



# WorleyParsons

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24 September 2014

Proj. No.: 407074-00016-400  
File Loc.: Calgary

Dear Sir/Madam:

**RE: NORMAN WELLS ENVIRONMENTAL LIABILITY ASSESSMENT: 2014  
METHODOLOGY FOR SOIL APEC VOLUMES ESTIMATION**

## 1. INTRODUCTION

WorleyParsons Canada Services Ltd. (WorleyParsons) was retained to assist in the quantification of soil and groundwater issues identified to date at the Norman Wells Site.

The Site comprises infrastructure (current and historical) associated with a former refinery, three former batteries, a central processing facility (CPF), and production and injection wells on both the Mainland adjacent to the Mackenzie River, and natural and artificial islands ("Islands") located within the Mackenzie River.

Given the large areal extent of the Site, as well as the inclusion of both Mainland and Islands areas, the Site has been subdivided into several geographic areas for discussion and data management purposes:

- Mainland West;
- Mainland Central;
- Mainland East;
- Mainland Sumps;
- Goose Island;
- Bear and Frenchy's Islands; and
- Artificial Islands.



This letter report provides documentation of the methodology utilized to identify areas of potential environmental concern (APECs) and estimate volumes of soil which exceed current regulatory guidelines for industrial and residential/parkland use, given the environmental setting and practical constraints which exist at the Site.

## **2. ASSESSMENT PARAMETERS/REGULATORY GUIDELINES**

### **2.1 General**

Analytical data compiled from more than 15 years of environmental investigations have been assessed relative to background conditions, as well as the current regulatory guidelines described below. This data assessment allows for identification and quantification of soil APECs.

Soil analytical results were assessed against the following guidelines:

- Canadian Environmental Quality Guidelines (CCME 2007 and updates); and
- Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil (CCME 2008).

Development of Tier 2 (site-specific) risk-based guidelines for assessment and remediation of soil is in progress for select petroleum hydrocarbon parameters.

Fine-grained soil guidelines are considered the default standard as analytical results from previous investigations have indicated the soil is predominantly fine-grained. For the purpose of this assessment, the only relevant soil or groundwater exposure pathway excluded in the selection of applicable guidelines was potable groundwater. The shallow groundwater aquifer beneath the Site (located 3 to 6 m below grade) locally may contain naturally-occurring hydrocarbons and salts; therefore, the protection of potable groundwater exposure pathway was excluded in consideration of this unsuitable chemistry as drinking water. Deeper aquifers located 10 to 20 m below grade are hydraulically connected to the Mackenzie River, and are also locally affected by natural hydrocarbon and saline water seepage from the underlying oil reservoir. River water withdrawn upstream from the IOL lease is used as the drinking water supply.

The regulatory guidelines noted above were also developed for different land uses. In general and for the purpose of this soil volume update, the applicable guidelines were assumed to be industrial land use, fine-grained surface soil for the Mainland Areas, and residential/parkland land use, fine-grained surface soil for the Islands Areas.

### **2.2 Background Soil Conditions**

There are several unique environmental features/characteristics which have been considered when formulating a conceptual model of environmental conditions and identifying/ quantifying soil impacts at the Site. These features include the presence of:

- naturally occurring hydrocarbon seeps and hydrocarbons in the shallow subsurface;
- naturally occurring elevated sodium (sodicity) and select trace elements in the near surface bedrock underlying the Mainland Area;



- presence of intermittent permafrost and ice lenses;
- several naturally occurring metals in soil which are above guideline levels; and
- shallow depth to bedrock, limiting the soil development and practical excavation/remediation depths.

The above-noted naturally occurring conditions have been considered when determining and quantifying Site operations-related impacts, and the estimated soil volumes discussed herein.

### **3. METHODOLOGY**

#### **3.1 Soil Issue/Areas of Potential Environmental Concern Identification**

An APEC or soil issue, for the purpose of this report, is defined as a situation that satisfies one or both of the following:

- exceeds background conditions and/or environmental guidelines noted in Section 2; and/or
- has, or could potentially have, an adverse effect on the environment.

Contaminants have been subdivided into three broad categories: metals, salts, and petroleum hydrocarbons. Various combinations of these three categories were identified where appropriate.

