Environmental Guideline

for

Contaminated Site Remediation

November 2003

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1 Introduction

In the Northwest Territories (NWT) and across Canada, contaminated sites pose a threat to human health and the environment. In some cases the concern may also be financial, because of the loss of equity and the cost of remediating the property.

The purpose of this guideline is to help you solve a contamination problem on your property by setting soil standards for site remediation. This guideline describes the process that is used to manage (e.g. identify, assess, remediate) contaminated or potentially contaminated sites on Commissioner's Land including private land within municipalities.

In the NWT the federal government has environmental jurisdiction over surface and groundwater. If contaminated water is encountered, Indian and Northern Affairs Canada must be consulted.

The NWT *Environmental Protection Act (EPA)* gives the Government of the Northwest Territories (GNWT) the authority to take all necessary measures to ensure the preservation, protection or enhancement of the environment, with the goal of sustainability and stewardship.

Section 2.2 of the *EPA* gives the Minister of Resources, Wildlife, and Economic Development (RWED) the authority to develop, coordinate, and administer these guidelines (see Appendix 1).

1.1 Definitions

CCME	The Canadian Council of Ministers of the Environment (CCME) is the major intergovernmental forum in Canada for discussion and joint action on environmental issues of national, international and global concern. The 14 member governments work as partners in developing nationally consistent environmental standards and practices. See Appendix 8 for contact information.
Closure Report	The final report prepared by the qualified person and provided to RWED following successful implementation of the Remedial Action Plan.
Commissioner's Land	Lands in the NWT that have been transferred by Order-in-Council to the GNWT. This includes highways and block land transfers. Most Commissioner's Land is located within municipalities.
Contaminant	Any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment, (a) endangers the health, safety or welfare of persons, (b) interferes or is likely to interfere with normal enjoyment of life or property, (c) endangers the health of animal life, or (d) causes or is likely to cause damage to plant life or to property.

Contaminated Site	Areas of land, water, groundwater, or sediments that have levels of contaminants exceeding the remediation criteria. Contaminant sources can include on-site burial of wastes, small, frequent drips and spills, stockpiling and storage of materials, major spills, and releases during fires. Contamination may also be due to illegal dumping of contaminated soil. Contaminated sites may have short or long term consequences to the health of people or the quality of the environment.
Discharge	Includes any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping.
Environment	Means the components of the Earth and includes (a) air, land and water, (b) all layers of the atmosphere, (c) all organic and inorganic matter and living organisms, and (d) the interacting natural systems that include components referred to in paragraphs (a) to (c).
Inspector	Means a person appointed under subsection 3(2) of the *EPA* and includes the Chief Environmental Protection Officer.
Qualified Person	A person who has an appropriate level of knowledge and experience in all aspects of contaminated site investigation, remediation and management.
Remedial Action Plan	A report that identifies Site-Specific Remedial Objectives for a site, identifies remedial options and outlines their feasibility, and recommends and describes a preferred conceptual remediation plan, a performance monitoring plan, and if appropriate, requirements for ongoing site management.
Remediation	The improvement of a contaminated site to prevent, minimize, or mitigate damage to human health or the environment. Remediation involves the development and application of a planned approach that removes, destroys, contains or otherwise reduces availability of contaminants to receptors of concern.
Remediation Criteria	The numerical limits or narrative statements pertaining to individual variables or substances in water, sediment or soil which are recommended to protect and maintain the specified uses of contaminated sites. When measurements taken at a contaminated site indicate that the remediation criteria are being exceeded, the need for remediation is indicated.

Additional definitions can be found in Appendix 2.

1.2 Roles and Responsibilities

1.2.1 Environmental Protection Service

The Environmental Protection Service (EPS) of RWED is the main contact concerning remediation of contaminated sites on Commissioner's Land. EPS determines the required level of remediation using the remediation criteria cited in this document. EPS also reviews your remediation plan and monitors the progress of the project.

EPS programs are applied primarily to Commissioner's Land, municipal lands or lands involving GNWT activities. The *EPA* provides the legislative authority. Contact EPS for a listing of relevant legislation and guidelines or visit the web site at www.gov.nt.ca/RWED/eps/leg.htm.

> ***EPS will provide advice on remediation measures, but it is the sole responsibility of the polluter and landowner to provide adequate site remediation.***

1.2.2 Responsible Party

If the person responsible for a site is notified or otherwise has reason to believe that the site is potentially contaminated, that person shall immediately report the incident and ensure an appropriate evaluation of the potential adverse effects and risks is completed to determine what action, if any, is required under the *EPA* or this guideline.

These responsibilities can include the following:

- Exercising timeliness in all matters related to the contaminated site;
- Retaining a qualified person (see Section 1.1) to assess the site to determine the presence and extent of contamination;
- Developing a remedial action plan;
- Contacting affected or interested parties including: regional environmental health officer, Office of the Fire Marshal, local fire department, local government, landowner, affected adjacent landowners, Aboriginal claimant organization, or any other party as need be regarding health and safety concerns; and
- Remediating the contaminated site to acceptable levels.

1.2.3 Other Regulatory Agencies

Several external agencies may have to be involved with the management of a contaminated site due to their legislative responsibilities. Some of the other agencies that may be involved are:

1.2.4 Department of Transportation, GNWT

The Department of Transportation is responsible for administering the *Transportation of Dangerous Goods Act and Regulations* (NWT) including the transportation of contaminated soils (see Appendix 7).

1.2.5 Office of the Fire Marshal, GNWT

The Office of the Fire Marshal has authority over the storage, handling, use and processing of flammable and combustible liquids under the *Fire Prevention Act* and the withdrawal of tanks from service.

1.2.6 Office of the Chief Medical Officer, GNWT

Contaminated sites may impact residences or other buildings potentially affecting public health. The Office of the Chief Medical Officer or regional environmental health officers should be consulted regarding requirements under the *Public Health Act.*

