedale area as wolverines tend to prefer remote areas far away from humans and development (Canadian Wildlife Service, 2010). In addition, wolverines have very large ranges and would therefore have very little overall exposure to COCs on the site.

8.6.2 Valued Ecosystem Components (VECs)

Valued ecosystem components are defined as resources or environmental features important to human populations that have economic and/or social value, and/or have intrinsic ecological significance. These components also provide a baseline from which the impacts of development can be evaluated, including changes in management or regulatory policies.

Aquatic receptors considered to be VECs in this ecological risk assessment are salmonid fish and the benthic invertebrate communities. Risks to these VECs will be determined primarily by reference to CCME guidelines or equivalent benchmarks.

For the terrestrial ecological risk assessment, the following terrestrial mammals can be regarded as representative species for the site:

Masked shrew: The masked shrew (*Sorex cinereus*) is the most widely distributed shrew in North America, and is found throughout most of Canada (Lee 2001). It is common in moist environments and inhabits open and closed forests, meadows, riverbanks, lakeshores, and willow thickets (Lee 2001). The masked shrew weighs approximately 0.005 kg (US EPA 1993) and has home ranges varying from 2,000 to 6,000 m^2 in size (Saunders 1988). Masked shrews are preyed upon by many small predators such as weasels, hawks, falcons, owls, domestic cats, foxes, snakes, and short-tailed shrews (Lee 2001). The masked shrew does not hibernate (NWF 2003) and feeds year-round. Its diet includes insect larvae (dormant insects in winter), ants, beetles, crickets, grasshoppers, spiders, harvestmen, centipedes, slugs, snails, and seeds and fungi (NWF 2003; Lee 2001). It consumes approximately 0.003 kg of wet-weight food per day and 0.001 L of water or its equivalent per day. For this ERA, the shrew's diet is modeled as including 2.5% terrestrial plant material and 97.5% terrestrial invertebrates. Based on its consumption of these foods, the masked shrew is estimated to incidentally ingest 4.44E-05 kg/day of dry soil.

Meadow Vole: The meadow vole (*Microtus pennsylvanicus*) is a small rodent (approximately 0.042 kg) which makes its burrows along surface runways in grasses or other herbaceous vegetation (US EPA 1993). It is active year-round and is the most widely distributed small grazing herbivore in North America, inhabiting moist to wet habitats including grassy fields, marshes, and bogs (US EPA 1993). Meadow voles are found throughout Canada, roughly to the limit of the tree line in the north. Home ranges vary considerably, from less than 200 m^2 to greater than 830 m^2 (US EPA 1993). Meadow voles are a major prey item for predators such as hawks and foxes, and they feed primarily on vegetation such as grasses, leaves, sedges, seeds, roots, bark, fruits, and fungi, but will occasionally feed on insects and animal matter (US EPA 1993; Neuburger 1999). Meadow voles consume approximately 0.011 kg of wet-weight food and 0.006 L of water or its equivalent per day. For this ERA, the meadow vole's diet is modelled as including 98% terrestrial plant material and 2% terrestrial invertebrates. Based on its consumption of these foods, the meadow vole is estimated to incidentally ingest 3.15E-04 kg/day of dry soil.

Credit: US Fish and Wildlife Service

Arctic Hare: The Arctic hare (*Lepus arcticus*) is found north of the treeline in Canada to the northernmost point of land on Ellesmere Island, Northwest territories, and also on the rock-strewn plateaus and mountains of eastern Newfoundland and Labrador (Best and Henry, 1994). The home ranges of Arctic hares occupy about 2.5 km^2 (Canadian Museum of Nature, 2010). Woody plants are the basic year-round food of the Arctic hare (Hansen and Flinders, 1969) with their main food being Arctic willow (*Salix arctica*) in both winter and summer and they eat all parts of the plant (Klein and Bay, 1994; Canadian Museum of Nature, 2010). Arctic hare are also known to occasionally eat meat (Johnson, 1953) and have been found eating meat used as bait for traps (Freuchen, 1935) and nibbling on carcasses or foraging in garbage dumps (Canadian Museum of Nature, 2010). Foxes, owls and wolves may prey on Arctic hare. Arctic hare consume approximately 0.7 kg of wet-weight food per day and 0.4 L of water or its equivalent per day. For this ERA, the Arctic hare's diet is modelled as including 95% terrestrial plant material and 5% terrestrial mammals and birds. Based on its consumption of these foods, the Arctic hare is estimated to incidentally ingest 5.0E-03 kg/day of dry soil.

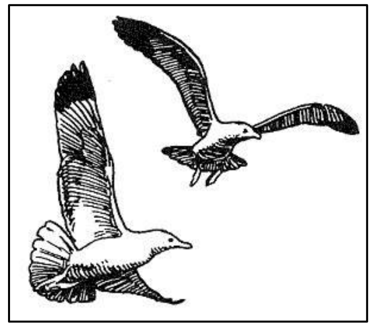
Red Fox: The red fox (*Vulpes vulpes*) weighs approximately 4.5 kg, and is found throughout continental Canada but prefers areas with broken and diverse upland habitats (US EPA 1993). Family territories, consisting of home ranges of individuals from the same family, vary from approximately 0.57 km^2 to over 30 km^2 (US EPA 1993). Foxes are active year-round and prey heavily on small mammals such as voles, mice and rabbits, and will consume birds, insects, fruits, berries, and nuts; they are also noted scavengers (US EPA 1993). Red foxes consume approximately 0.76 kg of wet weight food per day and 0.38 L of water or its equivalent per day. For this ERA, the red fox's diet is modeled as including 10% terrestrial plant material, 5% terrestrial invertebrates, and 85% small mammal and bird prey. Based on its consumption of these foods, the red fox is estimated to incidentally ingest 3.00E-03 kg/day of dry soil.

The following bird species can be regarded as representative species for the site:

American Robin: The American robin (*Turdus migratorius*) is a medium-sized bird (weighing approximately 0.08 kg; US EPA, 1993) that occurs throughout most of Canada during the breeding season and overwinters in mild areas of Canada (CWS & CWF 2005). Access to fresh water, protected nesting habitat, and foraging areas are important to the American robin. Nesting habitat includes moist forest, swamps, open woodlands, orchards, parks, and lawns (US EPA 1993), and the American robin is well adapted to urban living, as well as having a summer range that extends up to the tundra. The American robin consumes approximately 0.065 kg of wet weight food and 0.01 L of water or its equivalent per day. For this ERA, the American robin's diet is modelled as including 52.3% terrestrial plant material and 47.8% soil invertebrates. Based on its consumption of these foods, the American robin is estimated to incidentally ingest 4.85E-04 kg/day of dry soil.

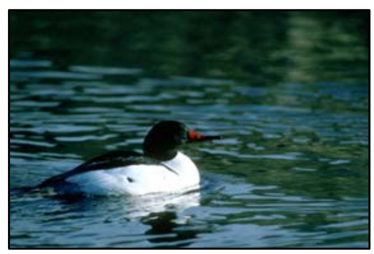
Short-eared Owl: The Short-eared owl (*Asio flammeus*) is widespread throughout all of North America, and is one of the most widely distributed owls in the world (Doan 1999), although it may be considered a species of special conservation status in some jurisdictions. The Short-eared owl weighs approximately 0.35 kg. Found in open, treeless areas, this species is a daylight and twilight hunter found in marshes and bogs and uses similar habitats during the summer and winter (Doan 1999). Short-eared owls have relatively small home ranges of approximately 0.15 km^2 to 2 km^2 (Lewis 2005) during the breeding season. Short-eared owls nest on the ground on dry sites in open country where small mammal prey is abundant (Doan 1999). In addition to small mammals such as voles and mice, Short-eared owls also prey upon birds and occasionally insects (Lewis 2005). They consume approximately 0.09 kg of wet weight food per day and 0.03 L of water or its equivalent per day. The Short-eared owl's diet is modeled as including 95% small mammals and 5% terrestrial invertebrates. Based on its consumption of these foods, the Short-eared owl is estimated to incidentally ingest 3.63E-04kg/day of dry soil. As noted above, this species is designated as a “Vulnerable” species in Newfoundland and Labrador under the provincial *Endangered Species Act* (NL ESA E-10.1, 2001), is of “Special

Concern" in Canada (Committee on the Status of Endangered Wildlife in Canada (COSEWIC), April 1994) and listed as a species of "Special Concern" under the federal *Species at Risk Act* (*SARA*, Schedule 3).



Credit: US Fish and Wildlife Service

Herring Gull: Herring gull (*Larus argentatus)* populations are found both inland, and near marine coasts. The Herring gull is a medium- to large-sized seabird, weighing approximately 1.1 kg (US EPA 1993). It has the largest range of any North American gull (US EPA 1993) and is one of the most widespread species in Canada (CWS & CWF 2005). The Herring gull is migratory with the exception of adult residents in the Great Lakes area, which are year-round residents (US EPA, 1993). Herring gulls always nest near a body of water, and may be found beside lakes, rivers, in grassy meadows, on garbage dumps, golf courses, islands, cliffs, and islands (CWS & CWF 2005). In winter, Herring gulls are most likely to congregate on beaches along oceans and other large bodies of water (CWS & CWF, 2005). Herring gulls feed on almost anything, including fish, squid, crustacea, molluscs, worms, insects, small mammals and birds, duck and gull eggs and chicks, amphibians, and garbage, with foraging home ranges from approximately 3 km^2 to 7850 km^2 (US EPA, 1993). They will consume approximately 0.25 kg of wet weight food and 0.06 L of water or its equivalent per day. The Herring gull's diet is modelled to include 7.5% soil invertebrates, 15% terrestrial mammals, 7.5% marine invertebrates, and 70% marine fish. Based on its consumption of these foods, the Herring gull is estimated to incidentally ingest 3.62E-04 kg/day of dry soil, and 9.59E-04 kg/day of dry marine sediment.



Credit: US Fish and Wildlife Service

Common Merganser: The Common merganser (*Mergus merganser*) is a large, cold-hardy, piscivorous duck that nests near large lakes and rivers in northern forested habitats (Mallory and Metz, 1999). This species is one of the largest of Canada's ducks (Environment Canada, 2010). The merganser feeds mainly on small fish (Dement'ev *et al*., 1952, Del Hoyo *et al*., 1992). Mergansers will consume approximately 0.3 kg of wet weight food and 0.08 L of water or its equivalent per day. The merganser's diet is modelled to include 100% freshwater fish. Based on its consumption of these foods, the merganser is estimated to incidentally ingest 8.6E-04 kg/day of dry sediment.

8.7 Hazard Identification

The ERA is concerned primarily with substances that are present in environmental media that are accessible to wildlife or aquatic biota. Therefore, the available data for the site were screened to consider data for surface soils (0 to 30 cm depth) as well as freshwater and marine sediments and surface waters. Subsurface soils and groundwater samples were not considered in the ERA, although they were considered in the Human Health Risk Assessment (HHRA). Therefore, although both the HHRA and the ERA draw from the same overall dataset, they are not based on identical subsets from that data.

In addition to sampling water, sediment, and soils, certain biological materials were also collected at the Hopedale radar site and were analyzed for selected high-priority COCs in order to reduce overall uncertainty that would otherwise be incorporated into the ERA model. These biological materials and analytes included:

- vegetation (primarily green leaves, grasses, moss analysed for metals and PCBs);
- berries (analysed for metals and PCBs);
- small mammals (voles and squirrels analysed for metals and PCBs); and,
- freshwater fish (analysed for metals and PCBs).

Data not included in the ecological assessment consisted of QA/QC samples such as field blanks, trip blanks, and matrix spike samples, and surrogate recovery results. For duplicate samples, the higher reported value from the duplicate pair was incorporated into the data set. In addition, where results were below reportable detection limits (RDLs), one half of the RDL was used as the representative COC concentration. As stated previously, sediment and soil samples that were collected from a depth greater than 30 cm were not included in the data set because ecological receptors would not contact soil and sediment at this depth.

8.7.1 Screening of Chemicals of Concern

Chemicals of concern were selected based on their concentration in surface soil, surface water and sediments, and their potential toxicity to ecological receptors (*i.e.*, metals and PCBs measured in plants, mammals and fish). An initial generic assessment of the potential for adverse effect associated with site-originated chemicals was conducted. In this assessment, the maximum detected concentration from each environmental medium in each area was compared to established environmental criteria (*i.e.*, "screening values") that are designed for the protection of ecological receptors.

The following values were used for the screening of chemicals in surface water and sediment for inclusion in the aquatic ecological risk assessment:

- Surface Water: Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 1999, updated 2007); and,
- Sediment: Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1999, updated 2002).

The following screening values, in order of preference, were used for the screening of chemicals in soil for inclusion in the terrestrial ecological risk assessment:

- CCME Canadian Soil Quality Guidelines for Residential/Parkland land use for protection of environmental health (1999, revised 2007, 2008, 2009 and 2010). Pathway-specific information from the individual fact sheets was reviewed to confirm ecological health guidelines;
- CCME Canada Wide Standards Tier I levels for surface soil for Residential/Parkland land use (2008);
- Alberta Environment Tier I and II Soil Remediation Guidelines for Residential/Parkland land use, ecological guidelines (2009); and,

- Ontario Ministry of the Environment guidelines for soil at a Residential site, ecotoxicity-based values (2004).

Maximum site concentrations were initially compared to the screening guidelines discussed above. Chemicals with concentrations that were less than the screening guideline were not carried forward for further assessment. Where an applicable guideline did not exist and a substance was detected in measurable concentrations above the guideline, the substance was carried forward to the next step in the screening framework, which was a comparison to background concentrations.

If concentrations exceed the applicable guideline, it does not necessarily mean that unacceptable risks exist. Concentrations of each chemical were also compared to background concentrations. If the concentration of a chemical was considered comparable to the selected background concentrations, the chemical was not carried forward any further in the risk assessment. Where no background concentrations were available, the substance was carried forward to the next step in the screening framework.

Substances that are major mineral forming elements of low inherent toxicity, or that are nutrients and of low inherent toxicity were excluded as chemicals of concern. These included aluminum, iron, manganese, calcium, magnesium, sodium, potassium, chloride, nitrate, nitrite, phosphorus, silica and sulfate. Elevated concentrations of iron and manganese can be associated with the discharge areas for chemical plumes in groundwater, particularly plumes of organic substances that can degrade in the environment and consume oxygen. Surface deposits of iron and manganese in wetlands or stream beds are typically readily identified by iron staining (typically a rusty orange deposit). These deposits are typically not hazardous to wildlife receptors by themselves, although substances associated with the groundwater plume may be. However, such areas are typically identified in the field and sampled as areas of potential contamination. Therefore, for the purpose of this ERA, iron and manganese are considered non-hazardous, and it is assumed that any associated organic contaminants (such as TPH, PAHs, or solvents) will be identified and assessed on a substance-specific basis.

Limited toxicity information exits for bismuth, boron, lithium, rubidium, and strontium. These elements often occur naturally or are associated with seawater spray. The presence of low concentrations of these metals is unlikely to be a result of historical site activities.

8.8 Hazard Identification Results – Aquatic ERA

As discussed previously, there are eight freshwater habitats and one marine habitat within the Hopedale site. Because most aquatic receptors spend their entire life within one particular water body, each aquatic habitat was assessed separately. The columns under the heading "Screening" in Tables 27.1 to 27.14 (Appendix 27) present the ecological screening for petroleum hydrocarbons, PCBs, PAHs and metals in sediment and surface water following the screening framework outlined above. For aquatic receptors, the risk assessment was limited to the separate consideration of the specific concentrations of substances in water or sediment that exceeded relevant guidelines or benchmarks.

Chemicals in surface water and sediment carried forward for further assessment at each aquatic site are summarized in Table 8.1. All other substances analysed for in the sediment and surface water of each aquatic habitat are either 1) not of toxicological concern, 2) were non-detectable in all samples, 3) in the event that they were detected, the maximum value was below the screening guideline, or 4) concentrations are comparable to background concentrations.

Table 8.1 Chemicals in sediment and surface water carried forward for further assessment in the aquatic ecological risk assessment

Site	Chemicals Requiring Further Assessment	
	Sediment	Surface Water
Subdivision Stream	TPH, PCBs, Barium, Cobalt, Vanadium, Uranium	Toluene, Xylenes, Barium, Cadmium, Copper, Uranium, Zinc
Old Dump Pond	TPH, PCBs, Antimony, Barium, Cadmium, Cobalt, Lead, Mercury, Molybdenum, Nickel, Silver, Tin, Uranium, Vanadium, Zinc	Cadmium, Copper, Lead, Uranium
Small Pond Bog	TPH, PCBs, Barium, Cobalt, Copper, Molybdenum, Nickel, Uranium, Vanadium	Not tested
Old Dam	Toluene, TPH, Cobalt, Nickel, Vanadium	Not tested
Valley Drainage Ponds	TPH, Vanadium	Not tested
Reservoir	Barium, Cobalt, Molybdenum, Nickel, Selenium, Uranium, Vanadium	None
Second Reservoir	Cobalt, Nickel, Selenium, Uranium, Vanadium	None
Big Lake	Barium, Cobalt, Nickel, Vanadium	Lead
Wharf Area	TPH, PCBs, Barium, Nickel, Vanadium	Not tested

8.9 Hazard Identification Results – Terrestrial ERA

Given the size of the Hopedale radar site and the complex pattern of anthropogenic contamination within the area, the site was assessed differently for terrestrial VECs with small home ranges than for terrestrial VECs with large home ranges. The home range for Arctic hare, Short-eared owl, American robin, Herring gull, and merganser are considered large enough so that it is likely that these VECs would spend substantial time foraging over the entire Hopedale radar site including areas of the Town. Therefore, when determining exposure for these VECs, the chemical data for each medium for the entire site were compiled. The maximum concentration identified in this dataset was used for screening purposes. If the maximum concentration identified exceeded the screening guideline, the chemical was carried forward. All the site data were used to calculate an EPC that these VECs would be exposed to. It is conservatively assumed that these VECs would spend all their time (except for migratory animals), within the Study Area exposed to the EPC.