For the purposes of this soil volume update, environmental impacts were defined as proven or potential as follows:

- a “proven” impact resulted when sufficient Phase II environmental site assessment (ESA) data indicated an impact exceeding the applicable guideline was present; and
- a “potential” impact resulted when contamination was inferred through Phase I ESA activities, but a reasonable quantity of Phase II ESA data were not available to confirm the type of impact or provide an estimate of its magnitude and extent. As such, potential impacts had limited supporting field data, may be anecdotal in nature, and their inferred presence, extent and magnitude were based on similar issues or experiences at similar sites.

#### **3.2 Impacted Soil Area/Volume Estimation**

All information obtained during previous Phase I and Phase II ESA programs was summarized, tabulated and reviewed by professional staff who have first-hand knowledge regarding the subsurface conditions and history of the site. These professionals supplied estimates of the extent and magnitude of impacts to the soil. These estimates were supported by Phase II intrusive and geophysical data where available. Where data were not available, the estimates were based on professional judgement of similar sites with similar conditions and contaminant types.

Areas of potential impact were identified through various Phase I and Phase II activities. The extent and magnitude of impacts were evaluated with consideration for the following parameters:

- likely source of impact;



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- mobility of the chemicals in question;
- distance from the likely source;
- concentration of the contaminants;
- experience with similar issues at similar sites; and
- density of data points to represent the area/zone of impact (from Phase I and Phase II ESAs).

## **Estimation of Areal Extent (X/Y Plane)**

For each area of potential impact identified, the assessor measured or estimated the area (in square metres) of the impact based on a polygon. Polygon boundaries were selected based on approximately half the distance between a location of confirmed/suspected impact, and an adjacent un-impacted location. All attempts were made to verify the areal extent of impact based on visible evidence, mobility, time, subsurface conditions, etc.

## **Estimation of Depth of Impact (Z Plane)**

For each area of potential impact identified, the assessor selected the minimum value from the following parameters:

- depth to groundwater, permafrost, and/or bedrock at the site;
- depth of practical excavation;
- depth of likely contaminant penetration; and/or
- depth of guideline exceedances shown in other data (Phase II information).

## **Calculation of Impact Volumes**

The in situ soil volume for each area of potential impact was estimated by multiplying the areal extent of the impact by the estimated depth.

The general assumptions made with respect to estimating volumes of impacted soils at the various areas of potential impact identified at the Norman Wells facilities are listed below.

- depth of impact was estimated through a review of analytical data, borehole logs, and presence of field indicators such as staining and elevated organic vapour levels;
- lateral extent of salt impacted soil zones was determined through terrain conductivity/resistivity mapping and borehole delineation (where available);
- potential soil remediation strategies selected for this liability estimation required subdivision of impacted soil depth into two primary intervals: impacted soil above 2 m (i.e. depth to establish self-sustaining vegetation cover, or depth to a comparatively impermeable barrier like permafrost or bedrock), and impacted soil below 2 m but above permafrost or bedrock;
- impacts were determined based on two sets of regulatory guidelines: CCME (2007 and updates, 2008) Industrial Land Use, and CCME (2007 and updates, 2008) Residential/Parkland Use;



- depths of impacted soils were further subdivided based on contaminant type: metals, hydrocarbons, salts, hydrocarbons + salts, and hydrocarbons + salts + metals. There is no salts + metals category, as this contaminant mix was not encountered at the Norman Wells facility;
- volumes of impacted soils were extrapolated based on similar facility types of similar age (e.g. 1940s vintage well sites, well sites with casing vent leaks, batteries, etc.);
- volume estimates for areas with little or no analytical data were based on professional experience with similar contaminant scenarios, or were extrapolated from similar sites in the same field;
- assume 50 m<sup>3</sup> of soil impact for every 1 m<sup>3</sup> fluid released on each spill site. Assumes no product recovery, and no associated groundwater impact given the generally discontinuous nature of any shallow groundwater bearing intervals, unless stated otherwise;
- increase soil impact volume by 50% from industrial to residential/parkland if spill >10 m<sup>3</sup> for oil and produced water, or produced water. Assume same volume if crude oil spill only;
- include glycol spills with hydrocarbon spills, assume same treatment method;
- all wellhead areas on the Mainland have 50 m<sup>3</sup> of hydrocarbon impacted soil, and 50 m<sup>3</sup> of hydrocarbon + salt impacted soil, excluding additional volume for documented spills;
- all wellhead areas on the Islands have 25 m<sup>3</sup> of hydrocarbon impacted soil, and 25 m<sup>3</sup> of hydrocarbon + salt impacted soil, excluding additional volume for documented spills;
- to avoid double counting of impacted soil volumes associated with wellheads which had a documented spill history, wells with documented spills >2 m<sup>3</sup> of fluids were not assigned the generic 50 to 100 m<sup>3</sup> noted above;
- abandoned wells were not assigned the generic 50 to 100 m<sup>3</sup> provision noted above, as it was assumed that some degree of wellhead cleanup had taken place; and
- in addition to the above generic provisions for individual wellheads, a 250 m<sup>3</sup> allowance for PHC and salt impacted soil was assigned to each artificial island wellpad.

