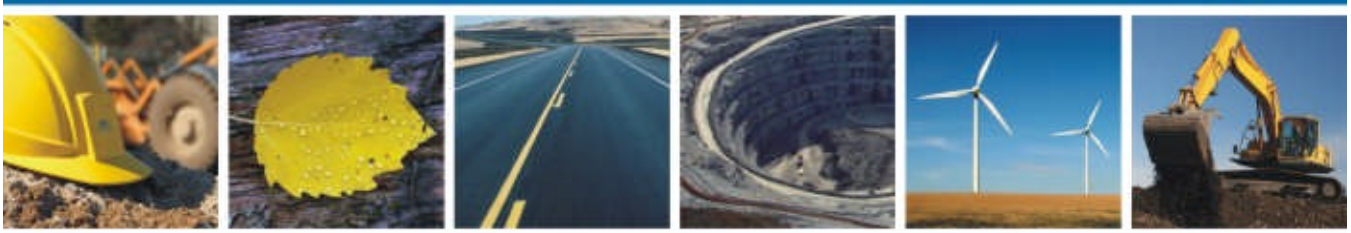


PARKS CANADA AGENCY

## GARDEN RIVER, AB COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIATION OPTIONS ANALYSIS



### REPORT

MARCH 2013  
ISSUED FOR REVIEW  
EBA FILE: E22103088-01

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## EXECUTIVE SUMMARY

Parks Canada Agency (PCA) retained EBA Engineering Consultants Ltd., operating as EBA, A Tetra Tech Company (EBA) to review previous environmental reports available for the Garden River Community Airstrip and Old Landfill, conduct a remediation options analysis and provide Remediation Action Plans (RAPs)(including Class C cost estimates) for these sites. The Garden River Community is a part of the Little Red River Cree Nation and is located at the western edge of Wood Buffalo National Park in Alberta. The location of Garden River is shown on Figure 1 and the Community Airstrip and Old Landfill locations are shown on Figure 2.

The Community Airstrip is located at the northern end of the community of Garden River and is currently in use. The unpaved airstrip was constructed in the 1960s for use by the sawmill that was previously located in the community. The Old Landfill is located at the eastern end of the community of Garden River, approximately 500 m south of the Community Airstrip. The Old Landfill is understood to have been excavated and operated without a liner in place. The volume and composition of waste at this site is understood to be highly variable, as no restrictions were imposed on disposal. It is understood that dump closure in this area consisted of covering waste with fill/soil when the dump site was abandoned in 1998. The Old Landfill comprises an approximate 4,000 m<sup>2</sup> area with additional off-site debris areas (approximately 2,000 m<sup>2</sup>) both north and south of the landfill. In this report, references to the Old Landfill site include both the Old Landfill and adjacent debris areas. The locations of Old Landfill and debris areas are shown on Figure 4a.

## Findings

EBA reviewed the four previous environmental investigation reports available for these sites. Based on the reports review, the impacted soil volume at the Community Airstrip is estimated to be 250 m<sup>3</sup> where identified parameters of concern were benzene, toluene, ethylbenzene, xylenes (BTEX) and petroleum hydrocarbon fractions F1 and F2. Hydrocarbon impacts are limited to surface soils to a maximum depth of 1 m below grade (mbg) (see Table C for details). At the Old Landfill site, the impacted soils are estimated to be 7,200 m<sup>3</sup> where metals were the main parameters of concern. The impacted soils are limited to the surface soils to an approximate depth of 1.5 mbg (see Table E for details). Figures 3a and 4a show the estimated impacted areas at the Community Airstrip and Old Landfill sites, respectively.

EBA assessed remediation options to determine the most feasible options that could be implemented for both the sites by considering the identified parameters of concern, on and off-site conditions and site locations (see Tables G and H in the report for details). Based on the remediation options analysis, EBA provides four feasible options for each site for consideration. These options are summarized in the following tables.

### Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 1 - Excavation and Landfarming	\$210,000	Years	On/Off-site	<ul style="list-style-type: none"> <li>Cost effective</li> <li>Can be carried out on-site or off-site</li> </ul>	<ul style="list-style-type: none"> <li>Time involved to remediate soils could be substantial</li> <li>Toxic by-products may be produced</li> <li>Microbial action may be impacted by salts, metals, and trace organic compounds</li> </ul>
Option 2 - Excavation and Landfill Disposal at Rainbow Lake, AB	\$200,000	Days to weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions at landfill location</li> <li>Expensive transportation costs</li> <li>Potential human and ecological risks in the event of an accident during transportation</li> <li>Regulatory liaison delays</li> <li>Impacts to roads</li> <li>Greenhouse gas emissions by trucks</li> <li>Accidental spills</li> </ul>
Option 3 - Excavate and Deposit in New Landfill Construct at Old Landfill Site	\$150,000	Days	Off-site	<ul style="list-style-type: none"> <li>Please, see Option 3 in Table J below</li> </ul>	
Option 4 - Excavate and Deposit in New Landfill Construct 3 Km West of community of Garden River	\$250,000	Days	Off-site	<ul style="list-style-type: none"> <li>Please, see Option 4 in Table J below</li> </ul>	