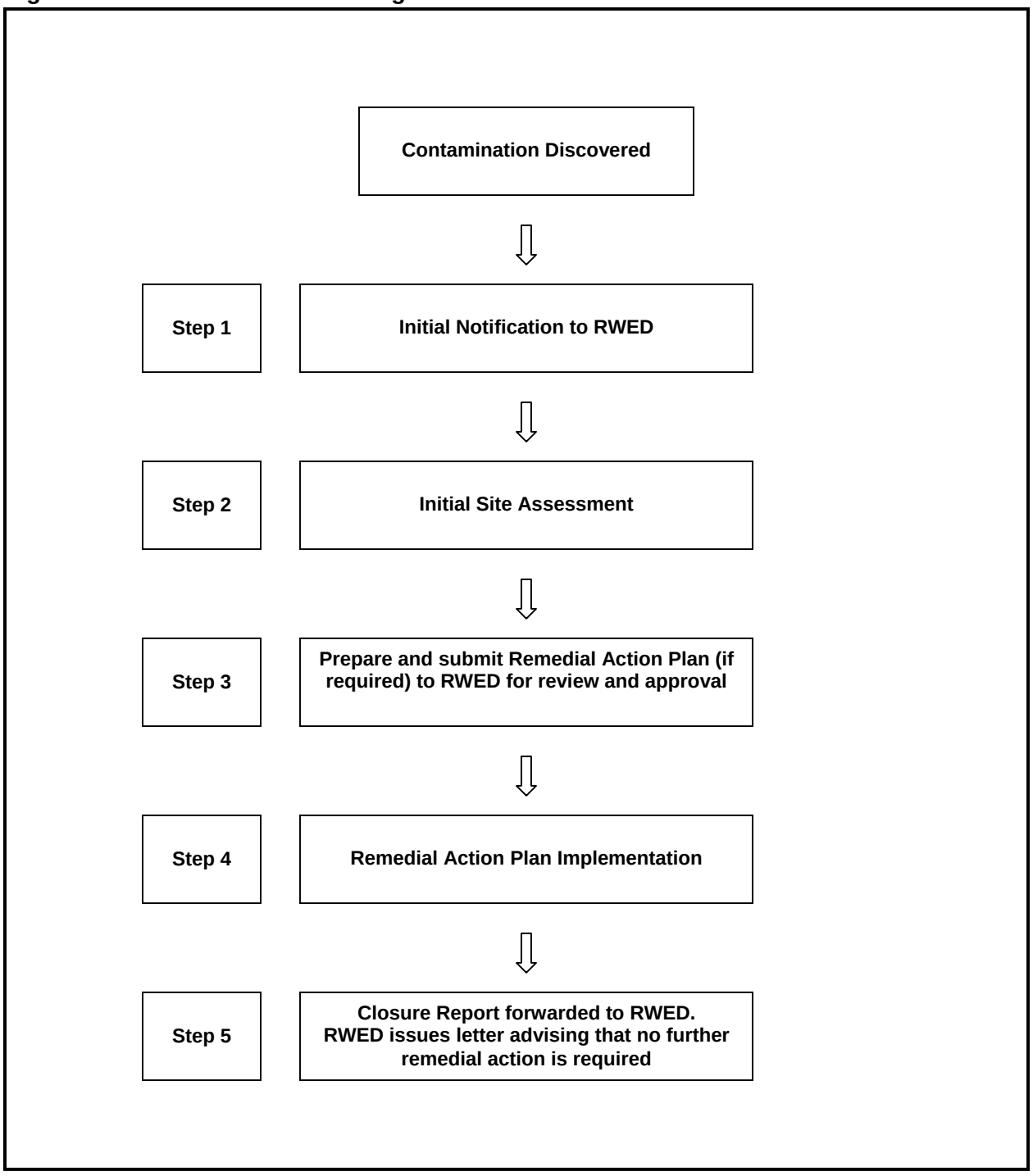
1.2.7 Local Government

The role of local governments is important in the management of contaminated sites. Firstly, cleanup standards are often determined by how the property is designated under local government planning documents. Secondly, infrastructure (e.g., landfill site, community landfarm) may be utilized with the consent of the local government. Thirdly, the fire department may have to be called upon if a fire or public safety issue is identified.

2 Contaminated Site Management Process

The Contaminated Site Management Process consists of five steps from the time that contamination is discovered to final site remediation and closure. The following flow chart defines the steps in the overall management process.

Figure 1. Contaminated Site Management Process



2.1 Step 1 - Initial Notification

This step covers the initial time period following discovery of contamination and represents the normal initial notification to RWED. The occurrence may be a result of spills, accidents, investigations completed for the sale or refinancing of a property, or other situations that identify contamination impacts to the environment.

Section 5.1 of the *EPA* states that the owner, or person in charge, management or control of a contaminant discharged into the environment must:

- report the discharge to the NWT 24-Hour Spill Report Line at (867) 920-8130;
- take all reasonable measures to stop the discharge and repair any damage; and
- make a reasonable effort to notify affected public.

RWED will assess the significance of the reported discovery of the contamination by either a site visit by a RWED inspector or reviewing site assessment findings. Should RWED determine that the contamination presently, or in the future, poses a risk to human health or the environment, the inspector will require remedial action to be taken to rectify the situation and the responsible party to carry out such action. The responsible party may be required to complete the work in a specified time frame. RWED will consult with Office of the Chief Medical Officer or regional environmental health officers when exposure to indoor air contaminants originating from the release area is a concern.

If the inspector determines the problem cannot be solved with limited remedial action, RWED will instruct the responsible party to obtain the services of a qualified person (Step 2). If evidence of groundwater contamination or explosive vapours is present, or another party's property is affected, the services of a qualified person are mandatory. RWED will then consider the site a "contaminated site" until the management process has been completed.

In all cases, the responsible party is required to inform any affected parties about the contamination event and provide proof of such disclosure to RWED. Any issues not related to health and/or the environment that arises between the responsible party and affected parties are considered to be civil matters to be settled by the two parties outside of this management process.

2.2 Step 2 - Initial Site Assessment

During this step the qualified person conducts a site assessment to collect necessary technical information. Soil and groundwater effects must be assessed as well as potential effects on the surrounding population. A critical factor in a site assessment is completely defining and delineating the extent of the contamination in both soil and groundwater, even if it has crossed the source property boundary. Once the contamination plume is defined, it must remain defined. For instance, if monitoring data indicates that the plume is migrating beyond monitoring wells, then additional wells must be installed.

2.2.1 Environmental Site Assessment

Environmental Site Assessment (ESA) should identify the nature and extent of contaminants. A well-planned, comprehensive assessment will allow site managers to make informed decisions about potential remediation. There are three stages of phased investigation, depending on the size and complexity of the contaminated site, ranging from the general to the specific. The three phases of investigation are described below.

Phase I: Site Information Assessment

The purpose of the Phase I ESA is to identify actual and potential site contamination. At a minimum, the Phase I ESA must meet or exceed the Canadian Standards Association (CSA) Standard Z768-01, *Phase I Environmental Site Assessment*. See Appendix 8 for contact information.

In Phase I, the objective is to assemble all available historical and current information to help develop a field-testing program, should one be required. The work will begin by reviewing all data gathered for legal, transactional or environmental reasons (e.g., site classification, if already conducted) and supplementing this information as required.

The work frequently encompasses three broad aspects:

Facility Characteristics**.** A current and historical description of the site and its facilities is developed, particularly as it relates to the areas of concern like contaminant sources and discharge points. Visual inspections, facility records reviews and discussions with informed personnel are employed. In addition, above and below ground structures are reviewed (using blueprints, if available) as possible sources of contaminant migration. Prior site uses and surrounding land uses are also considered.

Contaminant Characteristics**.** Contaminants that may be present at the site are identified. Their quantities and concentrations are estimated by visual inspections, reviews of documentation and discussions with informed staff.

Physical Site Characteristics**.** The geology, hydrology and hydrogeology are examined using available data. The overall aim is to provide a more comprehensive description and understanding of the local site characteristics and to develop a current and historical description of the area.

The sources of information can include:

- aerial photographs;
- geology and groundwater reports;
- topographical, geological and other maps;
- RWED's Hazardous Materials Spill Database; and
- previous site investigation reports.

The review will also include a site inspection and discussions with personnel and local residents informed about the site and its history and conditions. The site inspection will examine vegetation stress, key ecological receptors, leachate breakout and signs of contamination discharge. Surrounding land uses will also be considered. Drinking water sources and wells will be noted using published well records correlated to site observations. Proximity of the site to surface water bodies or sensitive habitats (e.g., wetlands) should also be identified.

Phase II: Reconnaissance Testing Program

The objective of the Phase II ESA is to confirm the presence and characterize the substances of concern at the site. The Phase II ESA must meet or exceed the CSA Standard Z769-00, *Phase II Environmental Site Assessment*.

Characterization of the contamination (i.e., degree, nature, estimated extent and media affected) and site conditions (i.e., geological, ecological, hydrogeological and hydrological) are necessary to develop a remedial action plan or to identify the need for more specific Phase III investigations. It also may be decided that no further action is required or that immediate action is needed. Further study may be necessary to determine risks to public health, safety or the environment. This may take the form of human health and ecological risk assessments using Phase II investigation data.