The home ranges for masked shrew, meadow vole and red fox are potentially smaller than the radar site. It is therefore possible that these VECs could spend their entire life in one particular portion of the radar site. Therefore, the site was separated into three smaller areas (shown on Drawing No. 121410103-EE-27b) for assessment. These areas include:

- Area 1 (0.61 km^2): BMEWS, Valley Drainage Ponds, Reservoir
- Area 2 (0.69 km^2): Main Base, Pit No. 2, Mid Canada Line, Old Base1, Pallet Line

- Area 3 (0.29 km^2): Pit No. 1, Pit No. 3, Small Pond Bog, POL Compound, Old Dump Pond

The data for each of the sites within each Area were compiled and the maximum concentration from the Area was used for screening purposes. The dataset for each Area was used to calculate an EPC that these VECs would be exposed to. It is further conservatively assumed that these VECs would spend all their time, within the area assessed exposed to the EPC. It should be noted here that the Town of Hopedale and the newer residential area were not considered as an area for small mammals, although it was considered in the overall ERA for the larger VECs. It is recognized that the home ranges of the vole (as small as 0.0002 km^2) and the shrew (may range from 0.0003 km^2 to 0.0007 km^2) are smaller than the areas assessed. This was necessary, however, because few surface soil samples were collected from several sites (*e.g.*, POL Compound, Mid-Canada Line). It was considered more representative to combine sites that are within close proximity to calculate an EPC.

As discussed in the human health risk assessment, concentrations of several metals including copper, mercury, molybdenum, and nickel were elevated in one test pit (TP229) from the Old Dump Pond area but were not elevated in any other samples from the Residential Area. In addition, concentrations of antimony and lead were particularly elevated in this test pit. During excavation of the test pit, metal debris was noted to be present. This test pit is considered an anomaly for several metals and the results may skew the EPCs for metals such as antimony and lead. Therefore, the analytical results from this test pit were not included in the calculations and the risk assessment. Instead, recommendations will be made later in this report to remove the soil and associated debris from this area. This test pit is not included further in the ecological risk assessment.

Tables 27.15 to 27.18 (Appendix 27) present the ecological screening for petroleum hydrocarbons, PCBs, PAHs, and metals in soil following the screening framework outlined above. Chemicals in surface soil carried forward for further assessment at each Area are summarized in Table 8.2. All other substances analysed for in the soil at each Area are either 1) not of toxicological concern, 2) were non-detectable in all samples, 3) in the event that they were detected, the maximum value was below the screening guideline, or 4) concentrations are comparable to background concentrations.

Table 8.2 Chemicals in soil carried forward for further assessment in the terrestrial ecological risk assessment.

Site	Chemicals Requiring Further Assessment
	Soil
Area 1:	TPH, PCBs, Cadmium, Tin, Zinc
Area 2:	TPH, PCBs, Cadmium, Chromium, Cobalt, Copper, Lead, Molybdenum, Selenium, Tin, Zinc
Area 3:	TPH, PCBs, PAHs, Antimony, Chromium, Copper, Lead, Mercury, Molybdenum, Nickel, Selenium, Tin, Zinc
Whole Site:	TPH, PCBs, PAHs, Antimony, Cadmium, Chromium, Copper, Lead, Molybdenum, Nickel, Selenium, Tin, Zinc

For mammals and birds, it is not realistic to assess the potential effects of a substance in one medium, to the exclusion of other media. This is because the dose to the receptor organism may exceed a critical level if doses from all media are summed, regardless of whether the concentration in any one medium was within an acceptable range or not. Therefore, when assessing exposure of mammals and birds, if a substance was carried forward for one medium, it was also carried forward for the other media.

8.10 Statistical Summary for COCs Carried Forward

The ESA process results in positively biased data, because the majority of samples are collected at locations where contamination is expected, or to delineate known areas of contamination. As a result, relatively few samples are usually taken from areas of the site where human impacts have been minor or negligible, and the data will tend to overstate or over-represent the true presence and concentration of COCs in soil and other media.

In addition to this inherent source of conservatism, an additional layer of conservatism is introduced through statistical analysis of the data. The primary purpose of the statistical analysis is to determine representative exposure point concentrations (EPCs) for estimating potential risks associated with COCs in the various media. The EPC is an estimate of a reasonable upper limit value for the average chemical concentration in the medium, determined for each exposure unit (US EPA, 1989). The appropriate upper confidence limit (UCL) provides reasonable confidence that the true site average will not be under estimated (US EPA, 1992). ProUCL 4.0 (US EPA, 2007) was used to determine the appropriate upper confidence limit (UCL) given the specific distribution of the site specific analytical results data.

At several sites, limited data were available for certain chemicals carried forward. If the number of samples analysed was less than ten, the maximum was used as the EPC. Where a chemical was not detected in any sample for one medium, but the concentration exceeded the screening guideline in another, the substance was assessed at half the detection limit in the former medium.

EPCs are presented in the screening tables in Appendix 27.

8.11 Exposure 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 (US EPA, 1989):

- a source of COC must be present;
- release and 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 ingestion, inhalation, or direct contact.

The sources of the COCs for the study area are:

- surface soils distributed throughout the site;
- freshwater sediment and surface water associated with streams and ponds at the site;
- marine sediment and surface water in Hopedale Harbour; and,
- terrestrial and aquatic plants, soil and aquatic/sediment invertebrates, fish and small mammals and birds consumed as prey items by VEC.

Subsurface soils and groundwater were not considered as potential sources of COC exposure. There are no direct exposure pathways for ecological receptors for either of these environmental media and transport of contaminants from these sources to surface soil was expected to have a negligible contribution.

An exposure route is the mechanism by which a receptor species might be exposed to a chemical from a given source medium. For surface soils and terrestrial receptors, including mammals and birds, exposure to COC may occur through one or more of the following routes:

- dermal contact (skin/fur/feathers) with soils;
- incidental ingestion of soil (*i.e.*, as a result of feeding or grooming and including inhalation of dusts);
- ingestion of surface water;
- ingestion of plants or prey species that have accumulated chemicals from the soil; or,
- inhalation of volatile contaminants migrating from the soil to ambient air.

The inhalation pathway is typically of negligible importance for wildlife receptors in open air situations. Therefore, inhalation of vapours has not been considered a significant exposure pathway for the ERA at the site. Ingestion of dust and soil particles through feeding and grooming activities, however, is assumed to also implicitly account for both dermal contact and inhalation of dust.

In aquatic habitats, exposure of birds and mammals to contaminants in surface water and sediment may occur through the following routes:

- dermal contact with surface water and sediment;
- ingestion of surface water;
- incidental ingestion of sediment (*i.e.*, as a result of feeding or grooming); or,
- ingestion of aquatic prey species (amphibians, fish and/or invertebrates) that have accumulated chemicals from sediment or surface water.

Although in some cases aquatic plants are considered in an ERA, at the site there were no significant stands of aquatic plants (weedbeds or reed-beds) that justified their inclusion.

Aquatic and sediment dwelling species such as amphibians, fish, invertebrates, and plants are subject to equivalent exposure pathways as those listed for birds and mammals. However, exposure pathways for the former are more typically limited to direct contact with surface water and sediment. This is primarily for practical reasons since quantitative data describing exposure factors and food-web interactions between aquatic species is incomplete, and contaminant aquatic toxicity is typically expressed in terms of either concentration in surface water or sediment. Deriving an exposure rate (mg/kg-day) for a fish would be difficult and of limited value for the risk assessment. The ingestion and related food-web pathways are not ignored. It is simply assumed that these pathways have been included in the overall guideline or benchmark that is assumed to be protective for these biota.

The choice of site-specific exposure pathways is dependent on the nature of the contaminants, their source environmental media, and nature of VECs being considered in the ecological risk assessment.

8.12 Conceptual Site Model

A conceptual site model was developed for the Hopedale radar site, and is presented in Figure 27-1 in Appendix 27. This figure schematically represents the interactions between the VECs and the COCs, via the exposure pathways identified in previous elements of the problem formulation phase of the assessment. In Figure 27-1, the relevant exposure pathways are designated by arrows leading from the contaminant source media to each VEC. The pathway is considered to be complete (*i.e.*, functioning) for a VEC when the exposure pathway box is marked with an X.

8.13 Selection of Assessment and Measurement Endpoints

Assessment endpoints are explicit expressions of environmental values or characteristics to be protected at a site, and reflect societal and ecological values (Suter, 1993). Societal values address the need to protect species that are endangered, threatened, or of special interest, important as game or commercial species, or that are recognized as having aesthetic value. Ecological relevance refers to the importance of the species to the function of the ecosystem. Therefore, evaluation of potential for adverse effects at the population level (*i.e.*, the entity) is used to infer potential for adverse effects at higher levels of organization, such as communities and ecosystems. For the site, assessment endpoints (*i.e.*, the attribute) implicitly focus on populations of aquatic organisms such as plants, fish and invertebrates that may be reduced due the presence and concentrations of chemicals of concern in surface water and sediments. For birds and mammals inhabiting the site, assessment endpoints also focus on maintenance and protection of their populations, such that contaminants in the surface water, sediment and soil would not substantially affect either species abundance or diversity.

Based on the conceptual model for each ecological habitat, the following assessment endpoints are identified for the ecological risk assessment:

- Assessment Endpoint 1: Populations of aquatic invertebrates and fish should not be reduced as a result of increased mortality or decreased reproduction because of the presence of COCs in surface water or sediments.
- Assessment Endpoint 2: Populations of birds or mammals should not be reduced as a result of increased mortality or decreased reproduction because of the presence of COCs in soils, sediment or surface water.

The information needed to deal directly with the assessment endpoints is difficult to generate and rarely available. Thus measurement endpoints are used to bridge the gap. Measurement endpoints are measurable responses to stressors related to assessment endpoints, and are intended to provide a basis for assessing risk potential for the assessment endpoint. They may be defined in terms of an unacceptable level of impact to ecological receptors, such as a certain relative percent decrease in survival, growth or reproduction of ecological populations (Suter, 1993). As part of a weight-of-evidence approach, one or more measurement endpoints may be used for each assessment endpoint.

Choice of measurement endpoints for each interaction between a VEC and a chemical of concern is typically limited by available toxicity data. Those most commonly used to quantify the survival, growth and reproduction of receptors in bioassays include the lethal concentration, 50% (LC50) and lethal dose, 50% (LD50) (concentrations or doses that will be lethal to 50% of exposed organisms, over a defined period of exposure); the effective concentration, 50% (EC50) and effective dose, 50% (ED50) (concentrations or doses that elicit a defined response or effect over a defined period of time); the Lowest Observed Adverse Effect Level (LOAEL); and the No-Observed Adverse Effect Level (NOAEL). Although the dose-response relationships derived from these measurement endpoints are characteristic of test species exposed under controlled conditions, appropriate safety factors are included in order to consider the response of species in the natural environment.

The measurement endpoints for each ecological habitat type in this assessment are as follows.

Measurement Endpoints for Assessment Endpoint 1:

- Whether observed concentrations of chemicals in surface water or sediment are likely to result in increased mortality or decreased reproduction of fish, or decreased biomass, species richness, or diversity of aquatic invertebrates upon chronic exposure.

Measurement Endpoints for Assessment Endpoint 2:

- Whether observed concentrations of chemicals in water, sediment or soils are likely to results in doses to birds or mammals that are greater than those observed to result in increased mortality or decreased reproduction upon chronic exposure.

Therefore, the key component of this ecological risk assessment is:

- Characterization of relationships between the dose resulting from the amount of a chemical present in surface water, sediment and surface soils and a threshold dose for adverse effects.

8.14 Derivations of Oral Toxicity Reference Values for Mammalian and Avian Receptors

The toxicological database in support of a toxicity reference value (TRV) preferably includes a number of chronic or multi-generational exposure studies involving exposure of relevant test species (*i.e.*, the ecological receptor of interest or a phylogenetically similar species) to appropriate chemical forms of the substance of interest. Ideally, one or more relevant biological endpoints such as growth, reproductive effects, or survival were measured in the study.

Databases that meet this requirement are available for some chemicals, but in most cases, available toxicity data are limited to studies conducted with laboratory animals (*e.g.*, mammals: mice, rats, rabbits; birds: quail, chicken, ducks).

TRVs for this ERA are based on dose-response studies, typically conducted with laboratory animals where the lowest observed adverse effects level (LOAEL) or no observed adverse effects level (NOAEL) has been quantified. Toxicity reference values used in this risk assessment were determined from studies in which endpoints were derived from the administered dose, rather than the absorbed dose. This is a conservative approach because compounds are often administered in a more available form than would be found in the environment

The preferred toxicity measure used for derivation of TRVs in this ERA is the LOAEL; however, in the absence of a suitable LOAEL, NOAEL-based TRVs were used. Generally, LOAELs used towards TRV derivation are based on long-term growth or survival, or sub-lethal reproductive effects determined from chronic exposure studies. As such, these endpoints are relevant to the maintenance of wildlife populations. The LOAEL represents a threshold dose at which adverse outcomes are likely to become evident (Sample et al. 1996). This threshold is considered an appropriate endpoint for ERA because TRVs are used as the denominator in the hazard quotient (HQ) calculation, and HQs equal to or greater than one may be considered indicative of potential adverse environmental effects. Hazard quotients calculated with NOAEL-based TRVs are more conservative because NOAELs relate to the threshold at which no individual environmental effects from COC exposure are observed.

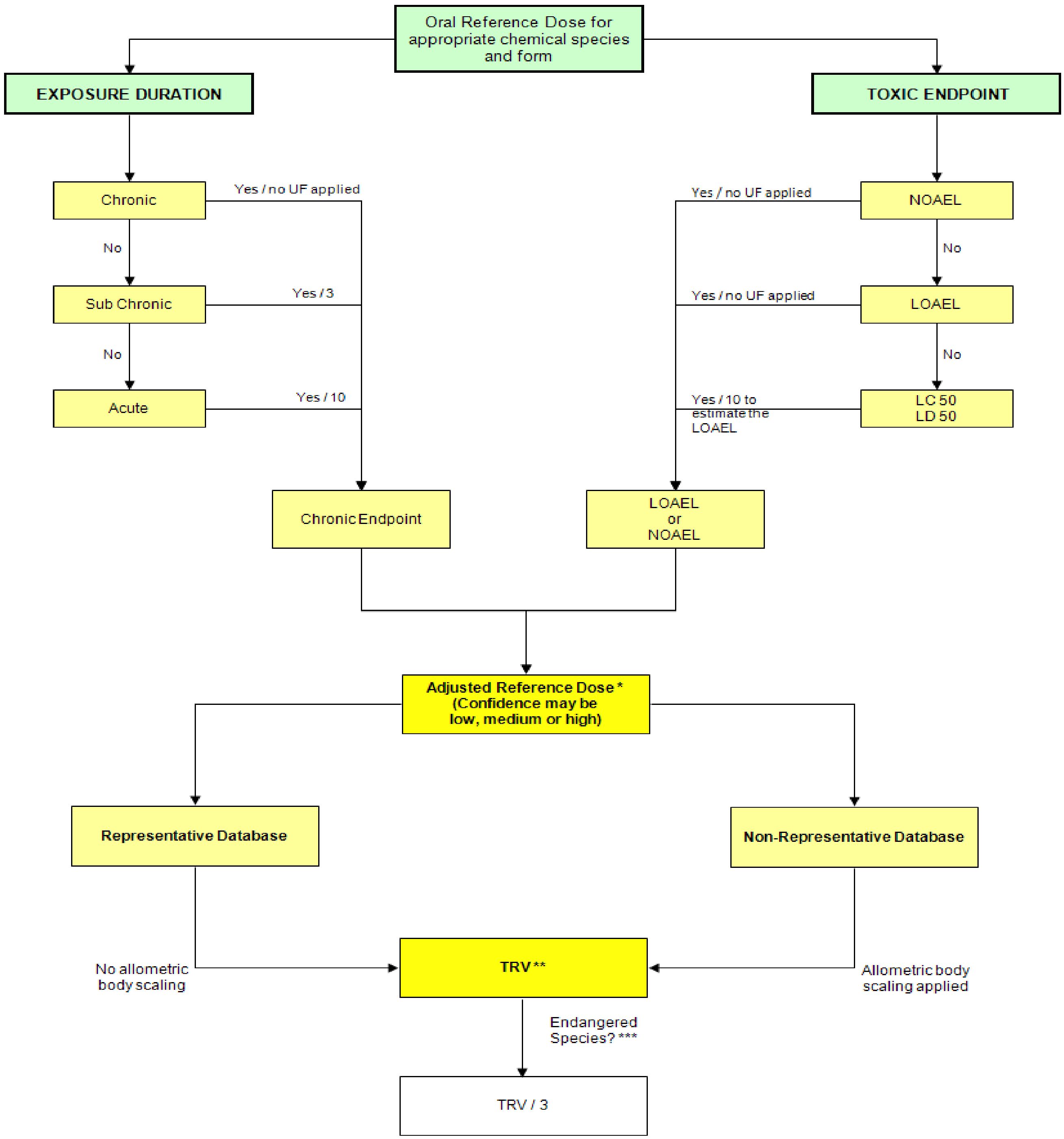
Numerous sources were reviewed to obtain the most relevant TRVs for ecological receptors. Information sources included, but were not limited to:

- Oak Ridge National Laboratory Toxicity Benchmarks for Wildlife (Sample et al. 1996);
- US Environmental Protection Agency's Ecological Soil Screening documents;
- Agency for Toxic Substances and Disease Registry (ATSDR);
- Canadian Environmental Protection Act (CEPA), Priority Substance List Assessment Reports; and
- primary scientific literature.