### Remediation Options for Impacted Soils at Old Landfill

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 1 - Capping and Monitoring	\$1,570,000	Weeks	On-site	<ul style="list-style-type: none"> <li>Lower cost</li> <li>Less time period possible</li> <li>Potential end land uses – pasture, recreational, cultivation, and forestry</li> </ul>	<ul style="list-style-type: none"> <li>Contaminated soils remains on-site</li> <li>Future monitoring (groundwater monitoring) required to verify soil leaching to groundwater and groundwater transport not occurring</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>Restricts nearby for residential development</li> </ul>
Option 2 - Excavation and Landfill Disposal at Rainbow Lake, AB	\$3,920,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions at landfill location</li> <li>Expensive transportation costs</li> <li>Potential human and ecological risks in the event of an accident during transportation</li> <li>Regulatory liaison delays</li> <li>Overall costs are high</li> <li>Impacts to roads</li> <li>GH6 emissions</li> <li>Accidental spills</li> </ul>
Option 3 - Excavate and Disposal in New Landfill Construct at Old Landfill site	\$1,960,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants</li> </ul>	<ul style="list-style-type: none"> <li>AESRD may not approve the location of the new landfill</li> <li>Additional cost for constructing and capping new landfill</li> <li>Continued groundwater monitoring required</li> <li>Regulatory liaison delays</li> <li>Contaminated soils remain on-site</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>Lack of feasibility for residential</li> </ul>

### Remediation Options for Impacted Soils at Old Landfill

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
					development
Option 4 - Excavate and Deposit in New Landfill Construct 3 km West of the Community of Garden River	\$3,270,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> <li>Could be sited at old Lagoon east of community if conditions are favorable</li> </ul>	<ul style="list-style-type: none"> <li>AESRD may not approve the location of the new landfill</li> <li>The proposed site has not been seen if it is suitable place for new landfill</li> <li>Additional cost for constructing and capping new landfill</li> <li>Continued groundwater monitoring required</li> <li>Potential human and ecological risks in the event of an accident during transportation.</li> <li>Regulatory liaison delays</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> </ul>

Findings of the previous reports review identified that select metal concentrations in groundwater exceeded the applicable guidelines. Figures 3b and 4b show the monitoring well locations at the Community Airstrip and Old Landfill, respectively, where those exceedances were observed. Columbia - Franz, 2011 concluded that there were exceedances of metal concentrations but they were not due to the Old Landfill site. In addition, by considering the soil and groundwater analytical results (discussed in detail in Section 5.0 of the report), elevated concentrations of select metals in groundwater were considered to be naturally occurring and/or not due to on-site activities. Therefore, a remediation option analysis and action plan was not considered applicable for groundwater at either the Community Airstrip or at the Old Landfill and focussed on soils only.

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## ACRONYMS

AENV	Alberta Environment
AESRD	Alberta Environment and Sustainable Resource Development
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CCME	Canadian Council of Ministers of the Environment
CSQG	Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health
ESA	Environmental Site Assessment
F1, F2	Petroleum Hydrocarbon Fractions 1 and 2
INAC	Indian and Northern Affairs Canada
LRRCN	Little Red River Cree Nation
PAH	Polycyclic Aromatic Hydrocarbon
PCA	Parks Canada Authority
RAP	Remedial Action Plan
TDS	Total Dissolved Solids

## 1.0 INTRODUCTION

Parks Canada Agency (PCA) retained EBA Engineering Consultants Ltd., operating as EBA, A Tetra Tech Company (EBA) to review previous environmental reports available for the Garden River Community Airstrip and Old Landfill, conduct a remediation options analysis and provide Remediation Action Plans (RAPs), including Class C cost estimates, for these sites. The Garden River Community is a part of the Little Red River Cree Nation and is located at the western edge of Wood Buffalo National Park in Alberta. The location of Garden River is shown on Figure 1 and the Community Airstrip and Old Landfill locations are shown on Figure 2.