The Phase II sampling program should include the adoption of sampling procedures, quality assurance/quality control procedures and laboratory analytical protocols (see Appendix 6). In addition, preliminary environmental quality remediation criteria must be selected. See the CCME *Guidance Document on the Management of Contaminated Sites in Canada, April 1997* for further information.

Phase III: Detailed Testing Program

The results of the Phase II investigation will determine the need for a Phase III ESA. If sufficient data have been obtained at Phase II to characterize the site and/or the risk to human health and the environment, then the process may move directly to a remedial action plan (if it is required).

Alternatively, a Phase III detailed investigation may be necessary if the Phase II results indicate that significant contamination exists that will require remediation. This investigation will specifically address outstanding issues with a view to obtaining enough information to formulate a remedial action plan. The objectives of Phase III investigation are:

- to target and delineate the boundaries of identified contamination;
- to define, in greater detail, site conditions to identify all contaminant pathways, particularly with respect to possible risk assessment;
- to provide contaminant and other information necessary to finalize environmental quality remediation criteria or risk assessment; and
- to provide all other information required to develop a remedial action plan and input to specifications and tender documents.

Generally, the Phase III detailed testing program will concentrate on areas identified in the Phase II program and involve a similar systematic process of sampling and analysis, evaluation, conclusions and recommendations. However, a greater number of samples are usually collected and a smaller suite of chemical substances may be analyzed as the program converges on the environmental issues.

Once the environmental condition of the site has been assessed, the qualified person will compare it to applicable remediation criteria (numerical limits) in order to determine whether further investigative or remedial actions are required.

2.2.2 Land Use

The remediation criteria are presented in the context of four types of land use: agricultural, residential/parkland, commercial and industrial (as defined below). The criteria are considered generally protective of human and environmental health for specified uses of soil at contaminated sites. It is important to note that it is the *intended* future land use that governs the decision on the level of remediation performed at a site. Identifying the type of land use will help you assess the extent of human and ecological exposure to contaminants in the soil, and is essential for planning practical remediation programs. *The type of land found adjacent to the contaminated site may affect the remediation criteria levels that you have to follow.*

Agricultural	All uses of land where the activity is primarily related to the productive capability of the land or facility (e.g., greenhouse) and is agricultural in nature, or is related to the feeding and housing of animals such as livestock.
Residential/Parkland	All uses of land in which dwelling on a permanent, temporary or seasonal basis is the primary activity. Institutions, hospitals, schools, daycare and playgrounds are also indicated under this land use. This includes activity that is recreational in nature, and requires the natural or human designed capability of the land to sustain that activity. Residential/Parkland is often readily accessible to the public.
Commercial	All uses of land in which the primary activity is related to the buying, selling, or trading of merchandise or services.
Industrial	All land uses in which the primary activity is related to the production, manufacture or storage of materials. This does not include institutions (e.g., schools, hospitals, playgrounds). The public does not usually have uncontrolled access to this type of land.

2.2.3 Application of Remediation Criteria at Contaminated Sites

There are three basic approaches that may be utilized for the development of Site-Specific Remediation Objectives:

- **Tier 1** Direct adoption of remediation criteria (Criteria-based Approach)
- **Tier 2** Adoption of remediation criteria, with limited modifications (Modified Criteria Approach); and
- **Tier 3** The use of risk assessment (Risk-based Approach)

The criteria-based approach is designed to require fewer resources while providing a scientifically defensible basis for protection that is sufficiently flexible to account for certain site-specific factors. This approach is believed to provide an effective alternative to detailed risk assessment methods. The risk-based approach can be more complex and more costly, and is generally utilized when a criteria-based approach is not suitable for a site (e.g., large, complex industrial site).

Utilization of any of the three approaches is subject to the approval of RWED.

Tier 1 - Criteria-Based Approach

Under this approach, the remediation criteria selected for a site are adopted as the remediation objectives. In general, this method is most applicable where site conditions, receptors, and exposure pathways are similar with those assumed in the development of the criteria. Other factors that may bear weight on the decision to directly adopt criteria include cost, time, simplicity and technical considerations.

Table 1 below presents a summary of Tier 1 remediation criteria for petroleum hydrocarbons (PHC) in surface soil. Additional remediation criteria for other contaminants in soil (i.e., BTEX, metals, PAHs) can be found in Appendix 5.

Table 1. Summary of Tier 1 levels (mg/kg) for PHCs in surface soil.*

Land Use	Soil Texture	Fraction 1	Fraction 2	Fraction 3	Fraction 4
Agricultural	Coarse-grained soil	130	450 (150[a])	400	2800
	Fine-grained soil	260 (180[b])	900 (250[b])	800	5600
Residential/Parkland	Coarse-grained soil	30[c]	150[c]	400	2800
	Fine-grained soil	260 (180[b])	900 (250[b])	800	5600
Commercial	Coarse-grained soil	310 (230[a])	760 (150[a])	1700	3300
	Fine-grained soil	660 (180[b])	1500 (250[b])	2500	6600
Industrial	Coarse-grained soil	310 (230 [a])	760 (150 [a])	1700	3300
	Fine-grained soil	660 (180 [b])	1500 (250 [b])	2500	6600

* Additional Tier 1 levels for PHC soils are presented in the Appendix 3.
a = Where applicable, for protection against contaminated groundwater discharge to an adjacent surface water body.
b = Where applicable, for protection of potable groundwater.
c = Assumes contamination near residence with slab-on-grade construction.

Where a Tier 1 approach determines that applicable criteria are exceeded for the land use, specific remedial actions will be required unless a Tier 2 approach justifies the application of site-specific objectives and/or on-going site management.

Tier 2 - Modified-Criteria Approach

In certain circumstances, remediation criteria may be modified, within specified limits, and adopted for use as the remediation objective for the site. The acceptability of a Tier 2 approach for evaluation of off-site impacts may be subject to review by EPS and the acceptance of other affected parties.

In general, the method may be utilized in situations where site conditions, land use, receptors or exposure pathways differ only slightly from those assumed in the development of the "generic" criteria. Specific guidance on situations in which modifications are allowed to the criteria, as well as details concerning implementation of the approach are provided in the *Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites (CCME 1996).*

Tier 3 - Risk-Based Approach

In certain circumstances, the criteria-based approach may not be suitable for a site (e.g., pathways of exposure, target chemicals, receptors or other site characteristics differ from those used to develop the criteria-based approaches) and risk assessment procedures may be required in the development of Site-Specific Remediation Objectives. Site-specific objectives are developed from the results of the risk assessment to establish a concentration corresponding to an acceptable risk to human or ecological receptors.

Site-Specific Remediation Objectives for soil should be developed using risk assessment when there are:

- significant ecological concerns (e.g., critical or sensitive habitats for wildlife; rare, threatened or endangered species; parkland or ecological reserves; hunting or trapping resources);

- unacceptable data gaps. Examples include:
  - exposure conditions are particularly unpredictable or uncertain;
  - there is a lack of information about receptors;
  - there is a high degree of uncertainty about hazard levels;

- special site characteristics. For example:
  - the site is so large, or the estimated cost of remediation is so high, that a risk assessment is needed to provide a framework for site investigation and to set remediation priorities;
  - site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivation of criteria.

For example, Table 2 presents site-specific human health-based soil quality remediation objectives developed for arsenic in the Yellowknife area.