8.14.1 Uncertainty Factors

For COCs where LOAELs or NOAELs were not available, sub-chronic or acute toxicity measures such as median lethal dose (LD50) were obtained and modified using Uncertainty Factors (UFs) to convert these values to surrogate chronic values. Chronic LOAEL data derived from studies that assess reproductive, survival, or growth endpoints, as the basis for predicting wildlife population-level responses to contaminants is preferred. The LOAEL-based benchmark represents a threshold level at which adverse health outcomes are likely to become evident (Sample et al. 1996). The use of the LOAEL is appropriate because a TRV based on the LOAEL is used as the denominator in the hazard quotient (HQ) calculation, and HQ greater than 1.0 are considered indicative of potential adverse environmental effects. In cases where no chronic LOAEL is available, a NOAEL toxicity value may be selected, or UFs may be applied to other existing exposure and toxicological data using a tiered process to derive suitable ecological TRVs. When TRVs are based on US EPA Ecological Soil Screening Levels (Eco-SSLs), NOAELs are often the selected endpoint, but can vary depending on the chemical. The UF scheme outlined here (Figure 8.2) is based on guidance provided by Ohio EPA (2003, 2008), US EPA (2002), Sample and Arenal (1999) and professional judgment

Figure 8.2 Tiered Approach for the Application of Uncertainty Factors in ERA



* A NOAEL can be used if no appropriate LOAEL is available but the resultant RfD should be considered more conservative than if it was derived using the LOAEL. Refer to document text for details.
** No inter-class UF is used to derive TRVs (*i.e.*, mammalian data are not used as the basis to derive avian TRVs)
*** An UF of 3 is not required if the RfD for an endangered species is based on a NOAEL. Refer to document text for details.

8.14.2 Uncertainty Factors for Exposure Duration

In cases where a search of scientific data indicates a lack of chronic studies for a particular COC, UFs may be applied to adjust toxicity data to a chronic exposure basis. Acute studies are those that are of short duration, generally less than one week. Sub-chronic exposures are of longer duration (generally less than 90 days), but may be considered equivalent to a chronic study if a critical life stage (such as the gestational period) is included. Chronic exposures would generally be greater than 90 days in length, exceeding 50% of the animal's lifespan, or including a reproductive period. An UF of 3 (half an order of magnitude on a log scale) is applied to adjust from sub-chronic to chronic, and 10 to adjust from acute to chronic. It should be noted that preference is given to longer duration exposure assessments in cases where published data are available, and acute data are relied on only when absolutely necessary.

8.14.2.1 Uncertainty Factors for Toxicity Endpoint

In cases where a search of scientific data indicates the absence of reproductive or other performance-based toxicity endpoints that would indicate a potential for adverse environmental effects at the population level, other less sensitive toxicity endpoints may be considered. Where only a lethal dose (LD50) is available, an UF of 10 (an order of magnitude) is applied to derive a LOAEL from LD50 data. Again, it should be noted that preference is always given to sub-lethal data, and lethal data are relied on only when absolutely necessary.

NOAELs are not adjusted upwards to estimate LOAELs. Where the only chronic endpoint available is a NOAEL, it is used directly and reported as such in the discussion of uncertainties. Hazard quotients based on the NOAEL may be permitted to exceed a value of 1.0 because the NOAEL is not an endpoint that signifies toxicological effects.

8.14.2.2 Uncertainty Factors for Individual Risk

In ERA, the focus of the assessment is normally to provide protection for wildlife at the population level. This is in contrast to human toxicology and human health risk assessment, where protection of individuals is of paramount concern. An exception to this, which has regulatory force through federal legislation such as the *Species at Risk Act* and equivalent legislation in most provinces, occurs when species that are formally protected are evaluated. To ensure that endangered species are afforded an appropriate level of protection in ERA, TRVs that are based on the NOAEL, or LOAEL with an UF of 3 (half order of magnitude) applied are used. This is an arbitrary value based on professional judgment and is expected to be protective yet realistic. These two approaches are considered to be equivalent, and are intended to ensure that endangered wildlife receptors are not exposed to levels of COCs that would cause an adverse effect at the individual level.

8.14.2.3 Body Mass Scaling Factors

Aside from the use of UFs, a number of other methods have been used to extrapolate toxicity data between species with different body masses. The application of acute-based extrapolation factors (derived using lethal dose, 50% (LD50), hazardous dose, 5% (HD5), and standard deviation) to reproductive toxicity data (*e.g.*, Luttik et al. 2005), interspecies correlation estimation (ICE) models (Raimondo et al. 2007) and allometric scaling (Travis and White 1988; Chappell 1992; Mineau et al. 1996, Sample and Arenal 1999) have all been used in ERA. Each of these methods has positive and negative attributes, and none is without its drawbacks for extrapolating toxicity data between laboratory and wildlife species. Ultimately, the choice in method for use in an ERA comes to scientific defensibility, practicality, and professional judgment. In this ERA, an allometric scaling factor of body mass raised to the exponent of 0.75 for both mammalian and avian receptors in the ERA is applied. The allometric scaling factor should hold true in any direction, however, to maintain conservatism in the ERA, a large test animal is not scaled to a much smaller receptor animal, which could potentially inflate the TRV.

8.15 Exposure Assessment

To evaluate the level of exposure for each ecological receptor to each potential COC evaluated in the terrestrial ERA, it is necessary to first estimate the concentration of each COC in various media or biological tissues (*e.g.*, for the current site, this would include soil, water, and representative plant and animal tissues). Soil, surface water, sediment, fish, small mammals, terrestrial vegetation samples were analysed for metals and PCBs. Other COCs (*e.g.*, TPH) were not analysed in biological tissues because they are not considered to bioaccumulate.

To estimate the potential environmental effects at the site for each receptor, EPC values for soil, terrestrial plants, soil invertebrates, and small mammals were either calculated using site data where such data exists or in the absence of such data, were calculated using environmental fate and transport equations or uptake factors which describe the relationships between chemical concentrations in environmental media and concentrations in biota. In the following sections, details of the equations and methods used to derive EPC values for biota (where no such data exist for the site) in the ERA are discussed.

The term “uptake factor” (UP) may be used generically in this document to refer to any of several specific terms, including:

- Bioaccumulation Factor (BAF), the ratio of a COC concentration in an organism or biological tissue (*e.g.*, a soil invertebrate) to the concentration in a surrounding medium (*e.g.*, soil); and
- Bioconcentration Factor (BCF), a specific term that refers to the ratio of a COC concentration in an aquatic organism (*e.g.*, fish) to the concentration in the surrounding water.

Common sources of error in environmental fate and transport calculations involve confusion between wet and dry weight units for chemical concentrations in soil, sediment, and biota, and unit errors stemming from the fact that inorganic substances are commonly reported in units of milligrams (mg/L or mg/kg) in environmental media, whereas many organic substances are reported in units of µg (micrograms), ng (nanograms), or even pg (picograms). To manage these problems in this ERA, all chemical concentrations are converted to units of mg/L or mg/kg. For water, all chemical concentrations and intakes are based on units of mg/L. For soil or sediment, all concentrations are expressed on a dry weight basis (mg/kg dry weight soil or sediment). For plant and animal tissues, all concentrations are expressed on a wet weight basis (mg/kg wet weight tissue).

The uptake factor literature is likewise inconsistent, with some uptake factors being expressed on a wet tissue basis, others on a dry tissue basis, and still others being normalized on the basis of tissue lipid to sediment organic carbon content. The ERA model requires EPC values on a wet tissue basis for biota that are ingested as foods by ecological receptors. Therefore, where possible, uptake factors are expressed on a wet tissue basis; where necessary, correction factors are applied in order to convert from dry weight tissue units to a wet tissue basis.

8.15.1 Biological Uptake Factors

The generalized uptake factor equation used to calculate a COC concentration in an organism or biological tissue (*e.g.*, soil invertebrates) from the concentration in a surrounding medium (*e.g.*, soil) is as follows:

$$EPC_j = EPC_i \times UP_{ij}$$

Where:	EPC_j	=	exposure point concentration in biological compartment *j* (*e.g.,* mg/kg wet weight soil invertebrate tissue);
	EPC_i	=	exposure point concentration in environmental medium i (*e.g.,* mg/kg dry soil); and
	UP_{ij}	=	uptake factor from surrounding medium (in this case soil) to the target biological tissue (*e.g.,* mg/kg wet tissue / mg/kg dry soil).

8.15.1.1 Soil to Terrestrial Plants, UP_{SP}

Most uptake factors are initially reported in dry weight units (*i.e.*, mg/kg dry weight plant / mg/kg dry weight soil) and converted to wet weight for plants by assuming an 85% water and 15% dry solids content (typical value for dicots; US EPA 1993). The conversion is effected by multiplying dry weight transfer factors obtained empirically or from the literature by the fraction dry solids content, typically assumed to be 0.15 for herbaceous terrestrial plants.

Bioavailability of selected compounds to plants may be modified using a soil-to-plant bioavailability factor (unitless, potentially ranging from 0 to 1). This empirically represents factors that limit the potential for organic compounds to cross the soil-root barrier, where this is not already factored into the uptake models based on empirical data. Compounds that have a high tendency to sorb to soil solids become inactivated or have low bioavailability. Graham-Bryce (1984) noted that this occurs for substances that have K_d values greater than 1000 L/kg, and Ryan *et al.* (1988) relate this to organic compounds having log K_{ow} values of between 5 and 6, or greater. The Ryan et al. (1988) model reflects variable bioavailability by including partitioning and competition between soil organic carbon and plants for uptake of organic contaminants in soil pore water. Presently, the bioavailability factor is set at 1 (*i.e.*, all contaminants are fully bioavailable). Exceptions could be made based on professional judgment where the model of Ryan et al. (1988) is not already being used.

In addition to having limited bioavailability, some organic compounds are also potentially metabolized by plants, or may be volatilized across plant leaf surfaces. Therefore, the potential loss of selected organic compounds from plant tissues can be represented using an empirical metabolic factor (unitless, potentially ranging from 0 to 1). Presently, this factor is set at 1 for all contaminants (*i.e.*, contaminants are not metabolized or volatilized). Exceptions can be made based on professional judgment, but a rationale based on evidence of metabolism or volatility should be provided.

Organic Compounds

Soil-to-terrestrial-plant uptake factors UP_{SP} for organic compounds are generally based on the model of Ryan et al. (1988), although for selected compounds, UP_{SP} are derived from *Attachment 4-1, Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)* (US EPA 2007, Table 4b).

PAHs

For PAHs, compound-specific regression models are based on soil concentration or point estimators derived from measured data (US EPA, 2007). PAHs were classified as either low molecular weight (LMW; *i.e.*, less than or equal to 3 benzene rings) or high molecular weight (HMW; greater than 3 benzene rings) and class specific equations were calculated (US EPA 2007 Figure 4). Rinsed foliage equations were adopted for this model as soil or sediment ingestion by receptors is accounted for elsewhere in the model. These equations (US EPA 2007) are as follows:

$$\text{LMW PAHs: } UP_{SP} = e^{(4.544 \times \ln[Csoil] - 1.325)} / [C_{soil}];$$
$$\text{HMW PAHs: } UP_{SP} = e^{(0.9469 \times \ln[Csoil] - 1.7026)} / [C_{soil}]$$

These models apply to soil concentrations ranging from 1×10^{-8} to 100 mg/kg above and below which the uptake factor is set to the respective limiting value (*e.g.,* for concentrations above 100 mg/kg dw, the UP_{sp} is set to a concentration of 100 mg/kg dw).

Inorganics

Trace element uptake factors from soil to plant tissue are based on a combination of constant uptake factors, or where available, regression-based uptake factors that take into consideration the underlying concentration in soil.

UP_{SP} models for inorganic elements were derived from *Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants* (Bechtel Jacobs 1998) where available (*i.e.,* Barium, Copper, Lead, Nickel and Zinc).

8.15.1.2 Soil to Terrestrial Invertebrates UP_{SI}

Uptake factors for soil-to-terrestrial invertebrates (UP_{SI}) are generally reported for earthworms due to the availability of information in the literature, and a relative paucity of information with regards to insects. The ERA, therefore, focuses on earthworms as the "model" soil invertebrate, due to the relative abundance of data and models to predict contaminant uptake, as well as the perceived importance of earthworms in food webs.

The UP_{SI} are estimated in dry weight units (*i.e.,* mg/kg dry soil invertebrate / mg/kg dry soil) and are converted to wet weight where necessary assuming that the fresh earthworm contains 84% water and 16% dry solids (typical value for earthworms (US EPA 1993)).

Organics

The soil-to-earthworm bioaccumulation model for the organic compounds is derived from US EPA (2007) as based upon Jager (1998), presented here to give the uptake factor on the dry weight basis for the earthworm (mg/kg dw tissue / mg/kg dw soil) and is calculated as:

$$UP_{SI} = ((f_{water} + (f_{lipid} \times K_{ow})) / (F_{oc} \times K_{oc})) / 0.16$$

Where: f_{water} is the water content of the worm (0.84),

f_{lipid} is the lipid content of the worm (0.01),

f_{OC} is the fraction of organic carbon in soil (assumed to be 0.01), and

K_{OC} is the water to organic carbon partitioning coefficient (L/kg OC).

The value 0.16 is the dry solids content of the worm. Log KOW values were obtained from various sources and Log KOC values were calculated as Log Kow x 0.41.

Bioavailability and metabolic factors (unitless) for use with this equation as multipliers before calculating the final concentration in earthworms were estimated based on K_{OW}. Estimated values for bioavailability range from 0.1 to 1 while values for metabolic factor range from 0.05 to 1.

Inorganics

Soil-to-earthworm bioaccumulation models for inorganic elements were derived (on a dry weight basis) from Sample *et al.* (1998a), for the following COCs:

Copper: $UP_{SI}=(e^{(1.675 + 0.264*\ln(Csoil))}) / C_{soil}$

Lead: $UP_{SI}=(e^{(-0.218 + 0.807*\ln(Csoil))}) / C_{soil}$

Zinc: $UP_{SI}=(e^{(4.449 + 0.328*\ln(Csoil))}) / C_{soil}$

Point estimates of UP_{SI} were obtained from Sample *et al.* (1998a) for barium. For nickel, the regression equations presented by Sample *et al.* (1998a) were not considered to be of sufficient reliability to use. Therefore, for nickel the median value of the data presented by Sample *et al.* (1998a) was selected.

8.15.1.3 Soil or Plant to Terrestrial Animals, UP_{SA}

Concentrations of contaminants in small mammals are generally estimated using uptake or biotransfer factors directly from soil, or in some cases using biotransfer factors from feed (vegetation). Uptake factors (UP) are technically dimensionless and direct (*i.e.*, mg/kg dry weight mammal / mg/kg dry weight soil). Biotransfer factors (BA) are slightly different, with units of day/kg, and are multiplied by a soil or feed intake rate (kg/day) to generate an uptake factor, which is then multiplied by the contaminant concentration in the soil or feed (mg/kg) to estimate the concentration in the animal. It is very important to maintain consistency in wet weight or dry weight units.

To ensure this consistency, all uptake factors are initially reported in dry weight units (*i.e.*, mg/kg dry weight mammal / mg/kg dry weight soil) and subsequently converted to wet weight assuming that small mammals typically have approximately 68% water content and 32% dry solids content (data for small mammals; US EPA 1993). The conversion to wet-weight mammal units is accomplished by multiplying dry-weight transfer factors by the dry solids fraction of 0.32 for small mammals.