### 1.1 Scope of Work

The scope of work for this project included the following:

- Reviewing historical reports (referenced in Section 1.2) available for both the sites and preparing figures showing potentially impacted areas at these sites;
- Summarizing specific environmental concerns/parameters of concern identified at these sites using the historical reports;
- Estimating the impacted soil and/or groundwater volumes based on the findings of the historical reports review;
- Assessing the potential risks associated with the identified parameters of concern at the sites, including impacts to surface and subsurface soils and to groundwater;
- Conducting a remediation options analysis to assess feasible/appropriate options for each site;
- Preparing Remediation Action Plans (RAPs) for both sites; and
- Preparing a report summarizing the reports review, risk analysis, remediation options analysis and RAPs.

### 1.2 Previous Investigations

EBA reviewed the following reports available for the Community Airstrip and Old Landfill sites:

- EBA Engineering Consultants Ltd. (EBA). 2006. Phase I (Modified) Environmental Site Assessment, Garden River Indian Reserve, Little Red River Cree Nation, Wood Buffalo National Park, Alberta. Report Prepared for Public Works and Government Services Canada. (EBA File: 5101390);
- AMEC Earth and Environmental (AMEC). 2006. Phase I Environmental Site Assessment, Garden River Land Claim Selection Areas, Wood Buffalo National Park, Alberta. Report prepared for AMEC Infrastructure Limited then provided to Indian and Northern Affairs Canada (INAC) and Little Red River Cree Nation (LRRCN). (AMEC File: EE-24794);
- EBA Engineering Consultants Ltd. (EBA). 2009. Contaminated Site Assessment, Initial and Detailed Testing Programs, Wood Buffalo National Park, various Locations in the Community of Garden River, Alberta. Report Prepared for Parks Canada Agency. (EBA File: C22101178); and

- Columbia Environmental Consulting Ltd. (Columbia) and Franz Environmental Inc. (Franz). 2011. Detailed Site Assessment, Garden River Old Dump in Wood Buffalo National Park. Prepared for Parks Canada Agency. Columbia – Franz File: 2018-1001.

## 2.0 SITE DESCRIPTION

There were two separate areas investigated in the Garden River community: the Community Airstrip and the Old Landfill.

The Community Airstrip is located at the northern end of the community of Garden River and is currently in use. The unpaved airstrip was reportedly constructed in the 1960s for use by the sawmill that was previously located in the community.

The Old Landfill is located at the eastern end of the community of Garden River, approximately 500 m south of the Community Airstrip. The Old Landfill is understood to have been excavated and operated without a liner in place. The volume and composition of waste at this site is understood to be highly variable, as no restrictions were imposed on disposal. It is understood that dump closure in this area consisted of covering waste with fill/soil when the dump site was abandoned in 1998. The Old Landfill comprises an approximate 4,000 m<sup>2</sup> area with additional off-site debris areas (approximately 2,000 m<sup>2</sup>) both north and south of the landfill. In this report, the Old Landfill site includes both the Old Landfill and adjacent debris areas. The locations of Old Landfill and debris areas are shown on Figure 4a.

For reference, select information (select tables and figures) from the previous reports are included in Appendix A of this report.

### 2.1 Regional Geology

Garden River is located in the Peace River Lowlands and the general area includes an active floodplain, terraces and levee deposits. The floodplain includes old cut-off channels and sloughs that are flooded much of the year. They are level to depressional; the water table is at or near the surface and drainage is poor. The alluvium is composed of stratified, stone-free, friable silts and sands with an average depth of 3 to 6 m. The terraces occur between 4 to 10 m above mean river level. They are level to depressional and are composed of stratified, uncompacted, non-stony silty clays to very fine sands. The levee deposits are found on top of the terraces 30 m above the river. The terrain is almost level but slopes slightly away from the river. The soils are stratified silt loams of alluvial origin and the drainage is good (AMEC, 2006).

### 2.2 Site Geology

As per the Atlas of Canada, surficial materials comprise alluvial deposits along the Peace River. Soils at the sites generally range from silt to sand to gravel, with clay stringers in the upper 7 m. Sand and gravel is generally located six metres below ground surface. No permafrost was encountered during site investigations (Columbia – Franz, 2011).

## 2.3 Site Hydrogeology

Groundwater is expected to follow local topography and discharge into the Peace River. The on-site groundwater flow direction inferred from groundwater elevation data collected in December 2010 was to the south-southeast toward the Peace River (see Figure 2 from Columbia – Franz, 2011 in Appendix A).

## 2.4 Potential Contaminant Transport Implications

Based on the Columbia – Franz, 2011 report, particle size analyses and borehole logs indicated sand and gravel at the groundwater table. Successful slug tests could not be performed because the monitoring wells recharged so quickly that accurate measurements could not be taken, indicating a high hydraulic conductivity. Sieve analysis data and corresponding literature values indicated the hydraulic conductivity to be  $10^{-3}$  m/s to  $10^{-4}$  m/s. Assuming the hydraulic conductivity of  $10^{-4}$  m/s, a gradient of 0.01 m/m, and sand and gravel porosity to be 25%, the groundwater flow velocity was calculated to be 136 m/year.