Table 2. Remediation Objectives (mg/kg) for Arsenic in Yellowknife area soils and sediment.*

Medium	Land Use		
	Residential	**Industrial**	**Boat Launch**
Soil	160	340	220
Sediment	N/A	N/A	150

* Further information and rationale is presented in Appendix 4.
N/A = Not Applicable.

If the developed site-specific remediation criteria are not exceeded, the qualified person may conclude that no further action is required and submit the evaluation report to RWED.

If site conditions exceed the applicable remediation criteria, the responsible party must submit the evaluation report to RWED and advise affected parties.

2.3 Step 3 - Preparation of a Remedial Action Plan

At this point the responsible party and qualified person will review the results of the site assessment and determine whether to remediate the site to the generic criteria or complete further work to develop site-specific remedial criteria using risk assessment approach.

Once the remediation criteria have been determined for the site, the qualified person must prepare a Remedial Action Plan (RAP) detailing the methodology for achieving these criteria as well as the proposed remedial action.

The RAP must:

- Include contact information, including names of key personnel, consultants, contractors, telephone, mail, fax, and email contacts, physical addresses;
- summarize all data on contaminants identified during the site investigation(s);
- identify contaminants of concern and the media affected;
- identify the proposed cleanup criteria and method(s) by which they have been derived;
- identify, quantify and characterize the materials to be treated/removed;
- summarize remedial options evaluated and the method used to select the preferred remedial strategy;
- describe the selected cleanup method and its technical feasibility;
- detail an implementation plan, including a schedule;
- discuss control measures to minimize fugitive air emissions, surface water control, worker health and safety;
- identify the fate of residual contaminants; and
- identify remedial verification and long-term monitoring plans.

The final action in this step is to submit the RAP to RWED for approval.

2.4 Step 4 - Remedial Action Plan Implementation

The responsible party and the qualified person shall proceed with the approved RAP and submit monitoring reports to RWED on the pre-determined schedule.

The responsible party must advise RWED if activities deviate from the approved RAP. RWED will assess the significance of any deviations and respond accordingly. In situations where predictions included in the RAP fail to be achieved, the responsible party may be required to re-evaluate Step 3 and enhance the RAP.

2.5 Step 5 - Site Closure

When the responsible party and qualified person are satisfied that all the requirements of the RAP have been met, a closure report will be forwarded to RWED.

Upon receipt and acceptance of the closure report, RWED will conclude the management process by issuing a letter advising that no further remedial action is required.

3 Conclusion

This is a brief introduction to the contaminated site remediation process. This document is intended to inform you about some of the basic issues involved in contaminated site remediation. Once you have read this document and verified that you have a contaminated site, you must contact EPS before proceeding though the Contaminated Site Management Process.

For more information, contact:

ENVIRONMENTAL PROTECTION SERVICE
Department of Resources, Wildlife, and Economic Development
Government of the Northwest Territories
7th Floor Scotia Centre
5102-50th Avenue
Yellowknife, NWT

Mailing Address: P.O. Box 1320
Yellowknife, NT, X1A 2L9
Phone: (867) 873-7654; Fax: (867) 873-0221

4 References

Canadian Council of Ministers of the Environment (CCME). Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, (2001).

Canadian Council of Ministers of the Environment (CCME). Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement, (2001).

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Canadian Council of Ministers of the Environment (CCME). Guidance Manual for Sampling, Analysis and Data Management, Volume 1: Main Report, (1993).

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Canadian Council of Ministers of the Environment (CCME). Subsurface Assessment Handbook for Contaminated Sites, (1994).

Canadian Standards Association (CSA). CSA Standard Z768-01 Phase I Environmental Site Assessment, (2001).

Canadian Standards Association (CSA). CSA Standard Z769-00 Phase II Environmental Site Assessment, (2000).

GNWT Resources, Wildlife, and Economic Development. Environmental Guideline for the General Management of Hazardous Waste, (1998).

Risklogic Scientific Services Inc. Determining Natural (Background) Arsenic Soil Concentrations in Yellowknife NWT, and Deriving Site-Specific Human Health-Based Remediation Objectives for Arsenic in the Yellowknife Area, (2002).

APPENDIX 1

Environmental Protection Act

The following is a subset of the *Environmental Protection Act,* R.S.N.W.T. 1988, c. E-3.

1. In this Act,

"contaminant" means any noise, heat, vibration or substance and includes such other substance as the Minister may prescribe that, where discharged into the environment,

(a) endangers the health, safety or welfare of persons,
(b) interferes or is likely to interfere with normal enjoyment of life or property,
(c) endangers the health of animal life, or
(d) causes or is likely to cause damage to plant life or to property;

"discharge" includes, but not so as to limit the meaning, any pumping, pouring, throwing, dumping, emitting, burning, spraying, spreading, leaking, spilling, or escaping;

"environment" means the components of the Earth and includes

(a) air, land and water,
(b) all layers of the atmosphere,
(c) all organic and inorganic matter and living organisms, and
(d) the interacting natural systems that include components referred to in paragraphs (a) to (c).

"inspector" means a person appointed under subsection 3(2) and includes the Chief Environmental Protection Officer.

2.2 The Minister may

(a) establish, operate and maintain stations to monitor the quality of the environment in the Territories;
(b) conduct research studies, conferences and training programs relating to contaminants and to the preservation, protection or enhancement of the environment;
(c) develop, co-ordinate and administer policies, standards, guidelines and codes of practice relating to the preservation, protection or enhancement of the environment;

3. (2) The Chief Environmental Protection Officer may appoint inspectors and shall specify in the appointment that powers that may be exercised and the duties that may be performed by the inspector under this Act and regulations.

5. (1) Subject to subsection (3), no person shall discharge or permit the discharge of a contaminant into the environment.

(2) REPEALED, R.S.N.W.T. 1988,c.117(Supp.),s.8.

(3) Subsection (1) does not apply where the person who discharged the contaminant or permitted the discharge of the contaminant establishes that

(a) the discharge is authorized by this Act or the regulations or by an order issued under this Act or the regulations;
(b) the contaminant has been used solely for domestic purposes and was discharged from within a dwelling house;
(c) the contaminant was discharged from the exhaust system of a vehicle;
(d) the discharge of the contaminant resulted from the burning of leaves, foliage, wood, crops or stubble for domestic or agricultural purposes;

(e) the discharge of the contaminant resulted from burning for land clearing or land grading;
(f) the discharge of the contaminant resulted from a fire set by a public official for habitat management of silviculture purposes;
(g) the contaminant was discharged for the purposes of combatting a forest fire;
(h) the contaminant is a soil particle or grit discharged in the course of agriculture or horticulture; or
(i) the contaminant is a pesticide classified and labelled as "domestic" under the *Pest Control Products Regulations* (Canada).

(4) The exceptions set out in subsection (3) do not apply where a person discharges a contaminant that the inspector has reasonable grounds to believe is not usually associated with a discharge from the excepted activity.

5.1. Where a discharge of a contaminant into the environment in contravention of this Act or the regulations or the provisions of a permit or licence issued under this Act or the regulations occurs or a reasonable likelihood of such a discharge exists, every person causing or contributing to the discharge or increasing the likelihood of such a discharge, and the owner or the person in charge, management or control of the contaminant before its discharge or likely discharge, shall immediately:
(a) subject to any regulations, report the discharge or likely discharge to the person or office designated by the regulations;
(b) take all reasonable measures consistent with public safety to stop the discharge, repair any damage caused by the discharge and prevent or eliminate any danger to life, health, property or the environment that results or may be reasonably expected to result from the discharge or likely discharge; and
(c) make a reasonable effort to notify every member of the public who may be adversely affected by the discharge or likely discharge.