Based on the above general assumptions the high level volume estimates, presented in Table 1 below, were calculated for each geographic area.

**Table 1 – Estimated Volumes of Soil Impact**

<b>Geographic Area</b>	<b>Estimated Total Volume (m3)</b>
Mainland West	49162
Mainland Central	101928
Mainland East	239068
Goose Island	10458



<b>Geographic Area</b>	<b>Estimated Total Volume (m3)</b>
Bear and Frenchy's Islands	37575
Artificial Islands	7583

It should be noted that APECs with potential in-situ management strategies such as containment have not been included in the above volume estimates.

### **3.3 Well Counts**

The list of wells present on the Norman Wells site (producing, injector, suspended and abandoned) was extracted from the NEB database and verified by IOL personnel familiar with the current status of the facilities.

### **3.4 Spill Records**

To assist in the estimation of potential impacted soil associated with Site spills, an updated summary of spills reported to the NEB was obtained from the time period 2011 to 2014. A sample spill record is provided as Appendix 1. Those spills attributed to activities on locations outside the Site boundaries, or to parties other than IOL were not included in this impacted soil volume update.



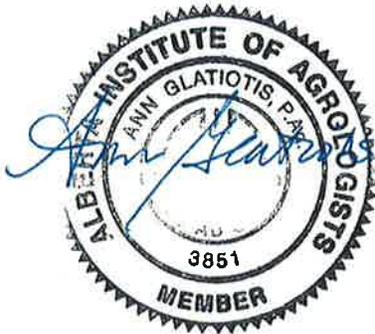
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## 4. CLOSURE

We trust that this report satisfies your current requirements and provides suitable documentation for your records. If you have any questions or require further details, please contact the undersigned at any time.

Report Prepared by



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Principal Environmental Scientist

Senior Review by



Michael Brown, M.Sc., P.Geol. (NT)  
Principal Hydrogeologist

NAPEGG Permit to Practice P029

**Prairie Business Unit**  
**Infrastructure & Environment**  
**WorleyParsons Canada Services Ltd.**



## 5. REFERENCES

CCME (Canadian Council of Ministers of the Environment), 2007 and updates. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

CCME (Canadian Council of Ministers of the Environment), 2008. Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale Supporting Technical Document. January, 2008.



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## Appendices



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## Appendix 1



Canada

# NT-NU SPILL REPORT

OIL, GASOLINE, CHEMICALS AND OTHER HAZARDOUS MATERIALS

117 023

NT-NU 24-HOUR SPILL REPORT LINE  
 TEL: (867) 920-8130  
 FAX: (867) 873-6924  
 EMAIL: spills@gov.nt.ca