For biotransfer factors for organic contaminants, the most recent literature (*e.g.*, US EPA 2005b and RTI 2005) focuses on transfer from feed to lipid fraction in the animal. The lipid content of small mammals on a dry matter basis varies considerably, both seasonally and between species, with low-range values of <3% recorded for snowshoe hares, and high-range values of >40% recorded for Guinea Pig (Dierenfeld et al. 2002). Typical lipid content values for wild voles and mice appear to be in the range of 20% (of dry weight), and this can be converted to a value of 6.4% (wet weight) and this value (0.064) will be adopted for the purposes of deriving small mammal transfer factors from feed to lipid and whole body. Thus, where the biotransfer factor has provided an estimate of the contaminant concentration in the lipid fraction of a small mammal, multiplying this value by a correction factor of 0.064 will convert to whole animal wet weight units.

Organics

TPH and PAHs

For reasons that will be explained below, biotransfer into small mammal tissues for some organic contaminants is modeled on the basis of measured or expected contaminant concentration in feed (plant tissue) as well as from soils. Thus, the soil-and-plant-to-animal (SPA) biotransfer factor is defined as BA_{SPA} (day/kg). Note that this approach does not apply to dioxins and furans, or pentachlorophenol.

The uptake factor for soil and plant to animals (UP_{SPA}, mg/kg wet weight animal / mg/kg soil or plant) for TPH and PAHs was derived from BA_{SPA} values obtained following "*Methodology for Predicting Cattle Biotransfer Values*" (RTI 2005). This work was performed by Research Triangle Institute (RTI) on behalf of the United States Environmental Protection Agency, and is endorsed by the US EPA through the *Human Health Risk Assessment Protocol*. A key assumption is that the best available predictor of the contaminant concentration in small mammal tissues would be the contaminant concentration in a cow occupying the same habitat. Because the available BA_{SPA} values were developed for cattle, and must be multiplied by feed or soil intake rates and concentrations in order to convert them to animal tissue values, the appropriate feed ingestion rate is that of cattle. To multiply by the feed ingestion rate of individual VEC organisms, which range in weight from <10 g to more than 10^5 g, would make the expected contaminant concentration in tissues directly proportional to the feed ingestion rate, which is clearly not appropriate.

The UP_{SPA} value can therefore be visualized as the product of the cattle biotransfer factor (BA_{SPA}, day/kg, from RTI 2005) and the cattle food or soil ingestion rates (kg/day). When multiplied by the contaminant concentrations in the soil and feed (mg/kg) the result is the predicted contaminant concentration for the lipid compartment in cattle (mg/kg lipid). As always, careful attention to wet weight and dry weight units in the application of this approach is essential.

The biotransfer factor from soil or plant to animal (BA_{SPA}) is thus estimated as:

$$BA_{SPA} = 0.064 \times 10^{((-0.099 \log Kow^2) + (1.07 \log Kow) - 3.56)}$$

Where 0.064 is the lipid content of the small mammal relative to its wet weight (Dierenfeld et al. 2002); and the remaining equation (from RTI 2005) predicts the tendency for an organic contaminant compound to be concentrated in lipid, as a function of the log K_{OW} value. Note that the lipid fraction identified here for small mammals is lower than the lipid fraction for cattle as defined by RTI (2005). The equation is valid in the range of log K_{OW} values between -0.67 and 8.2, and the log K_{OW} values outside this range should be capped at the upper or lower range limits, respectively.

It is important also to note that the equation developed by RTI (2005) is applicable to organic compounds that are both bioavailable (*i.e.*, readily absorbed from feed), and relatively persistent (*i.e.*, resistant to metabolic breakdown and excretion). It is noted by RTI (2005) that many compounds are susceptible to breakdown and excretion, and such compounds were methodically removed from the database used to develop the equation predicting BA_{SPA} values. Further, it is noted by RTI (2005) that metabolic factors ranging from 0 to 1 can be implemented to better predict the bioaccumulation of non-persistent organic compounds, and that one such value of 0.01 has already been developed by the US EPA for bis(2-ethylhexyl)phthalate to reduce the predicted tendency to bioaccumulate by two orders of magnitude. Factors to represent bioavailability and metabolism will therefore be applied to those organic compounds that are considered to have low bioavailability or persistence as follows (refer to Table 8.3).

The expected contaminant concentration in small mammals is then estimated based on cattle tissue concentrations as:

$$C_{mammal} = BA_{SPA} \times ((60 \times C_{plant}) + (0.4 \times C_{soil})) \times B_i \times M_i$$

Where C_{mammal} is the contaminant concentration in animal tissue (mg/kg wet weight), BA_{SPA} is the biotransfer factor from soil or plant to animal (day/kg), 60 is the plant feed intake rate (60 kg wet weight/day for cattle), C_{plant} is the contaminant concentration in plants (mg/kg wet weight), 0.4 is the soil ingestion rate (0.4 kg dry weight/day for cattle), C_{soil} is the contaminant concentration in soil (mg/kg dry weight), B_i is the bioavailability of the contaminant in feed and soils (unitless, ranging from 0 to the default value of 1), and M_i is the metabolic factor for the contaminant (unitless, ranging from 0 to the default value of 1).

As a further check on bioconcentration by small mammals, which have relatively short life spans compared with cattle, a mass limitation is imposed on the bioaccumulation of contaminants. This mass limitation is based on the meadow vole, assuming a median 90 day lifespan (US EPA 1993), the daily food ingestion rate (0.011 kg wet weight/day), the daily soil ingestion rate (3.15E-04 kg dry weight/day) and the contaminant concentrations in wet food and dry soil, respectively. No credit is taken for metabolic losses or excretion of contaminants. The total lifetime contaminant intake (mg) is divided by the body mass of the meadow vole (0.042 kg) to derive the maximum theoretical contaminant concentration in meadow vole tissues (C_{max}) as:

$C_{max} = (90 \times ((0.011 \times C_{plant}) + (0.000315 \times C_{soil})) \times B_i) / 0.042$, where C_{max} is lower than C_A, C_{max} is selected as the maximum possible contaminant concentration in small mammal tissues.

Table 8.3 Correction Factors for Bioavailability and Metabolism of Organic Compounds from Plant Foods by Small Mammals

Chemical or Chemical Class	Bioavailability Correction Factor	Rationale	Metabolic Correction Factor	Rationale
PAHs 3-ring 4-ring 5-ring	 1 1 1	Bioavailability decreases with increasing molecular size.	 0.1 0.1 0.5	Potential to be metabolized decreases with increasing molecular size.

Note: Bioavailability and metabolic factors apply only to organic compounds, and for inorganic substances (elements) are defined as 1.0 in all circumstances. These correction factors are based upon professional judgment.

Inorganics

Uptake from soil to animals (UP_{SA}) for inorganic substances is generally modeled directly (based on correlations or empirical regressions), without direct consideration of concentrations in plant tissues. Values for UP_{SA} for inorganic elements were derived from regression equations presented by Sample et al. (1998b) where available (*i.e.,* for As, Cd, Cr, Zn).

It is important to note that for those elements where regression equations are used, the resulting uptake factors are dependent upon the concentrations of the respective elements in soil. These equations should therefore only be used within realistic concentration ranges. For example, when estimating risk due to very small incremental inorganic element loadings, it may be necessary to first estimate risk for the baseline element concentration, and then to add the incremental concentration and re-estimate risk to determine the risk of the incremental concentration by difference.

Uptake factors or regression equations were not available for all elements. Therefore, biotransfer from soil or plant to animal (BASPA) point estimates for some elements were derived from A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture (Baes et al. 1984). These BASPA values were handled in the same manner as for most organic compounds to derive expected concentrations in small mammals based upon exposure of cattle to ingested soil and plant materials, except that metabolic factor is required to have a value of 1.0 because inorganic elements are not metabolized.

$$C_{mammal} = BA_{SPA} \times ((60 \times C_{plant}) + (0.4 \times C_{soil})) \times B_i \times M_i$$

As for organic contaminants, C_{max} can also be calculated, and where the estimated C_{mammal} value is greater than C_{max}, C_{max} is selected as the mass-limited concentration in small mammal (meadow vole) tissues.

8.16 Risk Characterization

Risk characterization is the final step of an ecological risk assessment. It includes a quantification of the potential nature and magnitude of adverse effects that may occur to receptor species due to presence of chemicals in identified ecological habitats at the site. In this step, characterization of exposure and characterization of ecological effects for each chemical, are integrated into quantitative estimates (ecological hazard quotients or EHQ values) of the potential for adverse effects to ecological receptors.

8.16.1 Approach

The potential for adverse effects is quantified by comparing the dose of a substance that can be tolerated, or below which adverse effects are not expected (*i.e.*, TRV), to the expected daily dose, the amount of a COC an organism is expected to be exposed to on a daily basis (*i.e.*, average daily dose (ADD)). The quotient of the two is referred to as an ecological hazard quotient (EHQ) and the magnitude by which values differ from parity (*i.e.*, TRV = daily dose) is used to make inferences about the possibility of ecological risks. For birds and mammals, the exposure measure is the total ingested dose (mg/kg-day) summed over all exposure pathways. For the assessment of potential risk to community-based receptors (*e.g.*, benthic invertebrates and fish), the EPC of the associated environmental media (*e.g.*, sediment or surface water) is divided by a toxicological benchmark (rather than dividing an ADD by a TRV, as was done for birds and mammals).

An EHQ of <1.0 indicates that the exposure concentration is less than the threshold for adverse effects, and a low probability exists that adverse effects might occur. Given the overall tendency to introduce conservatism (through the use of data or assumptions that are likely to overstate, rather than understate risk) into risk assessments, it is likely no adverse effect would occur. Alternatively, an EHQ of >1.0 does not automatically indicate that there is an unacceptable level of risk. In this case, the conservative approach reduces the certainty of this conclusion, and dictates a need for more careful review of both predicted exposure levels and exposure limit derivations. As a result, EHQs greater than 1.0 should be examined carefully, and further more focused investigations may be required to reduce conservatism and provide a more realistic assessment of the actual risk level before selecting a risk management approach.

Occupancy factors are an estimate of the time spent at the subject site and estimate the time that an ecological receptor will be exposed to a contaminated area. Occupancy factors can be based on many factors including home range and migratory behaviors of the ecological receptor. For the current assessment, it is assumed that the masked shrew, meadow vole, red fox, Arctic hare, and Short-eared owl have 100% exposure to the impacted portions of the site. Taking the migratory patterns into account, it is assumed that the merganser and the American robin would spend 50% of their time on the site.

For the purposes of this assessment, the conservative assumption is made that each of the animals listed above will spend all of its time foraging at the site, even though in many cases the home range size or migratory movements of the animals will take them elsewhere for some portion of the year. Further, they are assumed to be exposed to the EPC of each COC in water, sediments, and soil at all times. In addition, the foods they consume are assumed to have grown or fed on media exposed to the EPC of each COC at all times. Therefore, this preliminary set of calculations has been completed in a highly conservative manner.

8.16.2 Risk Characterization for Aquatic Receptors

Exposure point concentrations of those substances that were identified as requiring further assessment during the hazard identification stage (Section 8.8) were subsequently compared to toxicological benchmarks intended for screening COCs for potential effects on aquatic biota. These benchmarks (where available) have been tabulated with the maximum and EPC values for the retained COCs in Tables 27.1 to 27.14 (under the heading "risk assessment") in Appendix 27. EHQs were calculated by comparing the concentrations of COC to the toxicological benchmark. COCs in sediment and surface water that exceed their applicable benchmark for each site are shown in Table 8.4. Only COCs in sediment (PCBs, TPH and tin) were identified as potential chemicals of concern (*i.e.*, PCBs: CCME sediment quality guidelines; TPH: Toxicity value for benthic invertebrates; tin: no guidelines available).

Table 8.4 Magnitude of Impacts for Chemicals in Aquatic Habitats at Hopedale Radar Site

Site	Sediment	Surface Water	Magnitude of Impacts
Subdivision Stream	PCBs	None	PCBs: Localised; two samples exceeded the PEL. No toxicity value could be calculated due to lack of organic carbon data
Old Dump Pond	Tin	None	Tin: widely distributed in sediment
Small Pond Bog	TPH	Not Tested	TPH: widely distributed in sediment
Old Dam	TPH	Not Tested	TPH: Localised; site is not considered significant habitat and may dry up seasonally
Valley Drainage Ponds	None	Not Tested	Not applicable
Reservoir	None	None	Not applicable
Second Reservoir	None	None	Not applicable
Big Lake	None	None	Not applicable
Wharf Area	TPH, PCBs	Not tested	PCBs: Localised; mainly near where stream enters ocean and near the wharf TPH: localised; exceeds value in one sample near where stream enters ocean

8.16.3 Discussion of Risk Characterization for Aquatic Receptors

<u>Subdivision Stream</u>

The ecological risk assessment indicated that there is potential for adverse effects to aquatic biota from exposure to PCBs in the Subdivision Stream. These effects are believed to be localised because only two sediment samples had concentrations that exceeded the PEL. It was not possible to calculate a toxicity value for the Subdivision Stream because the amount of organic carbon was unknown. A conservative assumption is 1% organic carbon which equals a toxicity value for the Subdivision Stream of 38 mg/kg. The maximum concentration of PCBs in the Subdivision Stream is 0.48 mg/kg. Therefore, it is unlikely that PCBs are causing adverse effects to benthic invertebrates at the Subdivision Stream.

Old Dump Pond

Because no guideline or toxicity value exists for tin in sediment, it was identified as being a potential concern in sediment of Old Dump Pond. Metals debris was observed to be present in Old Dump Pond and this may be contributing to the elevated levels of tin in sediment. There are no guidelines available for tin in sediment, however, most of the aquatic toxicity testing with tin is carried out with soluble tin(II)chloride which is classified as moderately toxic (Howe and Watts, 2005). Speciation under environmental conditions favours tin oxide compounds which have low toxicity mainly due to their low solubility, poor absorption, low accumulation in tissues and rapid excretion (Howe and Watts, 2005). Therefore, adverse effects on aquatic life due to tin in Old Dump Pond are considered unlikely. The removal of the metal debris from Old Dump Pond is recommended later in this report.

Concentrations of PCBs in sediment of Old Dump Pond were not considered to be a concern because the concentrations were below the toxicity value. Concentrations of PCBs in three sticklebacks collected from Old Dump Pond had concentrations of 4.8 mg/kg, 5.6 mg/kg, and 5.9 mg/kg. The effects of PCBs on fish vary depending on the species, developmental stage and mode of exposure (Reiser et al., 2004). Hansen et al., (1973) estimated a lowest observed adverse effect concentration (LOAEC) (*i.e.*, body burden) of 9.3 mg/kg based on fry mortality of sheepshead minnow (*Cyprinodon variegatus)* exposed to PCBs in water for 28 days. In two chronic laboratory studies, LOAECs of 14.3 mg/kg in channel catfish exposed to PCB1242 for twenty weeks (*Ictalurus punctatus)* (Hansen et al., 1976) and 13.7 mg/kg in fathead minnow exposed to PCB 1254 for sixteen weeks *(Pimephales promelas)* (United States Army Corps of Engineers (ACOE), 1988) were associated with adverse effects on growth and reproduction, respectively. Other studies report a higher LOAEC (*e.g.*, 125 mg/kg for brook trout fry exposed to Aroclor 1254 for 118 days (Nebeker et al., 1974). Monosson (1999) indicated that liver concentrations ranging from 25 mg/kg to 70 mg/kg interferes with the proper functioning of the reproductive system of fish while Niimi (1996) indicated that concentrations exceeding 100 mg/kg in females causes adverse effects in mortality and reproduction. The concentrations of PCBs in stickleback from old Dump Pond are less than the reported LOAECs reported in the literature. Therefore, adverse effects to fish at old Dump Pond are considered unlikely.

Small Pond Bog

Petroleum hydrocarbon impacts in sediment from Small Pond Bog are widespread and may cause adverse effects to aquatic biota. Small Pond Bog does not represent significant fish habitat but benthic invertebrates were observed to be present. Sampling for benthic invertebrates was conducted during the 2009 field work. Samples have been submitted for identification and once benthic invertebrate results have been identified and statistical analyses are completed, further conclusions and recommendations may be made for Small Pond Bog with respect to impacts of petroleum hydrocarbons on benthic invertebrates.

Old Dam

Petroleum hydrocarbon impacts at the Old Dam are considered localised. Old Dam is also not expected to represent significant habitat as it has been reported to dry up seasonally. No additional investigation is required at Old Dam.

Wharf

The TPH impacts at the Wharf area are considered localised because only one sample had an elevated concentration of 1000 mg/kg. PCB impacts are also considered to be confined to the immediate vicinity of the wharf and shoreline. While it is recognized that some localised effects to benthic invertebrates is possible, it is unlikely that the impacts are widespread. Fish and marine mammals would spend limited time in the wharf area due to their large home ranges and would not be considered to be adversely impacted.

8.17 Risk Estimates for Avian and Mammalian Receptors – Whole Site

As discussed in Section 8.9, the American robin, Short-eared owl, Herring gull, Arctic hare and Common merganser are considered to have a large home range and were thus assessed using chemical data from the entire site. A summary of the total EHQ for each VEC is provided in Tables 8.5 to 8.9. Tables showing the derivation of risk estimates for each VEC can be found in Appendix 27. The text below provides a synopsis of the risk estimates for each VEC. A summary of the total EHQ for each VEC is provided, with a detailed breakdown of the contribution of each exposure pathway provided in Appendix 27.