6. **(**1) Where an inspector believes on reasonable grounds that a discharge of a contaminant in contravention of this Act or the regulations or a provision of a permit or licence issued under this Act or the regulations has occurred or is occurring, the inspector may issue an order requiring any person causing or contributing to the discharge or the owner or the person in charge, management or control of the contaminant to stop the discharge by the date named in the order.

7. (1) Notwithstanding section 6, where a person discharges or permits the discharge of a contaminant into the environment, an inspector may order that person to repair or remedy any injury or damage to the environment that results from the discharge.

(2) Where a person fails or neglects to repair or remedy any injury or damage to the environment in accordance with an order made under subsection (1) or where immediate remedial measures are required to protect the environment, the Chief Environmental Protection Officer may cause to be carried out the measures that he or she considers necessary to repair or remedy an injury or damage to the environment that results from any discharge.

APPENDIX 2

Glossary

Accreditation	Formal recognition of the competence of an environmental analytical laboratory to carry out specified tests. Formal recognition is based on an evaluation of laboratory capability and performance; site inspections are utilized in the evaluation of capability.
Adverse Effect	An undesirable or harmful effect to an organism, indicated by some result such as mortality, altered food consumption, altered body and organ weights, altered enzyme concentrations or visible pathological changes.
Assess or Assessment	Investigations, monitoring, testing and other information-gathering activities to identify: (1) the existence, source, nature and extent of contamination resulting from a release into the environment of a hazardous material or chemical substance; and (2) the extent of danger to the public health, safety, welfare, and the environment. The term also includes studies, services, and investigations to plan, manage and direct assessment, and decommissioning and cleanup actions.
Background Samples	Matrices minus the analytes of interest that are carried through all steps of the analytical procedure. They are used to provide a reference for determining whether environmental test sample results are significantly higher than "unpolluted" samples, which contain "zero", low, or acceptable levels of the analytes of interest. All matrices, sample containers, reagents, glassware, preparations, and instrumental analyses are included in the analysis of background samples.
Blank	The measured value obtained when a specified component of a sample is not present.
Chemical	Any element, compound, formulation or mixture of a substance that might enter the aquatic environment through spillage, application or discharge. Examples of chemicals that are applied to the environment are insecticides, herbicides, fungicides, and agents for treating oil spills.
Cleanup	The removal of a chemical substance or hazardous material from the environment to prevent, minimize or mitigate damage to the public health, safety or welfare, or the environment that may result from the presence of the chemical substance or hazardous material. The cleanup is carried out to attain specified cleanup criteria.
Concentration	The amount of chemical or substance in a given environmental

	medium. Concentration is typically expressed in units such mg/L (in water), mg/kg (in soil or food) and mg/m3 (in air).
Criteria	Numerical standards that are established for concentrations of chemical parameters in various media to determine the acceptability of a site for a specific land use.
Environmental Analytical Laboratory	A laboratory engaged in the physical, chemical or biological measurements of either the receiving environment or discharges to the receiving environment.
Groundwater	All subsurface water that occurs beneath the water table in rocks and geologic formations that are fully saturated.
Guidelines	Statements outlining a method, procedure, process or numerical value which, while not mandatory, should be followed unless there is a good reason not to do so, and includes the numerical limits or narrative statements that are recommended to protect and maintain the specified uses of water, sediment, soil or air.
Hazardous Material	Is material including but not limited to, because of its quality, concentration, chemical composition, corrosive, flammable, reactive, toxic, infectious or radioactive characteristics, either separately or in combination with any substance or substances, that constitutes a present or potential threat to human health, safety or welfare, or to the environment, when improperly stored, treated, transported, disposed of, used or otherwise managed.
Migration	The movement of chemicals, bacteria and gases in flowing water or vapour in the subsurface.
Monitoring	The routine (e.g., daily, weekly, monthly, quarterly) checking of quality, or collection and reporting of information.
Objective	A numerical limit or narrative statement that has been established to protect and maintain a specified use of water, sediment or soil at a particular site by taking into account site-specific conditions. Objectives may be adopted directly from generic criteria or formulated to account for site-specific conditions.
Procedures	Methods used by a regulatory agency to establish environmental quality criteria. In contrast to an approach, a procedure does not include the philosophical basis of the process (e.g., guiding principles).
Quality Assurance/Quality Control (QA/QC)	Those procedures and controls designed to monitor the conduct of a study in order to ensure the quality of the data and the integrity of the study.

Receptor	A person or organism subjected to chemical exposure. An ecosystem component that is, or may be, adversely affected by a pollutant or other stress emanating from a contaminated site. Receptors may include biological or abiotic (e.g., air or water quality) components.
Risk	Risk is a measure of both the severity of health effects arising from exposure to a substance and the probability of its occurrence.
Risk Assessment	Procedure designed to determine the qualitative aspects of hazard identification and usually a quantitative determination of the level of risk based on deterministic or probabilistic techniques.
Screening	Rapid analysis to determine if further action (e.g., detailed analysis or cleanup) is warranted.
Site-Specific Remedial Objectives	The objectives established for a specific site to be met by the implementation of a Remedial Action Plan and, if appropriate, ongoing site management.
Surface Water	Natural water bodies, such as rivers, streams, brooks and lakes, as well as artificial water courses, such as irrigation, industrial and navigational canals, in direct contact with the atmosphere.
Test Pit	A shallow pit made to characterize the subsurface.

APPENDIX 3

Remediation Criteria for Petroleum Hydrocarbons in Soil

The definition of Petroleum Hydrocarbons (PHC) describes a mixture of organic compounds found in and derived from geological substances such as oil, bitumen and coal. Petroleum products released into the environment, such as crude oil and jet fuel, typically contain thousands of compounds in varying proportions, composed predominantly of carbon and hydrogen, with minor amounts of nitrogen, sulphur and oxygen. PHC contamination in soils varies with the petroleum source, soil type, the composition, degree of processing (crude, blended or refined) and the extent of weathering caused by exposure to the environment. Such factors have complicated the assessment of the human and environmental health risks associated with PHC contamination in soil. This complicated assessment of risk has made it necessary to evaluate PHC as four fractions: F1, F2, F3, and F4. This is different from previous guidelines where PHC contamination in soil was assessed by one parameter - total petroleum hydrocarbons.

For the purposes of this document, PHC are subdivided according to specified ranges of equivalent carbon number (ECN). Each fraction is, in turn, made of subfractions. The subfractions have been described according to their relevant physical and chemical properties and toxicological characteristics. The divisions between the fractions have been established in consideration of analytical factors, physical and chemical properties, the expected relevance to biological response in soils and the ability to utilize the definitions and associated properties.

Fraction 1 (F1) encompasses the range of ECN from C6 to C10. It represents the volatile fraction of most hydrocarbon mixtures and consists of aromatic subfractions in the range >C8 to C10, as well as aliphatic subfractions in the ranges of C6 to C8 and >C8 to C10. Specific aromatic compounds falling within this fraction (i.e., benzene, toluene, ethylbenzene and xylene, BTEX) are normally managed separately and would therefore be subtracted from the aromatics in this fraction.

Fraction 2 (F2) encompasses the range of ECN from >C10 to C16. It represents the semi-volatile fraction and comprises aromatics and aliphatic subfractions in the ranges >C10 to C12 and >C12 to C16.

Fraction 3 (F3) encompasses the range of ECN from >C16 to C34. It includes both aromatics and aliphatics in the >C16 to C21 and >C21 to C34 ranges.