REPORT LINE USE ONLY

A	REPORT DATE: MONTH - DAY - YEAR <b>February 9, 2011</b>	REPORT TIME <b>11:50</b>	<input type="checkbox"/> ORIGINAL SPILL REPORT, OR		REPORT NUMBER <b>11-023</b>
	B	OCCURRENCE DATE: MONTH - DAY - YEAR <b>February 9, 2011</b>	OCCURRENCE TIME <b>09:00</b>	<input type="checkbox"/> UPDATE # _____ TO THE ORIGINAL SPILL REPORT	
C	LAND USE PERMIT NUMBER (IF APPLICABLE)		WATER LICENCE NUMBER (IF APPLICABLE) <b>S03L1-001</b>		
D	GEOGRAPHIC PLACE NAME OR DISTANCE AND DIRECTION FROM NAMED LOCATION <b>Imperial Oil Resources, Norman Wells, NT</b>		REGION <input checked="" type="checkbox"/> NWT <input type="checkbox"/> NUNAVUT <input type="checkbox"/> ADJACENT JURISDICTION OR OCEAN		
E	LATITUDE DEGREES <b>65</b> MINUTES <b>17</b> SECONDS		LONGITUDE DEGREES <b>126</b> MINUTES <b>51</b> SECONDS		
F	RESPONSIBLE PARTY OR VESSEL NAME <b>Imperial Oil Resources</b>	RESPONSIBLE PARTY ADDRESS OR OFFICE LOCATION <b>Bag 5000 Norman Wells, NT X0E 0V0</b>			
G	ANY CONTRACTOR INVOLVED <b>JFSL</b>	CONTRACTOR ADDRESS OR OFFICE LOCATION <b>Bag 5000 Norman Wells, NT X0E 0V0</b>			
H	PRODUCT SPILLED <b>Nalco 1415A - Corrosion Inhibitor</b>	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES <b>1000 L</b>	U.N. NUMBER <b>3286</b>		
	SECOND PRODUCT SPILLED (IF APPLICABLE)	QUANTITY IN LITRES, KILOGRAMS OR CUBIC METRES	U.N. NUMBER		
I	SPILL SOURCE <b>Chemical Tote</b>	SPILL CAUSE <b>Human Error</b>	AREA OF CONTAMINATION IN SQUARE METRES <b>30</b>		
J	FACTORS AFFECTING SPILL OR RECOVERY <b>None</b>	DESCRIBE ANY ASSISTANCE REQUIRED <b>None</b>	HAZARDS TO PERSONS, PROPERTY OR EQUIPMENT <b>Flammable liquid</b>		
K	ADDITIONAL INFORMATION, COMMENTS, ACTIONS PROPOSED OR TAKEN TO CONTAIN, RECOVER OR DISPOSE OF SPILLED PRODUCT AND CONTAMINATED MATERIALS On February 9, 2011 at 9am Imperial Oil Resources (IOR) had a 1000L chemical spill, which was confined to site. A JFSL (contractor) employee was loading chemical totes from IOR's warehouse onto a trailer in the warehouse yard. While loading the chemical totes onto the trailer, the loader operator punctured the chemical totes. This resulted in a 1000 L of the chemical being released to the ground. The chemical totes were being loaded for transport from the warehouse yard out to the field for use. The affected area (snow and soil) is currently being cleaned up and removed. Once cleaned up, IOR anticipates no adverse environmental affects with result from this release.				
L	REPORTED TO SPILL LINE BY <b>Nikole Andres</b>	POSITION <b>Environmental Advisor</b>	EMPLOYER <b>Imperial Oil</b>	LOCATION CALLING FROM <b>Norman Wells</b>	TELEPHONE <b>867-587-3215</b>
M	ANY ALTERNATE CONTACT <b>Jim Brown</b>	POSITION <b>Field Foreman</b>	EMPLOYER <b>Imperial Oil</b>	ALTERNATE CONTACT LOCATION <b>Norman Wells</b>	ALTERNATE TELEPHONE <b>867-587-3214</b>
REPORT LINE USE ONLY					
N	RECEIVED AT SPILL LINE BY	POSITION <b>STATION OPERATOR</b>	EMPLOYER	LOCATION CALLED <b>YELLOWKNIFE, NT</b>	REPORT LINE NUMBER <b>(867) 920-8130</b>
LEAD AGENCY <input type="checkbox"/> EC <input type="checkbox"/> CCG <input type="checkbox"/> GNWT <input type="checkbox"/> GN <input type="checkbox"/> ILA <input type="checkbox"/> INAC <input checked="" type="checkbox"/> NWT <input type="checkbox"/> OTC			SIGNIFICANCE <input type="checkbox"/> MINOR <input type="checkbox"/> MAJOR <input type="checkbox"/> UNKNOWN		FILE STATUS <input type="checkbox"/> OPEN <input type="checkbox"/> CLOSED
AGENCY	CONTACT NAME		CONTACT TIME	REMARKS	
LEAD AGENCY	<b>Kirk Turner</b>		<b>22/09/11 12:10</b>		
FIRST SUPPORT AGENCY					
SECOND SUPPORT AGENCY					
THIRD SUPPORT AGENCY					