Risk Estimates for American Robin

For the American robin, the intake pathways include soil ingestion, terrestrial invertebrate ingestion, surface water ingestion and terrestrial plant ingestion. The robin feeds on invertebrates and fruit. The American robin is assumed to forage over the entire site area and not just in impacted areas. Taking the migratory patterns into account, it is assumed that the American robin would spend 50% of their time on the site.

As shown in Table 8.5, the risk (EHQ) for TPH, PCBs, cadmium, chromium and lead for the American robin exceeds 1.0 thus indicating a potentially adverse risk for American robin exposed to these COCs at the Hopedale radar site.

Table 8.5 Total Ecological Hazard Quotients for the American Robin

Chemical	EHQ	Target EHQ
Total TPH	**13**	1.0
PCBs	**3.8**	1.0
PAHs	NA	1.0
Antimony	NA	1.0
Barium	0.011	1.0
Cadmium	**3.2**	1.0
Chromium	**1.7**	1.0
Cobalt	0.077	1.0
Copper	0.56	1.0
Lead	**1.1**	1.0

Chemical	EHQ	Target EHQ
Molybdenum	0.12	1.0
Nickel	0.32	1.0
Selenium	0.28	1.0
Silver	0.1	1.0
Tin	0.055	1.0
Uranium	0.00088	1.0
Vanadium	1.0	1.0
Zinc	0.58	1.0

Notes:
For PAHs and antimony, there is insufficient data to define TRVs for avian receptors. However, available evidence (Kapustka, 2004) suggests that mammals are generally more sensitive to PAHs than birds, so if small mammals are protected, birds should also be adequately protected.
Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Short-eared Owl

For the Short-eared owl, the intake pathways include soil ingestion, terrestrial invertebrate ingestion, surface water ingestion, and mammal/bird ingestion. The Short-eared owl forage opportunistically, having been noted to have also consumed insects, small mammals such as muskrats, and birds. The Short-eared owl is assumed to forage over the entire site area.

As shown in Table 8.6, the risk (EHQ value) for TPH and PCBs for the Short-eared owl exceeds 1.0 thus indicating a potentially adverse risk for Short-eared owl exposed to PCBs and TPH at the Hopedale radar site.

Table 8.6 Total Ecological Hazard Quotients for the Short-eared Owl

Chemical	EHQ	Target EHQ
Total TPH	**2.4**	1.0
PCBs	**3.9**	1.0
PAHs	NA	1.0
Antimony	NA	1.0
Barium	0.0031	1.0
Cadmium	0.095	1.0
Chromium	0.13	1.0
Cobalt	0.0045	1.0
Copper	0.061	1.0
Lead	0035	1.0
Molybdenum	0.026	1.0
Nickel	0.02	1.0
Selenium	0.2	1.0
Silver	0.029	1.0
Tin	0.038	1.0
Uranium	0.00026	1.0
Vanadium	0.074	1.0
Zinc	0.2	1.0

Notes:
For PAHs and antimony, there is insufficient data to define TRVs for avian receptors. However, available evidence (Kapustka, 2004) suggests that mammals are generally more sensitive to PAHs than birds, so if small mammals are protected, birds should also be adequately protected.
Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Herring Gull

For the herring gull, the intake pathways include soil ingestion, terrestrial invertebrate ingestion, mammal/bird ingestion, marine sediment ingestion and marine invertebrate ingestion. Drinking water and exposure to fish is likely negligible. However, to account for possible exposure to some of the COCs in fish, a target EHQ of 0.9 was selected. The Herring gull is assumed to forage over the entire site area. As shown in Table 8.7, risks (EHQ values) for the Herring gull were less than 0.9 for all substances that were assessed. Given the high level of conservatism built into the assessment, risks associated with other substances are not considered to be significant. It is concluded that the site poses no significant risk to the Herring gull or other seabirds or omnivorous avian species.

Table 8.7 Total Ecological Hazard Quotients for the Herring Gull

Chemical	EHQ	Target EHQ
Total TPH	0.79	0.9
PCBs	0.48	0.9
PAHs	NA	0.9
Antimony	NA	0.9
Cadmium	0.16	0.9
Chromium	0.066	0.9
Cobalt	0.002	0.9
Copper	0.018	0.9
Lead	0.017	0.9
Molybdenum	0.073	0.9
Nickel	0.015	0.9
Selenium	0.021	0.9
Silver	0.011	0.9
Tin	0.0092	0.9
Uranium	0.000062	0.9
Vanadium	0.035	0.9
Zinc	0.025	0.9

Notes:
For PAHs and antimony, there is insufficient data to define TRVs for avian receptors. However, available evidence (Kapustka, 2004) suggests that mammals are generally more sensitive to PAHs than birds, so if small mammals are protected, birds should also be adequately protected.
Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Merganser

For the merganser, the intake pathways include freshwater fish ingestion, surface water ingestion, and sediment ingestion. The merganser is assumed to forage over the entire site area.

As shown in Table 8.8, risks (EHQ values) for the merganser were less 1.0 for all of the substances assessed. Given the high level of conservatism built into the assessment, risks associated with other substances are not considered to be significant. It is concluded that the site poses no significant risk to merganser or other piscivorous avian species.

Table 8.8 Total Ecological Hazard Quotients for the Merganser

Chemical	EHQ	Target EHQ
Total TPH	0.014	1.0
PCBs	0.73	1.0
PAHs	NA	1.0
Antimony	NA	1.0
Barium	0.0014	1.0
Cadmium	0.011	1.0
Chromium	0.019	1.0
Cobalt	0.0026	1.0
Copper	0.0026	1.0
Lead	0.0053	1.0
Molybdenum	0.0014	1.0
Nickel	0.0075	1.0
Selenium	0.15	1.0
Silver	0.0018	1.0
Tin	0.0053	1.0
Uranium	0.000039	1.0
Vanadium	0.042	1.0
Zinc	0.12	1.0

Notes:
For PAHs and antimony, there is insufficient data to define TRVs for avian receptors. However, available evidence (Kapustka, 2004) suggests that mammals are generally more sensitive to PAHs than birds, so if small mammals are protected, birds should also be adequately protected.
Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Arctic Hare

For the Arctic hare, the intake pathways included soil ingestion, terrestrial plant ingestion, surface water ingestion and terrestrial mammal/bird ingestion. The Arctic hare feeds mainly on plants, but also consumes some meat as minor components of the diet. The Arctic hare is assumed to forage over the entire site areas.

As shown in Table 8.9, the risk (EHQ value) for TPH, PCBs, antimony, cadmium and molybdenum for the Arctic hare exceeds 1.0 thus indicating a potentially adverse risk for Arctic hare exposed to these COCs at the Hopedale radar site.

Table 8.9 Total Ecological Hazard Quotients for the Arctic hare

Chemical	EHQ	Target EHQ
Total TPH	**3.9**	1.0
PCBs	**1.5**	1.0
PAHs	0.0011	1.0
Antimony	**4**	1.0
Barium	0.022	1.0
Cadmium	**5.5**	1.0
Chromium	1.0	1.0
Cobalt	0.056	1.0
Copper	0.73	1.0
Lead	0.19	1.0
Molybdenum	**1.6**	1.0
Nickel	0.1	1.0
Selenium	0.90	1.0
Silver	0.00094	1.0
Tin	0.010	1.0

Chemical	EHQ	Target EHQ
Uranium	0.018	1.0
Vanadium	0.31	1.0
Zinc	0.23	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Characterization for Mammalian Receptors with Small Home Ranges

As discussed in Section 8.9, the site was separated into smaller areas for assessment of VECs with smaller home ranges (red fox, masked shrew and meadow vole). Tables showing the derivation of risk estimates for these receptors can be found in Appendix 27. The text below provides a synopsis of the risk estimates for each VEC. A summary of the total EHQ for each VEC is provided, with a detailed breakdown of the contribution of each exposure pathway provided in Appendix 27.

Area 1

Risk Estimates for Red Fox

For the red fox, the intake pathways included soil ingestion, terrestrial plant ingestion, terrestrial invertebrate ingestion, surface water ingestion and terrestrial mammal ingestion. The red fox feeds mainly on small mammals, but also consumes some invertebrates and plant material as minor components of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied, which assumes that the fox spends all of its time in the impacted area.

As shown in Table 8.10, the risk (EHQ value) for TPH and PCBs for the red fox exceeds 1.0 thus indicating a potentially adverse risk for red fox exposed to these COCs at Area 1.

Table 8.10 Total Ecological Hazard Quotients for the Red Fox

Chemical	EHQ	Target EHQ
Total TPH	**5.1**	1.0
PCBs	**8.4**	1.0
Cadmium	0.22	1.0
Tin	0.0059	1.0
Zinc	0.062	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Masked Shrew

For the masked shrew the intake pathways include soil ingestion, terrestrial plant ingestion, surface water ingestion and terrestrial invertebrate ingestion. The masked shrew feeds mainly on soil invertebrates, with vegetation included as a minor component of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied, which assumes that the shrew spends all of its time in the impacted area.

As shown in Table 8.11, the risk (EHQ values) for the masked shrew exceeds 1.0 for TPH, PCBs and cadmium thus indicating a potentially adverse risk for a masked shrew exposed to these COCs at Area 1.

Table 8.11 Total Ecological Hazard Quotients for the Masked Shrew

Chemical	EHQ	Target EHQ
Total TPH	**79**	1.0
PCBs	**140**	1.0
Cadmium	**5.3**	1.0
Tin	0.025	1.0
Zinc	0.43	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Meadow Vole

For the meadow vole, which is a herbivore, the intake pathways included soil ingestion, terrestrial plant ingestion, surface water ingestion and terrestrial invertebrate ingestion. The meadow vole eats fresh grasses, sedges, herbs, bark, roots and fruit as well as a variety of seeds and grains. Voles may also sometimes eat insects. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the vole spends all of its time in the impacted area.

As shown in Table 8.12, the risk (EHQ value) for the meadow vole exceeds 1.0 for TPH and PCBs thus indicating a potentially adverse risk for a meadow vole exposed to these COC at Area 1.

Table 8.12 Total Ecological Hazard Quotients for the Meadow Vole

Chemical	EHQ	Target EHQ
Total TPH	**22**	1.0
PCBs	**2.1**	1.0
Cadmium	0.51	1.0
Tin	0.0046	1.0
Zinc	0.2	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

<u>Area 2</u>

Risk Estimates for Red Fox

For the red fox, the intake pathways included soil ingestion, terrestrial plant ingestion, terrestrial invertebrate ingestion and terrestrial mammal ingestion. The red fox feeds mainly on small mammals, but also consumes some invertebrates and plant material as minor components of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the fox spends all of its time in the impacted area.

As shown in Table 8.13, the risk (EHQ value) for the red fox exceeds 1.0 for PCBs and cadmium thus indicating a potentially adverse risk for a red fox exposed to these COCs at Area 2.

Table 8.13 Total Ecological Hazard Quotients for the Red Fox

Chemical	EHQ	Target EHQ
Total TPH	0.98	1.0
PCBs	**4.9**	1.0
Cadmium	**1.3**	1.0
Chromium	0.24	1.0
Cobalt	0.011	1.0
Copper	0.19	1.0
Lead	0.079	1.0
Molybdenum	0.42	1.0
Selenium	0.33	1.0
Tin	0.00062	1.0
Zinc	0.091	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Masked Shrew

For the masked shrew the intake pathways include soil ingestion, terrestrial plant ingestion and terrestrial invertebrate ingestion. The masked shrew feeds mainly on soil invertebrates, with vegetation included as a minor component of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the shrew spends all of its time in the impacted area.

As shown in Table 8.14, the risk (EHQ values) for the masked shrew exceeds 1.0 for TPH, PCBs, cadmium, chromium, and molybdenum thus indicating a potentially adverse risk for a masked shrew exposed to these COCs at Area 2.

Table 8.14 Total Ecological Hazard Quotients for the Masked Shrew

Chemical	EHQ	Target EHQ
Total TPH	**15**	1.0
PCBs	**25**	1.0
Cadmium	**6.2**	1.0
Chromium	**2.6**	1.0
Cobalt	0.018	1.0
Copper	0.9	1.0
Lead	0.5	1.0
Molybdenum	**3.1**	1.0
Selenium	0.66	1.0
Tin	0.029	1.0
Zinc	0.58	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Meadow Vole

For the meadow vole, which is a herbivore, the intake pathways included soil ingestion, terrestrial plant ingestion and terrestrial invertebrate ingestion. The meadow vole eats fresh grasses, sedges, herbs, bark, roots and fruit as well as a variety of seeds and grains. Voles may also sometimes eat insects. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the vole spends all of its time in the impacted area.

As shown in Table 8.15, the risk (EHQ value) for the meadow vole exceeds 1.0 for TPH, cadmium, chromium, and copper thus indicating a potentially adverse risk for a meadow vole exposed to these COCs at Area 2.

Table 8.15 Total Ecological Hazard Quotients for the Meadow Vole

Chemical	EHQ	Target EHQ
Total TPH	**4.3**	1.0
PCBs	0.92	1.0
Cadmium	**8.4**	1.0
Chromium	**2.9**	1.0
Cobalt	0.067	1.0
Copper	**2**	1.0
Lead	1	1.0
Molybdenum	1	1.0
Selenium	0.83	1.0
Tin	0.0054	1.0
Zinc	0.4	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Area 3

Risk Estimates for Red Fox

For the red fox, the intake pathways included soil ingestion, terrestrial plant ingestion, terrestrial invertebrate ingestion, surface water ingestion and terrestrial mammal ingestion. The red fox feeds mainly on small mammals, but also consumes some invertebrates and plant material as minor components of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the fox spends all of its time in the impacted area..

As shown in Table 8.16, the risk (EHQ value) for the red fox exceeds 1.0 for PCBs thus indicating a potentially adverse risk for a red fox exposed to PCBs at Area 3.

Table 8.16 Total Ecological Hazard Quotients for the Red Fox

Chemical	EHQ	Target EHQ
Total TPH	0.29	1.0
PAHs	0.00048	1.0
PCBs	**1.3**	1.0
Antimony	0.59	1.0
Chromium	0.13	1.0
Copper	0.14	1.0
Lead	0.074	1.0
Molybdenum	0.077	1.0
Nickel	0.029	1.0
Tin	0.29	1.0
Zinc	0.057	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Masked Shrew

For the masked shrew the intake pathways include soil ingestion, terrestrial plant ingestion, surface water ingestion and terrestrial invertebrate ingestion. The masked shrew feeds mainly on soil invertebrates, with vegetation included as a minor component of the diet. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the shrew spends all of its time in the impacted area.

As shown in Table 8.17, the risk (EHQ values) for the masked shrew exceeds 1.0 for TPH, PCBs, antimony, chromium, and lead, thus indicating a potentially adverse risk for a masked shrew exposed to these COCs at Area 3.

Table 8.17 Total Ecological Hazard Quotients for the Masked Shrew

Chemical	EHQ	Target EHQ
Total TPH	**4.4**	1.0
PAHs	0.0071	1.0
PCBs	**17**	1.0
Antimony	**15**	1.0
Chromium	**1.1**	1.0
Copper	0.79	1.0
Lead	**1.1**	1.0
Molybdenum	0.46	1.0
Nickel	0.43	1.0
Tin	0.35	1.0
Zinc	0.31	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

Risk Estimates for Meadow Vole

For the meadow vole, which is a herbivore, the intake pathways included soil ingestion, terrestrial plant ingestion, surface water ingestion and terrestrial invertebrate ingestion. The meadow vole eats fresh grasses, sedges, herbs, bark, roots and fruit as well as a variety of seeds and grains. Voles may also sometimes eat insects. Due to the small home range of this mammal, an occupancy factor of 1.0 was applied which assumes that the vole spends all of its time in the impacted area.

As shown in Table 8.18, the risk (EHQ value) for the meadow vole exceeds 1.0 for TPH and antimony thus indicating a potentially adverse risk for a meadow vole exposed to TPH at the site.

Table 8.18 Total Ecological Hazard Quotients for the Meadow Vole

Chemical	EHQ	Target EHQ
Total TPH	**1.3**	1.0
PAHs	0.0032	1.0
PCBs	0.56	1.0
Antimony	**1.4**	1.0
Chromium	0.27	1.0
Copper	0.52	1.0
Lead	0.34	1.0
Molybdenum	0.088	1.0
Nickel	0.04	1.0
Tin	0.0097	1.0
Zinc	0.066	1.0

Note: Bold/Shading indicates that the total calculated EHQ exceeds the target EHQ.

8.18 Summary

Table 8.19 summarizes the COCs at each area of the Hopedale Radar Site that were identified as potentially posing adverse risks to VECs based on the terrestrial ERA.