Fraction 4 (F4) encompasses the range of ECN from >C34 to C50+. PHC within this range often make up a significant proportion of crude oils and petroleum products, although the fraction is generally considered to be of low mobility, volatility and solubility.

Soil Texture Definition

Tier 1 and Tier 2 numerical values are prescribed for coarse-grained and fine-grained soils. Sufficient textural information should be obtained to permit classification of the soils as either coarse or fine. These are defined as follows:

Fine-grained soil means soil having a median grain size of <75 µm as defined by the American Society for Testing and Materials.

Coarse-grained soil means soil having a median grain size of >75 µm as defined by the American Society for Testing and Materials.

The cleanup criteria are different for surface soil than for subsoils. For the purpose of this document **subsoil** is that soil which is 1.5 metres or deeper from the surface.

Tier 1 levels for PHC in soils are presented in the next five tables.

Table A1. Summary of Tier 1 levels (mg/kg) for PHCs in surface soil.*

Land Use	Soil Texture	Fraction 1	Fraction 2	Fraction 3	Fraction 4
Agricultural	Coarse-grained soil	130	450 (150[a])	400	2800
	Fine-grained soil	260 (180[b])	900 (250[b])	800	5600
Residential/Parkland	Coarse-grained soil	30[c]	150[c]	400	2800
	Fine-grained soil	260 (180[b])	900 (250[b])	800	5600
Commercial	Coarse-grained soil	310 (230[a])	760 (150[a])	1700	3300
	Fine-grained soil	660 (180[b])	1500 (250[b])	2500	6600
Industrial	Coarse-grained soil	310 (230 [a])	760 (150 [a])	1700	3300
	Fine-grained soil	660 (180 [b])	1500 (250 [b])	2500	6600

* Additional Tier 1 levels are presented in the next four tables.
a = Where applicable, for protection against contaminated groundwater discharge to an adjacent surface water body.
b = Where applicable, for protection of potable groundwater.
c = Assumes contamination near residence with slab-on-grade construction.

Table A2. Tier 1 levels (mg/kg soil) for PHCs for fine-grained surface soils.

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15,000	8000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	2100	11,400	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Protection of GW for Livestock Watering[3]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5600
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC
Residential	Soil Ingestion	15,000	8000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	940	5200	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	260	900	800	5600
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	RES	29,000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	4600	25,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1500	2500	6600
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (indoor)	4600	25,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[4]	660	1500	2500	6600
	Offsite Migration	NA	NA	12,000	RES

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable. Calculated value exceeds 1,000,000 mg/kg or pathway excluded.
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.
4 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for textural factors.

Table A3. Tier 1 levels (mg/kg soil) for PHCs for coarse-grained surface soils.

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	15,000	8000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	200	1100	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Protection of GW for Livestock Watering[2]	9000	4000	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2800
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NC	NC	NC	NC
Residential	Soil Ingestion	15,000	8000	18,000	25,000
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, basement)	50	240	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	30	150	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	130	450	400	2800
	Produce	NC	NC	NC	NC
Commercial	Soil Ingestion	RES	29,000	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor)	310	1700	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1700	3300
Industrial	Soil Ingestion	RES	RES	NA	NA
	Dermal Contact	RES	RES	RES	NA
	Vapour Inhalation (indoor)	310	1700	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	TBD	TBD	TBD	TBD
	Eco Soil Contact[3]	330	760	1700	3300
	Offsite Migration	NA	NA	RES	RES

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Tier 1 values based mainly on laboratory bioassay response to fractions derived from fresh Federated Crude Oil.

Table A4. Generic levels for PHCs in fine-grained subsoil (>1.5 m depth).

Land Use	Exposure Pathways*	F1 (C6- C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	2100	11,400	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Protection of GW for Livestock Watering[3]	TBD	TBD	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[4]	750	2200	3500	10,000
	Eco Soil Ingestion	TBD	TBD	TBD	TBD
	Produce, Meat and Milk	NA	NA	NA	NA
Residential	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor: basement, slab)	(940, 990)	(5200, 5500)	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[4]	750	2200	3500	10,000
	Produce	NA	NA	NA	NA
Commercial	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	NA	RES	NA	NA
	Vapour Inhalation (indoor)	4800	26,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[4]	1000	3000	5000	10,000
Industrial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	4800	26,000	NA	NA
	Protection of Potable GW[1]	180	250	NA	NA
	Protection of GW for Aquatic Life[2]	TBD	TBD	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[4]	1000	3000	5000	10,000
	Offsite Migration	NA	NA	NA	NA

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes site is underlain by groundwater of potable quality in sufficient yield (K of 10^{-4} cm/sec or greater).
2 = Assumes surface water body at 10 m from site.
3 = Generally applicable for this land use as related to use of dugouts and wells for supply of livestock water.
4 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for texture, depth factors and other physical hazard considerations.

Table A5. Generic levels for PHC in coarse-grained subsoil (>1.5 m depth).

Land Use	Exposure Pathways*	F1 (C6-C10)	F2 (>C10-C16)	F3 (>C16-C34)	F4 (>C34)
Agricultural	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, 30 m offset)	200	1100	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Protection of GW for Livestock Watering[2]	9000	4000	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	350	1500	2500	10,000
	Produce, Meat and Milk	NA	NA	NA	NA
Residential	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	RES	RES	RES	RES
	Vapour Inhalation (indoor, basement)	50	240	NA	NA
	Vapour Inhalation (indoor, slab-on-grade)	40	190	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	350	1500	2500	10,000
	Produce	NA	NA	NA	NA
Commercial	Soil Ingestion	RES	RES	RES	RES
	Dermal Contact	NA	RES	NA	NA
	Vapour Inhalation (indoor)	340	1800	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	700	2000	3500	10,000
Industrial	Soil Ingestion	NA	NA	NA	NA
	Dermal Contact	NA	NA	NA	NA
	Vapour Inhalation (indoor)	340	1800	NA	NA
	Protection of Potable GW	860	1200	NA	NA
	Protection of GW for Aquatic Life[1]	230	150	NA	NA
	Nutrient Cycling	NA	NA	NA	NA
	Eco Soil Contact[3]	700	2000	3500	10,000
	Offsite Migration	NA	NA	NA	NA

* See *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil: Technical Supplement* (CCME 2001) for descriptions of Exposure Pathways.
NA = Not applicable
RES = Residual PHC formation. Calculated value exceeds 30,000 mg/kg and solubility limit for PHC fraction.
NC = Not calculated. Insufficient data to allow derivation.
TBD = To be determined.
1 = Assumes surface water body at 10 m from site.
2 = Includes use of dugouts and wells for supply of livestock water.
3 = Tier 1 values based primarily on laboratory bioassay response to fractions derived from fresh Federated Crude Oil and adjusted for depth factors and other physical hazard considerations.

APPENDIX 4

Remediation Criteria for Arsenic in the Yellowknife Area Soils and Sediment

The national soil guideline derived for arsenic by CCME is based on an assumed background (natural) arsenic soil concentration of 10 ppm, and the target incremental human health risk level of 1 in 1 million, which resulted in a national guideline of 12 ppm. However, CCME recognizes that inorganic elements vary significantly in natural concentration from one region to another. Also, CCME recognizes that the frequency, duration and intensity of use of a particular contaminated site or area may depart significantly from the assumptions used to derive the national guideline. Finally, although the CCME national guideline is based on a hypothetical risk level of 1 in 1 million, a *de minimis* risk level of 1 in 100,000 or lower is considered by Health Canada to be "essentially negligible." Following methods prescribed by CCME, to account for these site-specific factors and policy considerations, site-specific human health-based soil quality remediation objectives were derived for soil-borne and sediment-borne inorganic arsenic contamination in the Yellowknife area.