Table 8.19 Summary of Chemicals Identified as being of Potential Unacceptable Risk based on Terrestrial Ecological Risk Assessment at Hopedale Radar Site

Area	VEC	Chemicals
Area 1	Red fox	TPH, PCBs
	Masked shrew	TPH, PCBs, Cadmium
	Meadow vole	TPH, PCBs
Area 2	Red fox	PCBs, Cadmium
	Masked shrew	TPH, PCBs, Cadmium, Chromium, Molybdenum
	Meadow vole	TPH, Cadmium, Chromium
Area 3	Red fox	PCBs
	Masked shrew	TPH, PCBs, Antimony, Chromium, Lead
	Meadow vole	TPH, Antimony
Whole Site	American robin	TPH, PCBs, Cadmium, Chromium, Lead
	Short-eared owl	TPH, PCBs
	Herring gull	None
	Common merganser	None
	Arctic hare	TPH, PCBs, Antimony, Cadmium, Molybdenum

8.19 Site Specific Target Levels

Site specific target levels (SSTLs) for soil for the protection of VECs were estimated by adjusting the soil concentration in the model input file until the total EHQ for each COC equalled a value of 1.0. In this process, the expected concentrations of each COC in each environmental compartment that depends upon the soil concentration (*i.e.*, in terrestrial invertebrates, terrestrial plants, and small mammals) are recalculated as appropriate. Therefore, the overall EHQ value reflects the sum of all intakes.

At the same time, the COC concentrations in sediments, water, and any environmental compartments that depend upon water or sediments are held at the concentrations defined by the EPC. Therefore, exposure to present-day concentrations of COCs in water and sediments is maintained in the model while the soil concentration is manipulated. Risks to terrestrial biota at the Hopedale Radar Site were dominated by PCBs and TPH. Based on the calculated EHQs, American robin and masked shrew were the most exposed to these COCs.

Due to the highly localized distributions of PCBs and TPH in site soils, the ERA model as implemented (with biota exposed to the EPC at all times) is highly conservative. Nevertheless, the ERA model is helpful in establishing SSTLs for these substances. The conservative nature of the model helps to ensure that biota will be adequately protected provided the SSTL level is not exceeded on an area-wide basis.

Risks associated with the TPH fractions (C6-C10, C10-C21 and C21-C32) were summed, since the TPH compounds can be assumed to have a similar mode of toxic action and target organs. An SSTL for TPH was established by adjusting the concentrations of the TPH fractions until the summed HQ for the three fractions equalled 1.0. For the masked shrew, an SSTL was established at a TPH concentration of approximately 1,700 mg/kg dry soil, subject to the further requirements that the C6-C10 concentration does not exceed 50 mg/kg; the C10-C21 concentration does not exceed 900 mg/kg, and the C21-C32 concentration does not exceed 750 mg/kg. This SSTL would also be protective of other ecological receptors at the site. Removal of TPH impacted oil from the following areas of the site will result in an EPC that is lower than the calculated SSTL: BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Pit No. 3 and POL Compound (Drawing No. 121410103-EE-28f).

For PCBs in soil, an SSTL of approximately 1.5 mg/kg dry soil was established. At this concentration, masked shrews exposed to soil, vegetation, and soil invertebrates for their entire life cycle would be close to a threshold at which reproductive effects might be expected. This concentration is slightly higher than the CCME (1999) guidelines for PCBs in agricultural (0.5 mg/kg) and residential/parkland soils (1.3 mg/kg). In contrast, it is substantially lower than the CCME (1999) guideline for PCBs at commercial or industrial sites (33 mg/kg). Given the past history of the site, it may be reasonable to consider the human health risk assessment SSTL (22 mg/kg) as a clean-up criterion. The PCB impacted areas are quite localized and small in size relative to the overall area under consideration. Removal of PCB impacted oil from the following areas of the site is recommended: Old Dump Pond (Drawing No. 121410103-EE-28b), BMEWS (Drawing No. 121410103-EE-28c), and Old Base 1 (Drawing No. 121410103-EE-28d).

Lead was identified as a potential concern for American robin exposed to the whole site as well as masked shrew at Area 3. An SSTL of 75 mg/kg was established based on exposure of American robin to lead impacted soil at the site. This SSTL would also be protective of masked shrew and other VECs at the site.

Antimony was identified as a potential concern for Arctic hare exposed to the whole site as well as masked shrew and meadow vole at Area 3. An SSTL of 5 mg/kg was established based on exposure of masked shrew to antimony impacted soil.

Chromium was identified as a potential concern for masked shrew and meadow vole at Area 2, for masked shrew at Area 3 and for American robin exposed to the whole site. An SSTL of 20 mg/kg was established that would be protective of American robin at the site. This SSTL would also be protective of masked shrew and meadow vole as well as other VECs at the site.

Cadmium was identified as concern for American robin and Arctic hare at the whole site, masked shrew at Area 1, and for red fox, masked shrew and meadow vole at Area 2. The elevated exposure of these VECs was mainly due to elevated concentrations of cadmium identified in soil and plants at the site. An SSTL of 1.3 mg/kg was established for cadmium at the site based on exposure of masked shrew.

Molybdenum was identified as a potential concern for Arctic hare exposed to the whole site and masked shrew at Area 2. Molybdenum was detected in two soil samples of forty collected from Area 2 at concentrations of 5 mg/kg and 81 mg/kg. Because there was not enough data available for molybdenum to calculate an EPC, the maximum concentration (BS135: molybdenum = 81 mg/kg) was carried forward. This represents a localised area of molybdenum impacts at the Mid Canada Line and is not considered a concern for the VECs.

Recommendations will be made for remediation of this area due to elevated concentrations of other metals.

In order to obtain an area wide EPC that is less than the respective SSTLs for metals as discussed above, removal of metals impacted soil is required at Old Dump Pond (Drawing No. 121410103-EE-28b), BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Mid Canada Line (Drawing No. 121410103-EE-28e), and POL Compound (Drawing No. 121410103-EE-28f), Appendix 28.

Table 8.20 Summary of SSTLs calculated based on Terrestrial Ecological Risk Assessment

Chemical	SSTL (mg/kg)
PCBs	1.5
TPH	1700
Antimony	5
Cadmium	1.3
Chromium	20
Lead	75

8.20 Uncertainty Analysis

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. For the site, much site-specific data has been collected, but these data represent only soils.

Despite incorporation of a considerable amount of site-specific data, the ERA incorporates assumptions that lead to uncertainty. This section qualitatively discusses some significant aspects of uncertainty inherent in this risk assessment.

Valued Ecosystem Component (VEC) Selection. This risk assessment invested significant effort into a site visit and a thorough review of previous investigations carried out at the site. The VECs that were selected are known to be present, or can reasonably be expected to be present on the site. These VECs are also known to be reasonably or conservatively representative of other species that may be present on the site and exposed to COCs. Use of site-specific receptors decreases uncertainty because local species are considered.

Utilization of VECs as Sentinels to Represent Other Organisms. The use of VECs is intended to limit the number of ecological receptors to a reasonable number. The VECs selected are considered sensitive, and consistently present in the study areas, and to be highly exposed to the COCs present at the site via relevant exposure pathways. Therefore it is reasonable to assume that conclusions that are reached in respect of VEC organisms can be generalized to other biota that might use the site.

Receptor-Specific Toxicity Data. For most COCs and VECs, toxicity data are available in some form. However, it is important to note that toxicity data are not necessarily available for the particular VEC species under consideration. Toxicity values are not necessarily specific to the VEC species, or to a reproductive or population-level endpoint. As a result, there is uncertainty associated with the extrapolations that are used to translate toxicity data for one species into a TRV for a second species. The toxicity data represent an organism that is expected to be sensitive to the COC. The conversion factors that are used are scientifically based, and are applied in a manner that is believed to be reasonable.

Data Limitations. The quality of a risk assessment calculation often hinges on the size, extent and quality of the data. In addition to making use of existing site data, a large number of samples were collected for this risk assessment, and a significant amount of data was reviewed for this study. The time available for collection of data precluded consideration of fluctuations in measured concentrations due to daily or seasonal influences. Because these data sets were summarized statistically, including calculation of a conservative representative value, such as the 95% UCL as the EPC, the values presented are highly conservative estimators of the true concentration to which native species would be exposed.

Selection of Chemicals of Concern. Chemicals of concern were selected independently in each of the media evaluated in the ecological risk assessment, and the analysis was completed to include all media 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 chemicals of concern, and the physical and chemical properties of these chemicals. The approach for selecting chemicals of concern included comparison of each detected chemical value to 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 COCs 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. 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 COC is absorbed from ingested soil or food, and is available to the organism as a potentially toxic substance. This may be reasonable for some COCs, but will be highly conservative for others.

Food Chain Interactions. Very limited "real world" data exist that allow quantification of the true relationship between a chemical in an environmental medium and chemical transfer through the food chain. Only a few classes of chemicals appear to be magnified through the food chain. These substances include methyl mercury, PCBs, some chlorinated pesticides (such as DDT), and some PCDD/PCDF compounds. These substances all have a tendency to partition into fatty tissue rather than water. They are also resistant to natural degradation processes by metabolic enzymes. Petroleum hydrocarbons (TPH) and PAHs are another hydrophobic class of chemicals present in the environment. While TPH and PAHs are hydrophobic, they may be poorly absorbed (*e.g*. F2 and F3 TPH) or are readily metabolized and/or excreted by some invertebrates and most vertebrates. For these reasons, food chain magnification does not tend to occur with TPH or PAHs. The extent of food chain magnification is another uncertainty that is generally treated in a conservative manner. Collection and chemical analysis of tissue samples from mammalian and avian species could have further reduced uncertainties associated with these values but were beyond the scope of the ecological field program.

Wildlife Exposure Factors. Virtually every factor incorporated into dose calculations for wildlife species possesses a site-specific component. Validity of each exposure factor is dependent on consideration of the site-specific nature of these factors. In the absence of site-specific validation, exposure factors are incorporated based on validations performed elsewhere for other cases and sometimes for other species. Considerations such as food ingestion rates, water ingestion rates, incidental soil ingestion rates, dietary composition, home range, and time spent at the site were collected from the scientific literature based on other sites and locations. Because it has been assumed that each receptor organism spends its entire life cycle at the site (exposed to the EPC concentration for each COC) it is likely that the level of wildlife exposure has been substantially overestimated, particularly for large-bodied or migratory VECs.

Habitat Survey and Valued Ecosystem Component (VEC) Selection. This risk assessment completed a review of existing habitats and the species that exist within them. Terrestrial habitats were examined to identify relevant species, and to support the selection of appropriate VECs. Therefore, the VECs that were selected are known to be present, or can reasonably be expected to be present on the site. These VECs are also known to be reasonably or conservatively representative of other species that may be present on the site and exposed to COCs. Use of site-specific receptors decreases uncertainty since local species are considered.

Measurement Endpoints from the Toxicity Data. The preferred measure of toxicity for TRVs in this ERA is the chronic LOAEL. For certain COCs the only chronic endpoints available were NOAELs. In this situation, the NOAEL was used as the TRV (without the application of uncertainty factors). The decision not to apply uncertainty factors to translate a NOAEL to a LOAEL is a conservative measure to avoid overestimating the LOAEL (and consequently underestimating potential risks).

8.20.1 Summary of 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 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.

9.0 RECOMMENDATIONS

9.1 Background

Depending on the Province of Newfoundland and Labrador's future plans for the usage and ownership of the Former Radar Site in Hopedale, NL, the use of site-specific risk-based remedial clean-up values should be considered for remediation of identified impacts throughout the site instead of a criteria-based remedial approach. The end goals of the risk assessment were to quantify risk associated with the identified chemicals of concern at the site for the various receptor pathways that humans, animals and other biota may be exposed to. These receptor pathways have been determined for the site and associated risk evaluated for each of these pathways and, site-specific target levels (SSTLs) were calculated for the site. This output will assist NLDEC in focusing on those areas that require remedial efforts and provide more realistic clean up goals that are site specific and protective of both human health and ecological components, hence providing a cost effective approach to risk manage the site. Public consultation will be an essential component for remedial efforts at this site. The SSTLs calculated for the overall site are present in Table 9.1 below.

Table 9.1 Summary of SSTLs to be applied to the Former Radar Site and Residential Area

Chemical	SSTL (mg/kg)	Source	Areas Requiring Remediation
Residential Area			
PCBs	9	HHRA	Old Dump Pond (Drawing No. 121410103-EE-28b) and the Wharf Area (Drawing No. 121410103-EE-28a)
Antimony	30	HHRA	Old Dump Pond (Drawing No. 121410103-EE-28b)
Former Radar Site			
PCBs	22	HHRA	BMEWS (Drawing No. 121410103-EE-28c) and Old Base1 and Main Base (Drawing No. 121410103-EE-28d)
TPH	1700	ERA	BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Pit No. 3 and POL Compound (Drawing No. 121410103-EE-28f)
Metals	Lead: 75 Antimony: 5 Chromium: 20 Cadmium: 1.3	ERA	Old Dump Pond (Drawing No. 121410103-EE-28b), BMEWS (Drawing No. 121410103-EE-28c), Main Base (Drawing No. 121410103-EE-28d), Mid Canada Line (Drawing No. 121410103-EE-28e), and POL Compound (Drawing No. 121410103-EE-28f)

The exposure point concentration (EPC) is an estimate of a reasonable upper limit value for the average chemical concentration in a medium, determined for each exposure unit through statistical analysis (USEPA, 1989). Areas of soil requiring metals-remediation were selected in order to obtain area-wide EPCs that are less than the respective SSTLs for metals as indicated in Table 1.

9.2 Evaluation of Remedial Options

9.2.1 Remedial Scope and Objectives

Based on a review of site characterization and delineation information from the current investigation and results of the risk assessment, the following precautionary actions, remedial activities, and risk management strategies are recommended for the control of hazards related to petroleum hydrocarbon, PCB and metals impacts at the site. Some of these recommendations are intended to be flexible, and will be modified as appropriate, depending upon the results of consultation with regulators and the Town of Hopedale.

Actions

1. Issue an advisory (similar to that issued in 2009) advising of potential risks associated with consuming wild game and berries from the Former Radar Site.
2. Remove metal and other debris from Old Dump Pond as well as from the area of test pit TP229, which is located in the proximity of Old Dump Pond.
3. Remove the septic tank from the Main Base Site.
4. In order to assess the potential risks associated with inhalation of petroleum hydrocarbon vapours in indoor air, soil vapour monitoring should be considered for homes constructed within the footprint of the former landfill.
5. Soil samples should be collected from individual properties located in the footprint of the former landfill at the Residential Subdivision and analysed for petroleum hydrocarbons, PCBs and metals. The results of this additional sampling would require comparison to SSTLs calculated in this human health risk assessment.
6. Further evaluation is required for homes constructed on the former landfill with respect to the long term structural stability of these affected homes.
7. Additional fish samples should be collected from Big Lake to confirm that concentrations are below applicable fish advisory guidelines.
8. If site conditions or land uses change (e.g., residential usage, potable groundwater or if further development takes place on the site), the results of the on-site risk assessment may need to be revisited to ensure that there are no additional or increased risks to potential receptors, on-site or off-site.
9. It is recommended that if vegetable gardens are grown in the future, they are kept away from contaminated areas of the site. Clean imported topsoil should be brought in for this purpose.
10. It is our understanding that there is no current groundwater use for potable drinking water. The assumption is made that prior to any future use of groundwater for potable drinking water or other human use (i.e., showering, washing), the groundwater will be tested to demonstrate that groundwater quality is within the Guidelines for Canadian Drinking Water Quality.

Remedial Activities

1. Perform additional delineation and investigations in areas requiring soil remediation, as identified in the HHERA and listed in Table 9.2, to provide more accurate estimates of soil volumes to be remediated.
2. Carry out active remediation of site soil for those COCs which exceed the SSTLs developed as part of this human health and ecological risk assessment in the areas

identified in Table 9.1. PCB, TPH and metals impacts at Old Dump Pond and the Wharf Area should be given priority over other impacted areas identified throughout the site, due to the proximity of the Town of Hopedale. Remediation should be conducted as per priority levels indicated in Table 9.2.

3. Where possible, implement mitigative measures to reduce the potential for the remobilization of impacts and to enhance natural attenuation.
4. Following remediation, carry out a confirmatory sampling program for soil and groundwater to demonstrate that remedial goals have been attained.
5. Obtain closure for the site remediation from NLDEC.