Based on data available from the Geologic Survey of Canada, the Environmental Sciences Group of the Royal Military College of Canada and data provided by Miramar Mining Ltd. (Con Mine), the average natural background concentration of arsenic in and around Yellowknife was determined to be 150 ppm, with a reasonable upper limit of normal concentration (the 90th percentile value of the distribution of available data) of about 300 ppm.

Site-specific human health-based soil quality remediation objectives were derived following CCME procedures for residential and industrial land uses, as well as for non-residential, publicly-accessible areas (i.e., local public boat launch). Accounting for the observed background arsenic concentrations in soil, considering a 1 in 100,000 *de minimis* cancer risk level, and considering the limitations on land use (i.e., impacts on the frequency, duration and intensity of site use) presented by the local climate, the remediation objectives presented in Table A6 have been adopted.

Table A6. Remediation Objectives (mg/kg) for Arsenic in Yellowknife area soils and sediment.

Medium	Land Use		
	Residential	**Industrial**	**Boat Launch**
Soil	160	340	220
Sediment	N/A	N/A	150

N/A = Not Applicable.

The remediation objective for residential properties assumes that the yard soil is accessible for exposure for 5 months of the year. This objective should also be applied to playgrounds and urban parks within the City limits where children may frequent on a regular and routine basis for daily play. The remediation objective for industrial lands assumes that little or no public access is available, and the primary receptor is a worker on the site. The soil quality objective for sites, developed for a specific site assumes that a person is present on the site for 2 hours per day, every day throughout July and August. The proposed sediment quality objective also assumes that a person is wading bare foot each day throughout July and August.

APPENDIX 5

Table A7. Remediation Criteria for other Contaminants in soil (mg.kg^{-1})

Substance	Land Use			
	Agricultural	Residential/ Parkland	Commercial	Industrial
General Parameters				
Conductivity [dS/m]	2	2	4	4
pH	6 to 8	6 to 8	6 to 8	6 to 8
Sodium adsorption ratio	5	5	12	12
Inorganic Parameters				
Antimony	20	20	40	40
Arsenic (inorganic)*	12	12	12	12
Barium	750	500	2000	2000
Beryllium	4	4	8	8
Boron (hot water soluble)	2	-	-	-
Cadmium	1.4	10	22	22
Chromium				
Total chromium	64	64	87	87
Hexavalent chromium (VI)	0.4	0.4	1.4	1.4
Cobalt	40	50	300	300
Copper	63	63	91	91
Cyanide (free)	0.9	0.9	8.0	8.0
Fluoride (total)	200	400	2000	2000
Lead	70	140	260	600
Mercury (inorganic)	6.6	6.6	24	50
Molybdenum	5	10	40	40
Nickel	50	50	50	50
Selenium	1	1	3.9	3.9
Silver	20	20	40	40
Sulphur (elemental)	500	-	-	-
Thallium	1	1	1	1
Tin	5	50	300	300
Vanadium	130	130	130	130
Zinc	200	200	360	360
Monocyclic Aromatic Hydrocarbons				
Benzene	0.05	0.5	5	5
Monochlorobenzene	0.1	1	10	10
l,2-Dichlorobenzene	0.1	1	10	10
l,3-Dichlorobenzene	0.1	1	10	10
l,4-Dichlorobenzene	0.1	1	10	10
Ethylbenzene	0.1	1.2	20	20
Styrene	0.1	5	50	50
Toluene	0.1	0.8	0.8	0.8
Xylene	0.1	1	17	20
Phenolic Compounds				
Chlorophenols[a] (each)	0.05	0.5	5	5
Nonchlorinated[b] (each)	0.1	1	10	10
Pentachlorophenol (PCP)	7.6	7.6	7.6	7.6
Phenol	3.8	3.8	3.8	3.8

Table 1. Continued.

Polycyclic Aromatic Hydrocarbons (PAHs)				
Benzo(*a*)anthracene	0.1	1	10	10
Benzo(*b*)fluoranthene	0.1	1	10	10
Benzo(*k*)fluoranthene	0.1	1	10	10
Benzo(*a*)pyrene	0.1	0.7	0.7	0.7
Dibenz(*a,h*)anthracene	0.1	1	10	10
Indeno(I,2,3-c,d)pyrene	0.1	1	10	10
Naphthalene	0.1	0.6	22	22
Phenanthrene	0.1	5	50	50
Pyrene	0.1	10	100	100
Chlorinated Hydrocarbons				
Chlorinated aliphatics[c] (each)	0.1	5	50	50
Chlorobenzenes[d] (each)	0.05	2	10	10
DDT (total)	0.7	0.7	12	12
Hexachlorobenzene	0.05	2	10	10
Hexachlorocyclohexane (Lindane)	0.01	-	-	-
PCDDs and PCDFs[e] (dioxins and furans)	4 ng $TEQ.kg^{-1}$	4 ng $TEQ.kg^{-1}$	4 ng $TEQ.kg^{-1}$	4 ng $TEQ.kg^{-1}$
Polychlorinated biphenyls (PCBs)	0.5	1.3	33	33
Tetrachloroethylene (PCE)	0.1	0.2	0.5	0.6
Trichloroethylene (TCE)	0.1	3	31	31
Miscellaneous Organic Parameters				
Ethylene glycol	960	960	960	960
Nonchlorinated aliphatics (each)	0.3	-	-	-
Phthalic acid esters (each)	30	-	-	-
Quinoline	0.1	-	-	-
Thiophene	0.1	-	-	-

Notes:

- = Value not established.

* See Appendix A6 for Remediation Criteria for Arsenic in the Yellowknife Area Soils and Sediment.

[a]Chlorophenols include
chlorophenol isomers (ortho, meta, para)
dichlorophenols (2,6- 2,5- 2,4- 3,5- 2,3- 3,4-)
trichlorophenols (2,4,6- 2,3,6- 2,4,5- 2,3,4- 3,4,5-)
tetrachlorophenols (2,3,5,6- 2,3,4,5- 2,3,4,6-)
pentachlorophenol

[b]Nonchlorinated phenolic compounds include
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl 4,6-dinitrophenol
nitrophenol (2-,4-)
phenol
cresol

[c] Aliphatic chlorinated hydrocarbons include
chloroform
dichloroethane (1,1- 1,2-), dichloroethene (1,1- 1,2-)
dichloromethane
1,2-dichloropropane, 1,2-dichloropropene (cis and trans)
1,1,2,2-tetrachloroethane, tetrachloroethene
carbon tetrachloride
trichloroethane (1,1,1- 1,1,2-), trichloroethene

[d] Chlorobenzenes include
all trichlorobenzene isomers
all tetrachlorobenzene isomers
pentachlorobenzene

[e] PCDDs and PCDFs expressed in 2,3,7,8-TCDD equivalents. NATO International Toxicity Equivalency Factors (I- TEFs) for congeners and isomers of PCDDs and PCDFs are as follows:

Congener	TEF
2,3,7,8-T_4 CDD	1.0
1,2,3,7,8-P_5 CDD	0.5
1,2,3,4,7,8-H_6 CDD	0.1
1,2,3,7,8,9-H_6 CDD	0.1
1,2,3,6,7,8-H_6 CDD	0.1
1,2,3,4,6,7,8-H_7 CDD	0.1
O_8 CDD	0.001
2,3,7,8-T_4 CDF	0.1
2,3,4,7,8-P_5 CDF	0.5
1,2,3,7,8-P_5 CDF	0.05
1,2,3,4,7,8-H_6 CDF	0.1
1,2,3,4,7,8,9-H_6 CDF	0.1
1,2,3,6,7,8-H_6 CDF	0.1
2,3,4,6,7,8-H_6 CDF	0.1
1,2,3,4,6,7,8-H_7 CDF	0.1
1,2,3,4,7,8,9-H_7 CDF	0.01
O_8 CDF	0.001

APPENDIX 6

Sampling and Analysis

Intrusive Testing

Testing methods and techniques are expected to be consistent with current day professional standards. Regardless of the method/technique used, all efforts should be made to minimize the spread of contamination as a result of activities during the site assessment.

Field screening of samples, with portable instruments that provide relative results are considered to be acceptable if they are well founded in theory, capable of calibrating measurements to relative or absolute levels of contamination, verifiable in regard to procedures and results and finally, if results of such techniques can be correlated to *Canadian Association of Environmental Analytical Laboratories (CAEAL*) accredited laboratory results.

Test locations should provide an adequately detailed description of the nature, extent and fate of contamination in three dimensions. They should also provide information on potential subsurface contaminant migration pathways. The following should be considered minimum specifications:

- 3-5 boreholes or test pits per potential source area except very small sites where a minimum of 1. Potential source areas include but are not limited to tanks, lines, pump islands, loading areas, drum filling areas, previous underground installations and areas of visible staining. At a typical service station with 1 tank nest, 1 set of lines, 1 pump island, and 1 waste oil tank, this would equate to 4 source test locations.

- Any groundwater contaminant plume(s) associated with the site should be delineated to the minimum acceptable concentration of the contaminant.

- On sites where it cannot be confirmed through historical records that previous tanks and lines have been removed, an appropriate survey (geophysical or otherwise) must be carried out prior to drilling, to determine whether such tanks and lines may be present.

- Sufficient test locations to determine the direction of groundwater flow on-site (minimum of 3 groundwater monitoring wells or piezometers, including at least 1 multilevel installation to assess vertical gradients). Shallow wells are to be screened across the water table to intercept floating product. Bedrock monitoring wells may be required. Construction standards are to follow current day professional standards.

- All soil test locations should extend to the bottom of the contaminated soil zone, to the seasonal low water level, or to bedrock, whichever is shallower.

- All wells will be monitored for the presence of free product.

- Check on-site and off-site manholes and interceptors for hydrocarbons (liquid, vapours).

Sample Analysis

Soil samples may be screened in the field for vapours, staining or odour. All field observations must be included in reports.

Chemical analyses are to be conducted on at least 2 soil samples per well or borehole location (one surface <1.5 m depth, one subsurface >1.5 m depth).

Chemical analyses are to be conducted on at least one groundwater sample from each available well including any on-site water supply wells (Note: sampling may also be required for any nearby, off-site potable water wells).

Chemical analyses for petroleum hydrocarbon impacted sites will include PHC and BTEX (benzene, toluene, ethylbenzene, xylene). Analysis for site-specific parameters may be required, depending on past or present use (e.g., PAHs, lead).

Grain size analyses are to be conducted on at least 1 sample per hydrogeologic unit if the fine-grained soil criteria are to be applied.

Quality Assurance/Quality Control (QA/QC) except for small batches of soil samples (less than 5 samples), at least one blind duplicate should be analyzed per batch of samples submitted for QA/QC purposes. For larger batches (greater than 10 samples), 10% duplicates should be analyzed. The QA/QC results should be presented and interpreted in the report.

For groundwater samples, a blind duplicate and field blank sample should also be collected and analyzed with each batch of samples, regardless of the number of samples tested. Sampling and sample handling protocol must be consistent with accepted practices. In particular, samples for volatile organics must be collected such that there is no headspace in water samples and a minimum headspace in soil samples. Samples should be kept cool until they are delivered to the laboratory. Sample handling procedures should be verified with the receiving laboratory. See *Guidance Manual for Sampling, Analysis and Data Management, Volume 1: Main Report.* CCME, 1993 and *Guidance Manual for Sampling, Analysis and Data Management, Volume 2: Analytical Method Summaries.* CCME, 1993 for further information on sampling and analysis.

Accredited Laboratory

Laboratory analysis of contaminated materials, soil, and water must be conducted by laboratories that have been formally recognized as competent to perform specified tests by *CAEAL*. CAEAL is a non-profit organization dedicated to raising the level of competency, consistency, capability, and communication within environmental testing laboratories in Canada. Their member laboratories voluntarily participate in rigorous programs of proficiency testing and accreditation, demonstrating their commitment to generate high quality data. See Appendix 8 for contact information.

APPENDIX 7

Transportation of Contaminated Soil

The transportation of soils contaminated by flammable liquids is regulated under the *Transportation of Dangerous Goods Regulations* (TDGR). The TDGR require that a completed waste manifest form accompany shipments of hazardous waste. Manifest forms are available from EPS.

The completed manifest form provides:

- Detailed information on the types and amounts of hazardous waste shipped;
- A record of the parties involved in the shipment; and
- Information on the storage, treatment or disposal of the waste and conformation that the waste reached the final destination.

No test is required; as petroleum distillate(s) is a fully specified dangerous good in List II, schedule II of TGDR. The word “waste” must precede the shipping name.

Manifest requirements:

Shipping name:	waste Solids containing flammable liquid, n.o.s.*, (gasoline or diesel, as appropriate)
Classification:	4.1
UN number:	UN3175
Packing group:	II

or

Shipping name:	waste ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, n.o.s.*, (gasoline or diesel, as appropriate)
Classification:	9
UN number:	UN3077
Packing group:	III

For more information on the requirements of waste management, consult the G*uideline for the General Management of Hazardous Waste (February 1998)*.

The GNWT Department of Transportation can give you more information on the *TDGR.*

APPENDIX 8

Additional Contacts

Canadian Council of Ministers of the Environment (CCME)

CCME works to promote effective intergovernmental cooperation and coordinated approaches to interjurisdictional issues such as air pollution and toxic chemicals. CCME members collectively establish nationally consistent environmental standards, strategies and objectives so as to achieve a high level of environmental quality across the country. Comprehensive literature and technical documentation are available from:

Canadian Council of Ministers of the Environment
123 Main Street, Suite 360
Winnipeg, Manitoba R3C 1A3
Phone: (204) 948-2090; Fax: (204) 948-2125
Website: http://www.ccme.ca; E-mail: info@ccme.ca

Canadian Association for Environmental Analytical Laboratories (CAEAL)

Membership in CAEAL is open to individuals, institutions, user groups, consultants, industrial organizations, regulatory agencies, standard materials and laboratory equipment suppliers, and others interested in the work being carried out in environmental analytical laboratories. More information on CAEAL may be obtained from:

Canadian Association for Environmental Analytical Laboratories
Suite 532, 1 Nicholas Street
Ottawa, Ontario K1N 787
Phone: (613) 562-2200; Fax: (613) 562-2203
Website: http://www.caeal.ca/

Canadian Standards Association (CSA)

The CSA is a not-for-profit membership-based association serving business, industry, government and consumers in Canada and the global marketplace. As a solutions-oriented organization, CSA works to develop standards that address real needs, such as enhancing public safety and health. Advancing the quality of life and helping to preserve the environment. Contact CSA at:

Canadian Standards Association
5060 Spectrum Way
Mississauga, Ontario L4W 5N6
Phone: (416) 747-4000; Fax (416) 747-2473
Website: http://www.csa.ca