Table 9.2 Summary of Soil Requiring Remediation

Site	Remedial Objectives	Other Issues Identified[1]	Sample Locations	Area (m^2)	Depth[2] (m)	Volume (m^3)	Fully Delineated?	Maximum Concentration (mg/kg)	Priority Level[3]
BMEWS	TPH	-	MW-64, BS20	269	0.5	135	No	TPH: 94,000	3
		-	TP-102	135	0.1	13	No	TPH: 94,000	3
	PCBs	Zinc	BS5, BS9, BS14	1,200	0.9	1,080	No	PCBs: 100 Zinc: 460	1
	Cadmium	-	BS1, BS7	268	0.5	134	Yes	Cadmium: 15	4
Old Base 1	PCBs	Cadmium, Copper, Lead, Zinc	BS121, BS126	389	0.75	292	No	PCBs: 230 Cadmium: 29 Copper: 200 Lead: 3,000 Zinc: 1,800	2
Main Base	TPH	-	MW-6, BS112	781	0.5	390	No	TPH: 12,000	3
	PCBs, TPH	-	BS110	446	0.75	335	No	PCBs: 53 TPH: 71,000	2
	Chromium	TPH	TP-10	134	0.2	27	No	Chromium: 55 TPH: 2,200	4
Mid-Canada Line	Cadmium, Chromium, Lead	Copper, Zinc	BS135, BS257	147	0.5	74	No	Cadmium: 13 Chromium: 1,200 Lead: 3,200 Copper: 210 Zinc: 22,000	4
Pit No. 3	TPH	-	TP-161, TP-164, TP-169, MW-27	1,057	0.5	528	No	TPH: 77,000	3
POL Compound	TPH	-	TP-141, TP-142, MW-24, BS42	623	0.2	125	No	TPH: 21,000	3
	Antimony, Chromium, Lead	TPH*	BS39, BS41	283	0.1	28	No	Antimony: 120 Chromium: 350 Lead: 2,100	4
Pipeline	PCBs	TPH, Chromium, Zinc	BS229, BS230	810	0.5	405	No	PCBs: 24 TPH: 52,000 Chromium: 120 Zinc: 510	1

Site	Remedial Objectives	Other Issues Identified[1]	Sample Locations	Area (m^2)	Depth[2] (m)	Volume (m^3)	Fully Delineated?	Maximum Concentration (mg/kg)	Priority Level[3]
Old Dump Pond	PCBs	Copper* Nickel* Zinc*	MW-32	302	0.75	226	No	PCBs: 25	1
	PCBs	TPH	MW-61	158	0.5	79	No	PCBs: 29 TPH: 3,400	1
	Antimony, Cadmium, Chromium, Lead	Copper, Mercury, Nickel, Selenium, Zinc	TP-229, TP-233	533	0.5	267	No	Antimony: 99 Cadmium: 15 Chromium: 100 Copper: 2,500 Lead: 8,100 Mercury: 67 Nickel: 110 Selenium: 7 Zinc: 3,400	4

Totals for remediation[4]:	Volume (m^3)	Weight (tonnes)[5]
PCB-impacted soil	2,417	3,625
TPH-impacted soil	1,247	1,870
Metals-impacted soil	474	712

Notes
1. Based on TPH > 1,000 mg/kg, PCBs > 33 mg/kg or Metals > CCME Industrial guidelines
2. Based on the lesser of: [1.5 m for all impacted soil within the residential area, 1.5 m for PCB-impacted soil on the Former U.S. Military Site, 0.5 m for TPH and metal-impacted soil on the Former U.S. Military Site] or [depth of soil cover over bedrock]
3. Priority based on chemical of concern and location of impacts with 1 being the highest priority and 4 being the lowest priority
4. Based on governing contaminant (e.g., soil with PCB and TPH impacts would be remediated using PCB remedial option)
5. Based on an estimated soil density of 1.5 tonnes/m^3

* Impacts detected in nearby sample

9.2.2 Remedial Options Evaluation

Where active remediation of soil was recommended, various remedial options were identified for each chemical of concern that could potentially be implemented at the site. Potential remedial options were evaluated against a variety of criteria to assist in screening out the most appropriate alternative. As a minimum, all options must meet two fundamental threshold criteria:

- Overall protection of human health and the environment; and
- Compliance with applicable requirements.

Based upon the threshold criteria listed above, the list of options was reduced and were evaluated against the following secondary criteria:

- **Long-term effectiveness and permanence** with respect to residual risk after remediation;
- **Reduction of toxicity, mobility or volume**; for the noted contaminants on the site.
- **Implementability** (considering technical and administrative feasibility in the context of available services and materials necessary to implement the option);
- **Time Required** to implement and achieve remedial objectives; and
- **Cost** - both capital as well as operation and maintenance.

The options were evaluated on a relative basis against the secondary criteria. The applicability of each criteria as an option is shown as High, Moderate or Low. On a relative basis, High is preferred for long-term effectiveness and performance, reduction of toxicity, mobility and volume, and implementability, and Low is preferred for time required and cost.

The number of feasible options for site remediation at the Former U.S. Military Base and Residential Subdivision in Hopedale are limited by the relatively remote location of the site. The logistics of mobilizing heavy equipment, lack of infrastructure at the site and the fact that there is no approved soil treatment facility on the north coast of Labrador eliminates some of the more conventional remedial strategies. Therefore, based on the available site characterization information, remedial strategies described in the following sections are considered feasible for the remediation of impacted soil at the Former U.S. Military Base and Residential Subdivision in Hopedale.

A large portion of the contaminated soils on the site contain a mixture of TPH, PCBs and various metals above applicable disposal criteria. Soils with more than one contaminant will be remediated to levels below applicable criteria for all the contaminants concurrently. Various processes are available for the treatment of TPH and PCBs, but treatment options for metals contaminated soils are limited. In most cases for metals contaminated soils, the final remediation option involves some type of landfilling approach. If necessary, solidification or encapsulation processes can be carried out on metals contaminated soils to reduce leachability before landfilling is carried out. No leachability testing has been conducted to date on soil in areas requiring remediation, therefore further field sampling for metals leachate would be required prior to the selection of a remedial option for metals-impacted soil.

9.2.2.1 PCB-Impacted Soil

Based on the available site characterization information, the following ex-situ remedial strategies were considered for the remediation of PCB-impacted soil:

- Option 1: Pretreat PCBs in thermal treatment system, then place soil in local landfill
- Option 2: Transport soil to a newly constructed local hazardous waste landfill
- Option 3: Stock-pile soil and transport to an existing out-of-province hazardous waste landfill

A brief description and the characteristics of each option are presented below. Table 9.3 summarizes the relative merits and deficiencies of the options with respect to the secondary criteria.

Option 1 – Pretreat Soil in Thermal Treatment System, Then Place Soil in Local Landfill

The estimated 2,417 m3 of soil from the site would be excavated and treated in an on-site thermal desorption unit to lower the PCB levels to below 33 mg/kg, so that the residual treated soil would be considered suitable by NLDEC for disposal in the local landfill. SCC Environment Limited has a permitted portable thermal desorption unit, which could be moved to the site. The usage of the thermal desorption system on site to treat the noted materials would have to be approved by NLDEC before remediation could occur. The treated soil would then be transported to the Hopedale landfill for use as fill cover. It is assumed that permission would be obtained from the Hopedale landfill to place the treated soil in the landfill. This would have to be verified with the landfill operator.

Option 2 – Transport Soil to a Local Hazardous Waste Landfill

The impacted soil is not suitable for disposal in the local landfill without pretreatment to reduce the level of PCBs to below 33 mg/kg. Also, there are no existing commercial hazardous waste landfills in Labrador. Under this option, a hazardous waste landfill would be sited, designed, permitted and constructed on Province-owned land in the Hopedale area. The estimated 2,417 m3 of soil at the overall site would be excavated and stored in the landfill. The siting and permitting of a hazardous waste landfill on any Province-owned land in the Hopedale area may be difficult. An environmental assessment may be required for the construction of the landfill on the selected site. The owner of a hazardous waste landfill would incur long term maintenance and monitoring costs. The cost to site, design, permit and build a hazardous waste landfill can vary significantly depending on the size, proposed site locations and stakeholder issues.

Option 3 – Stock-pile Soil and Transport Soil to an Existing Out-of-Province Hazardous Waste Landfill

The estimated 2,417 m3 of soil from the overall site would be excavated and transported to a lay-down area on one of the Former U.S. military sites, or at the local landfill during the summer of 2010. The lay-down area would be designed and constructed to meet applicable provincial and federal regulations and such that impacts would not migrate to underlying or surrounding soil. The impacted soil would be transported to an existing commercial hazardous waste landfill in Quebec once sufficient funds are available in subsequent years.

Only vehicles approved for interprovincial transport of PCB wastes would be suitable, and transportation. Transportation costs would be significant under this option.

Recommended Remedial Option

Based on conditions and constraints, Option 3 (Stock-pile soil and transport soil to an out-of-province hazardous waste landfill) is the preferred remedial option for PCB-impacted soil at the Former U.S. Military and Residential Subdivision site.

The advantages and disadvantages of this option are noted below. Table 9.3 shows a summary of the considered options with respect to the secondary evaluation criteria.

Advantages

1. Long-term effectiveness;
2. Removes wastes from site;
3. Can be implemented using local resources and readily available technologies;
4. Can be implemented at a similar or lower cost to other options; and
5. NLDEC does not have to monitor and maintain a landfill in the future.

Disadvantages

1. Lay-down area must be permitted on the site or at the local landfill; and
2. Remediation cost per tonne is high.

Table 9.3 Summary of Options for Remediation of PCB- Impacted Soil

Criteria	Option 1 On-site thermal treatment system, local landfill	Option 2 On-site hazardous waste landfill	Option 3 Off-site hazardous waste landfill
Long-term effectiveness	Moderate	High	High
Reduction of toxicity, mobility or volume	Moderate	High	High
Implementability	Moderate	Moderate	Moderate
Time Required	High	Moderate	Moderate
Cost	Moderate	High	High

9.2.2.2 TPH-Impacted Soil

Based on the available site characterization information, the following ex-situ remedial strategies were considered for the remediation of TPH-impacted soil:

- Option 1: Pretreat soil in temporary on-site biopile, then place soil in local landfill
- Option 2: Pretreat soil in thermal treatment system, then place soil in local landfill
- Option 3: Transport soil to an existing hazardous waste landfill

A brief description and the characteristics of each option are presented below. Table 9.4 summarizes the relative merits and deficiencies of the options with respect to the secondary criteria.

Option 1 – Pretreat Soil in Temporary On-Site Biopile, Then Place Soil in Local Landfill

The estimated 1,247 m3 of soil from the designated parts of the overall site would be excavated and placed in an on-site temporarily constructed biopile to lower TPH levels to below 1,000 mg/kg, so that the residual treated soil would be considered suitable by NLDEC to be placed as cover at the local landfill. A biopile would be designed and constructed on a concrete or lined (i.e., synthetic) base at one of the Former U.S. Military sites or adjacent to the local landfill. The biopile design would include the addition of air and nutrients to the soil and would include a cover over the pile to minimize water infiltration. Leachate draining from the pile would be collected and put through an oil water separator. Ex-situ treatment and monitoring of the soil in the biopile would likely be required over a period of 1-3 years. The biopile design and location would have to be approved by NLDEC before remediation could occur.

Option 2 – Pretreat Soil in Thermal Treatment System, Then Place Soil in Local Landfill

The estimated 1,247 m3 of soil from the designated parts of the overall site would be excavated and treated in an on-site thermal desorption unit to lower the TPH level to below 1,000 mg/kg, so that the residual treated soil would be considered suitable by NLDEC for disposal in a municipal landfill. SCC Environment Limited has a permitted portable thermal desorption unit, which could be moved to the site. The usage of the thermal desorption system on site to treat the noted materials would have to be approved by NLDEC before remediation could occur. The treated soil would then be transported to the local landfill for use as fill cover. It is assumed that permission would be obtained from the local landfill to place the treated soil in the landfill. This would have to be verified with landfill operators.

Option 3 – Transport Soil to an Existing Out-of-Province Hazardous Waste Landfill

The estimated 1,247 m3 of soil from the designated parts of the overall site would be excavated and transported to an existing licensed commercial soil treatment facility. There is an existing commercial treatment facility in Goose Bay, Labrador. Transportation costs would be significant under this option.

Recommended Remedial Option

Based on conditions and constraints, Option 1 (Pretreat soil in temporary on-site biopile, then place soil in local landfill) is the preferred remedial option for TPH-impacted soil at the Former U.S. Military and Residential Subdivision site.

The advantages and disadvantages of this option are noted below. Table 9.4 shows a summary of the considered options with respect to the secondary evaluation criteria.

Advantages

1. Long-term effectiveness;
2. Removes wastes from site;
3. Can be implemented using local resources and readily available technologies;
4. Can be implemented at a lower cost than the other options; and
5. NLDEC does not have to monitor and maintain a landfill in the future.

Disadvantages

1. Requires NLDEC approval of biopile system;
2. Requires approval of local landfill to accept the treated soil;
3. Soil must be drained or dewatered for handling, transportation and usage as fill cover; and
4. Requires monitoring.

Table 9.4 Summary of Options for Remediation of Petroleum Hydrocarbon Impacted Soil

Criteria	Option 1 On-site biopile, local landfill	Option 2 On-site thermal treatment system, local landfill	Option 3 Off-site hazardous waste landfill
Long-term effectiveness	Moderate	Moderate	High
Reduction of toxicity, mobility or volume	Moderate	Moderate	High
Implementability	High	Moderate	Moderate
Time Required	High	High	Low
Cost	Low	Moderate	High

9.2.2.3 Metals-Impacted Soil

An estimated 474 m3 of metals-impacted soil from the overall site requires remediation. Prior to the selection of a remedial option for metals-impacted soil, a physiologically based extraction test (PBET) must be conducted on metals-impacted soil requiring remediation.

The PBET is an in vitro system for predicting the bioaccessibility of metals from a solid matrix and incorporates gastrointestinal tract parameters representative of a human (including stomach and small intestine pH and chemistry, soil to solution ratio, stomach mixing and stomach emptying rates) (Ruby et al 1996). The bioaccessibility of a substance is the fraction that is soluble in the gastrointestinal environment and is available for absorption. The PBET are simple extraction tests that involve simulating the gastrointestinal tract environment and measuring the dissolution of metals from the substrate. These tests have been traditionally used to assess the bioaccessibility of iron from food for studies of nutrition (Miller et al, 1982). The methodology for PBET testing proposed for the overall site is provided below:

<u>Gastric Fluid Extraction (GFE) Procedure</u>

The GFE will be carried out on additional soil samples collected from the overall site. In this procedure, the physio-chemical properties of the gastrointenstinal tract will be simulated employing a one (1) hour retention time in simulated gastric conditions (pH 1.5) and four (4) hours in simulated intestinal conditions (pH 7). The method carried out will be based on the method developed by Ollson (2003), derived from the original PBET method from Ruby et al (1999). The gastric fluid extraction procedure will be explained in detail during the oral presentation to NLDEC.

Once bioaccessibility of metals in soil requiring remediation is assessed, the SSTLs for metals within the HHERA will be re-evaluated. Based on the results of the re-evaluation, remediation of metals-impacted soil may not be necessary at the overall site. If remediation of metals-impacted soil is deemed necessary, metals leachability testing will be required on soil in the areas requiring remediation. Remedial options for metals-impacted soils will be provided if it is deemed necessary.

9.3 Remedial Action Plan / Risk Management Plan

9.3.1 General

The Remedial Action Plan (RAP)/ Risk Management Plan (RMP) described in this section is based on the regulatory framework, site characterization information and the Remedial Options Review presented in the previous sections. Changes may be required in the Remedial Action Plan depending on comments or directions from NLDEC, following review of this report.

9.3.2 Removal of Abandoned Septic Tank

The abandoned septic tank at the Main Base site would be emptied of septic sludge by qualified personnel, following standard procedures. The removed septic sludge would be disposed of at local approved facilities. The tank and associated piping would be cleaned and removed from the excavation. The tank would be cut up and disposed of at the local landfill. Removed piping (non-metal) would be disposed of at the local landfill. Similar procedures would be followed if additional abandoned septic tanks were discovered on the site during the site remediation program.

9.3.3 Disposal of Metal and Other Debris

Metal and other debris from Old Dump Pond, as well as from the area of TP229 would be transported by truck to a lay-down area where PCB swab sampling would be conducted. If results of PCB swab testing confirm that the debris does not contain measurable concentrations of PCBs, the items may be transported by truck to the Hopedale landfill for disposal. Alternatively, if the debris contains measurable concentrations of PCBs, the items would be handled as hazardous waste and would be removed and transported to an appropriate approved disposal facility. Only approved companies and facilities would be used for the handling, transport and disposal of hazardous wastes and special wastes.

Demolition and disposal of the concrete foundations and floor slabs on the site is not included in the remediation plan at this time. Additional costs will be incurred if removal of this concrete is required in the future.

9.3.4 Soil Remediation

Soil requiring remediation has been identified at eight (8) sites at the Former U.S. Military Base and Residential Subdivision, as identified in Table 9.2. Table 9.2 also identifies contaminant levels in the soil, shows the estimated volumes of soil, and the priority level for soil remediation. Prior to the remediation of site soils, additional delineation would be conducted to potentially reduce the areas of soil to be remediated.

Soil remediation would be executed as per the options selected in Section 9.2 and summarized as follows:

- PCB-Impacted Soil: Stock-pile soil and transport to an existing out-of-province hazardous waste landfill.

- TPH-Impacted Soil: Pretreat soil in temporary on-site biopile, then place soil in local landfill.
- Metals-Impacted Soil: Prior to selecting a remedial option, perform bioaccessibility testing on metals in soil requiring remediation and re-evaluate the SSTLs for metals within the HHERA.

Soil removal operations would be inspected on a continuous basis by an environmental consultant. Confirmatory soil sampling would be carried out in remediated areas to demonstrate that remedial objectives are obtained. Approval is needed from the local landfill and the hazardous waste landfill before soil can be sent there for disposal. It is assumed that approval would be received from the landfills to accept the soil described in the following sections, based on the site characterization information which describes the acceptable levels of contaminants in soil disposed of at the landfill.

Efforts would be made to preserve the integrity of the monitoring wells located within the zones to be remediated. If it becomes obvious that a well will be damaged, it will be properly decommissioned to avoid creating a long term preferential pathway to the water table.

9.3.5 Monitoring

As with all remediation systems, a monitoring program would be established to determine the effectiveness of the remedial approach for TPH-impacted soil. It is recommended that soil samples be collected from the biopile on an annual basis and analyzed for BTEX/TPH.

9.3.6 Site Closure

Once all soils requiring remediation have been removed from the site and the EPCs for the site are below the SSTLs and the identified human health and ecological risks at the site have been mitigated, a summary report would be prepared and submitted to NLDEC to obtain site closure for the property.

10.0 CLOSURE

This report is for the exclusive use of Newfoundland and Labrador Department of Environment and Conservation, and no other party shall have any right to rely on any service provided by Stantec Consulting Ltd. without prior written consent from Newfoundland and Labrador Department of Environment and Conservation and Stantec Consulting Ltd.

All parties are subject to the same limit of liability as agreed to in the Stantec Standard Terms and Conditions. Any use which a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Some of the information presented in this report was provided through existing documents. Although attempts were made, whenever possible, to obtain a minimum of two confirmatory sources of information, Stantec in certain instances has been required to assume that the information provided is accurate.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. The conclusions and recommendations presented represent the best judgement of Stantec based on the data obtained during the assessment. Due to the nature of assessment and the limited data available, Stantec cannot warrant against undiscovered environmental liabilities. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgement of Stantec based on the data obtained from the work. The conclusions are based on the site conditions encountered by Stantec at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. In addition, analysis has been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present.

Should additional information become available which differs significantly from our understanding of conditions presented in this report, we request that this information be brought to our attention so that we may reassess the conclusions provided herein. This report was prepared by Anna Roy, B.Sc.E., and Kelly Johnson, M.A.Sc, and reviewed by Robert Macleod, M.Sc., P.Geo, Tania Noble-Sharpe, M.Sc., P.Eng., and Loren Knopper, Ph.D.

Respectfully submitted,

STANTEC CONSULTING LTD.

Kelly Johnson

Kelly Johnson, M.A.Sc
Environmental Scientist

FOR

Jim Slade, P.Eng., P.Geo.
Group Leader, Site Assessment and Remediation

11.0 REFERENCES

Army Corps of Engineers (ACOE). United States. 1988. Environmental effects of dredging: Relationship between PCB tissue residues EEDP-01-13. US Army Engineer Waterways Experiment Station: Vicksburg.

Alberta Environment (AENV). 2009. Alberta Tier I Soil and Groundwater Remediation Guidelines. Climate Change, Air and Land Policy Branch: Edmonton.

American Society for Testing and Materials (ASTM), 2000. E-2081-00 Standard Guide for Risk-Based Corrective Action. Volume 11.04.

Atlantic Partners in RBCA (Risk-Based Corrective Action) Implementation (PIRI), 2003. Atlantic RBCA Reference Documentation for Petroleum Impacted Sites. Version 2.0. October, 2003.

Bechtel-Jacobs Company LLC. 1998. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Prepared for the U.S. Department of Energy, Office of Environmental Management. BJC/OR-133. September 1998.

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

CCME. 1996b. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. CCME: Winnipeg.

CCME. 1996a. Guidance Manual for Developing Site-Specific Soil Quality Objectives for Contaminated Sites in Canada. CCME: Winnipeg.

CCME. 1997 A Framework for Ecological Risk Assessment: Technical Appendices. CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. CCME:Winnipeg

CCME. 1999. Canadian Environmental Quality Guidelines. CCME: Winnipeg.

Canadian Museum of Nature. 2010. Ukaliq – The Arctic Hare. Last accessed on March 31, 2010 at http://nature.ca/ukaliq/

Best, T.L., T.H. Henry. (1994). "*Lepus arcticus*". Mammalian Species No. 457. American Society of Mammalogists.

Chappell, W.R. 1992. Scaling toxicity data across species. *Environmental Geochemistry and Health* 14(3): 71-80.

COSEWIC. Wildlife Species Search – Last accessed March 31, 2010 at http://www.cosewic.gc.ca/

Convention on International Trade in Endangered Species (CITES) of Wild Flora and Fauna. 2010. Last accessed on March 31, 2010 at http://www.cites.org/eng/resources/species.html

Del Hoyo, J., A. Elliot, and J. Sargatal. 1992. Handbook of the Birds of the World, Vol. 1: Ostrich to Ducks. Lynx Editions, Barcelona.

Dement'Ev, G. P., N. A. Gladkov, Y. A. Isakov, N. N. Kartashev, and S. V. Kirikov. 1952. Birds of the Soviet Union. Vol. 4. Israel Program for Scientific Translations, Jerusalem, Israel 1967.

Dierenfeld, E.S., H.L. Alcorn and K.L. Jacobsen. 2002. Nutrient Composition of Whole Vertebrate Prey (Excluding Fish) Fed in Zoos. Last accessed on March 31, 2010 at www.nal.usda.gov/awic/zoo/WholePreyFinal02May29.pdf

Doan, N. 1999. Asio flammeus (On-line). Animal Diversity Web. Last accessed on March 31, 2010 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Asio_flammeus.html

Environment Canada, Canadian Climate Normals 1971-2000. Last accessed on March 31, 2010 at http://www.climate.weatheroffice.ec.gc.ca

Environment Canada 2010. Common Merganser Canadian Wildlife Services Identification

guide. Last accessed on March 31, 2010 at http://www.qc.ec.gc.ca/faune/guide/html/grand_harle_e.html

Environmental Sciences Group – Royal Military College. 2009. Human Health Risk Assessment of the Hopedale Former Military Site, Hopedale, Newfoundland and Labrador. Environmental Sciences Group: Kingston.

Fuchsman, P.C., Barber, T.R., Lawton, C., Leigh, K.B. 2006. An evaluation of cause-effect relationships between polychlorinated biphenyls concentrations and sediment toxicity to benthic invertebrates. *Environmental Toxicology and Chemistry* 25: 2601-2612.

Government of Newfoundland and Labrador. 2006. Endangered Species Act SNL2001 Chapter E-10.1. Last accessed on March 31, 2010 at http://www.assembly.nl.ca/legislation/sr/statutes/e10-1.htm

Graham-Bryce, I.J. 1984. Optimization of physicochemical and biophysical properties of pesticides. In: Pesticide Synthesis through Rational Approaches. P.S. Magee, G.K. Kohn and J.J. Menn (eds.). American Chemical Society: New York

Hansen, L.G., Schimmel, S.C., Forester, J. 1973. Aroclor 1254 in eggs of sheepshead minnow: effects on fertilization success and survial of embryos and fry. *Proceedings of the Southeastern Game Fish Association of Commissioners* 27: 420-426.

Hansen, L.G., Wiekhorst, W.B., Simon, J. 1976. Effects of dietary Aroclor 1242 on channel catfish (*Ictalurus punctatus*) and the selective accumulation of PCB components. *Journal of the Fisheries Research Board of Canada* 33: 1343-1352.

Health Canada, 2004a. Federal Contaminated Site Risk Assessment in Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), September 2004.

Health Canada, 2004b. Federal Contaminated Site Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values (TRVs), September 2004.

Health Canada. 2009a. Federal Contaminated Site Risk Assessment in Canada Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0, May 2009.

Health Canada, 2009b. Federal Contaminated Site Risk Assessment in Canada Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical Specific Factors, Version 2.0, May 2009.

Health Canada. 2009c. Memorandum: Interim CSD Guidance on a TRV for Lead (Pb) and

Interpretation of Pb Bioaccessibility Data for Federal Contaminated Site Human Health Risk Assessment in Canada, December 2009.

Howe, P., and Watts, P. 2005. *Tin and Organic Tin Compounds*. World Health Organization: Geneva

Johnsen, P. 1953. Mammals observed on Amdrup's journeys to East Greenland 1899-1900. *Meddelelser orn Greenland* 29: 1-62.

Kapustka, L.A. 2004. Establishing Eco-SSLs for PAHs: Lessons revealed from a review of literature in exposure and effects to terrestrial receptors. *Human and Ecological Risk Assessment* 10(2): 185-205.

Klein, D.R., and Bay, C. 1994. Resource partitioning by mammalian herbivores in the high Arctic *Oecologia* 97:439-450.

Lee, W. 2001. Sorex cinereus Animal Diversity Web. Last accessed on March 31, 2010 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Sorex_cinereus.html

Lewis, D.P. 2005. The Owl Pages (On-line). Last accessed on March 31, 2010 at http://www.owlpages.com/

Mallory, Mark and Karen Metz. 1999. Common Merganser (Mergus merganser), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology. Last accessed on March 31, 2010 at http://bna.birds.cornell.edu.qe2a-proxy.mun.ca/bna/species/442doi:10.2173/bna.442

Meade, S.J. 1990. Natural Regions of Newfoundland and Labrador. A contract report submitted to the Protected Areas Association, July 31, 1990.

Miller, D.D. and Schriker, B.R. 1982. *In vitro* estimation of food iron bioavailability. In: Nutritional Bioavailability of Iron, 1982. Edited by C. Kies. ACS Symposium Series 23, American Chemical Society: Washington D.C. Pp 12 -25.

Monosson, E. 1999/2000. Reproductive and developmental effects of PCBs in fish: a summary of laboratory and field studies. *Reviews in Toxicology* 3:25-75.

Mineau, P., B.T. Collins, and A. Baril. 1996. On the use of scaling factors to improve interspecies extrapolation of acute toxicity in birds. *Regulatory Toxicology and Pharmacology* 24: 24-29.

Nebeker, AV., Puglisi, FA, DeFoe, DL. 1974. Effect of polychlorinated biphenyl compounds on survival and reproduction of the fathead minnow and flagfish. *Transactions of the American Fisheries Society* 3: 562-568.

Neuburger, T. 1999. *Microtus pennsylvanicus* (On-line), Animal Diversity Web http://animaldiversity.ummz.umich.edu/site/accounts/information/Microtus_pennsylvanicus.html

Newfoundland and Labrador Department of Environment and Conservation. Wildlife at Risk (on line). http://www.env.gov.nl.ca/env/wildlife/wildlife_at_risk.htm

Niimi, A.J. 1996. PCBs in Aquatic Organisms. In: Environmental Contaminants in Wildlife Interpreting Tissue Concentrations. (Beyer, W.N., Heinz, G.H., Redmon-Norwood, A.W., eds), Lewis Publishers: Boca Raton. Pp 117-152.

Ohio EPA. 2003. Ecological Risk Assessment Guidance Document. State of Ohio EPA DERR-00-RR-031.

Ohio EPA. 2008. Guidance for Conducting Ecological Risk Assessments. State of Ohio EPA DERR-00-RR-031.

Ollson, C. 2003. Arsenic Risk Assessments: The Importance of Bioavailability. Doctoral Thesis. Royal Military College of Canada.

Ontario Ministry for the Environment (OMOE). 1996. Rationale for the Development and Application of Generic Soil, Groundwater and sediment Criteria for Use at Contaminated Sites in Ontario.

Reiser, D.W., Greenburg, E.S., Helster, T.E., Branton, M., Jenkins, K.D. 2004. In-situ reproduction, abundance, and growth of young-of-year and adult largemouth bass in a population exposed to polychlorinated biphenyls*. Environmental Toxicology and Chemistry* 23 1762-1773.

Research Triangle Institute (RTI). 2005. Methodology for Predicting Cattle Biotransfer Factors. Prepared for USEPA, 2005.

Richardson, G.M. 1997. Compendium of Canadian Human Exposure Factors for Risk Assessments.

Rodway, M.S. 1998. Habitat use by Harlequin ducks breeding in Hebron fiord. *Canadian Journal of Zoology* 76: 897-901.

Ruby, M.V., Davis, A., Schoof, R., Eberle, S., and Sellstone, C.M. 1996. Estimation of Lead and Arsenic Bioavailability using a Physiologically Based Extraction Test. Environmental Science and Technology. 30: 422-430.

Ruby, M.V., Schoof, R., Brattin, W., Goldade, M., Post, G., Harnois, M., Mosby, D.D., Casteel, S.W., Berti, W., Carpenter, M., Edwards, D., Cragin, D., and Chapell, W. 1999. Advances in Evaluating the Oral Bioavailability of Inorganics in Soil for Use in Human Health Risk Assessment. Environmental Science and Technology. 33: 3697-3705.

Ryan,J.A., R.M. Bell, J.M. Davidson and G.A. O'Connor. 1988. Plant Uptake of Non-Ionic Organic Chemicals from Soils. *Chemosphere* 17:2299-2323.

Sample, B.E., Opresko, D.M., Suter II, G.W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. ES/ER/TM-86/R3. Final Report. Oakridge National Laboratories: Oakridge.

Sample, B.E. and C.A Arenal. 1999. Allometric models for interspecies extrapolation of wildlife toxicological data. *Bulletin of Environmental Contamination and Toxicology* 62: 653-663.

Saunders, D. A. 1988. Adirondack Mammals. State University of New York, College of Environmental Science and Forestry. 216pp.

Scheffel, U., Hill-Zobel, R., and Min-Fu, Y. 1982. Quantification of in-vivo distribution of platelets labelled with Indium-111 Oxine – Reply. Journal of Nuclear Medicine 23: 944-945.

Suter, G.W. 1993. Ecological Risk Assessment. Lewis Publishers, Boca Raton: Florida.

Suter, G.W. 1996. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Freshwater Biota. *Environmental Toxicology and Chemistry* 15: 1232-1241.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), 1997a. Selection of representative TPH fractions based on fate and transport considerations. Vol. III in a Series, Final Draft - July 97, Amherst Scientific Publishers, 102, pp.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), 1997b. Development of fraction specific reference doses (RfDs) and reference concentrations (RfCs) for total petroleum hydrocarbons (TPH). Vol IV in a Series, Amherst Scientific Publishers, 137, pp.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG). 1997c. A Risk-Based Approach for the Management of Total Petroleum Hydrocarbons in Soil-A Technical Overview of the Petroleum.

Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG), 1998. Analysis of Petroleum Hydrocarbons in Environmental Media, March 1998, Vol I in a Series, Amherst Scientific Publishers, 98, pp.

Travis, C.C. and A.D. Arms. 1988. Bioconcentration of organics in beef, mild, and vegetation. *Environmental Science and Technology* 22: 271-173.

Travis, C.C. and R.K. White. 1988. Interspecific scaling of toxicity data. *Risk Analysis* 8: 119-125.

United States Environmental Protection Agency (USEPA). 1989. Risk assessment guidance for superfund, Volume I. Human Health Evaluation Manual (Part A); EPA/540/1-89/002; U.S. Environmental Protection Agency, Office of Emergency and Remedial Response; Washington, DC.

USEPA. 1992. Framework for Ecological Risk Assessment. U.S. Environmental Protection Agency. Risk Assessment Forum, Washington, DC, EPA/630/R-92/001, 1992.

USEPA. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. Office of Solid Waste and Emergency Response: Washington, DC. Publication 9285.7-081. May 1992.

USEPA. 1993. Wildlife Exposure Factors Handbook. Office of Health and Environmental Assessment, Office of Research and Development. Washington, D.C. December 1993.

US EPA. 1995. Great Lakes Water Quality Initiative Technical Support Document for Wildlife Criteria. Office of Water. EPA/820/B-95/009.

USEPA. 1996. IRIS. Integrated Risk Information System. http://www.epa.gov/iriswebp/iris/index.html

USEPA. 1998. Guidelines for Ecological Risk Assessment. U.S. Environmental Protection Agency, Risk Assessment Forum, Washington, DC, EPA/630/R095/002F, 1998.

USEPA. 1999. Screening level ecological risk assessment protocol for hazardous waste combustion facilities. EPA530-D-99-001B. August, 1999.

USEPA. 2002. Region III Risk-Based Concentration Table. December, 2009.

USEPA. 2007. Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs). Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C. OSWER Directive 9285.7-55. Attachment 4-1 in Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSLs. Issued November 2003, revised February 2005 and April 2007. Last accessed on March 31, 2010 at:http://www.epa.gov/ecotox/ecossl/pdf/ecossl_attachment_4-1.pdf.

US EPA (United States Environmental Protection Agency). 2007. User's Guide T-REX Version 1.2.3 (Terrestrial Residue EXposure model). Last accessed March 31, 2010 at http://www.epa.gov/oppefed1/models/terrestrial/trex/t_rex_user_guide.htm

USEPA. 2007. ProUCL, Version 4.00.02. Statistical software developed by Anita Singh and Robert Maichle, Lockheed Martin Environmental Services, and Ashok Singh. University of Nevada: Las Vegas.

Usher, P.J. 1982. Renewable Resources in the Future of Northern Labrador. A Report to the Labrador Inuit Association, Nain, Labrador. P.J. Usher Consulting Services: Ottawa.