The Peace River is located approximately 850 m and 250 m south of the Community Airstrip and Old Landfill, respectively. Considering the groundwater velocity of 136 m/year and the groundwater direction being south-southeast, Columbia and Franz considered that potential leachate (if any) from the Old Landfill would have reached monitoring well 2018-10BH-3M at the time of sampling in 2010. See Figures 3a and 4a for groundwater monitoring well locations at the Community Airstrip and Old Landfill, respectively.

## 3.0 APPLICABLE GUIDELINES

The following guidelines were used in the previous reports for comparison against the soil and groundwater analytical results: (Note: some applicable guidelines changed between 2006 and 2011)

### Community Airstrip and Old Landfill (EBA, 2006)

Alberta Environment (AENV). 2001. *Soil and Water Quality Guidelines for Hydrocarbons at Upstream Oil and Gas Facilities*, Natural and Residential area land use; and

Canadian Council of Ministers of the Environment (CCME). 2003. *Canadian Environmental Quality Guidelines*, Residential land use.

### Community Airstrip and Old Landfill (EBA, 2009)

AENV. 2008. *Alberta Tier 1 Soil and Groundwater Remediation Guidelines*, Residential/Parkland land use;

CCME. 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health*, Residential/Parkland land use;

CCME, 2007. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*; and

Health Canada. 2008. *Guidelines for Canadian Drinking Water Quality*.

### Old Landfill (Columbia – Franz, 2011)

CCME, 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG)*, Agricultural land use;

CCME, 2008, *Canada-Wide Standards for Petroleum Hydrocarbons in Soil*, Tier 1 Levels for Agricultural land use in fine-grained surface soils and coarse-grained sub soils;

CCME, 2010. *Federal Interim Groundwater Quality Guidelines*, Generic Guidelines for Agricultural land use; and

Health Canada, 2010. *Guidelines for Canadian Drinking Water Quality*.

### 3.1 Current Applicable Guidelines

Based on the reports review, TOR and client discussions, the following guidelines will be used for risk assessment and remediation purposes as a part of the remediation options analysis.

CCME, 2008. *Canada Wide Standards for Petroleum Hydrocarbons*, Agricultural and Residential land use (coarse-grained soils);

CCME, 2007. *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG)*, Agricultural and Residential land use (coarse-grained soils);

CCME, 2010. *Federal Interim Groundwater Quality Guidelines*, Agricultural and Residential land use (coarse-grained soils); and

CCME, 1999. *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, Agricultural and Residential land use (referred in *Canadian Interim Groundwater Quality Guidelines*).

Any amendments in these guidelines should be considered at the time of remediation.

The CCME guidelines provide generic numerical standards corresponding to four generic land use scenarios: (i) Agricultural; (ii) Residential/Parkland; (iii) Commercial; and (iv) Industrial. Based on the land use considered in the previous environmental investigations, TOR and discussion with the client, the most appropriate land use categories are deemed to be Agricultural and Residential/Parkland land uses.

For the exposure pathway assessment (discussed below), the Marine Life pathway was not considered as there is no marine water in the Garden River area. All other potentially complete pathways were considered for remediation and/or risk assessment analysis.

### 3.2 Exposure Pathway Assessment for Community Airstrip

Based on the remediation options analysis (discussed in detail in Section 6.0), the remediation options for this site include removal of all hydrocarbon impacted soils. Therefore, the Tier 1 approach was considered for remediation purposes as was used in the previous investigations. In the Tier 1 approach, all exposure pathways are considered applicable regardless of the site conditions, and the guidelines have been developed using a number of conservative assumptions regarding site conditions at and in the vicinity of the site.

### 3.3 Exposure Pathway Assessment for Old Landfill

#### 3.3.1 Soil

The *Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health* (CCME, 2007) were used for comparison to the soil analytical results. For Agricultural and Residential land use categories, two potentially complete pathways are available for the parameters of concern. These pathways are human soil ingestion and ecological soil contact. It should be noted that CCME considers that these pathways are only potentially complete for soils up to 1.5 m deep (surface soils). Soil samples that are deeper than 1.5 m were therefore removed from further consideration. Table A presents the identified parameters of concern, available pathways, and guidelines. Upon completion of the data review, it was found that only two sampling locations had analytical soil concentrations exceeding the above pathway-specific guidelines. This does not include where pathways were not defined.

The following were the locations where there were exceedances for Agricultural land use:

- 2018-10-SS4 – Arsenic for human soil ingestion; and
- 2018-10-SS6 – Cadmium for human soil ingestion and ecological contact; copper, lead and zinc for ecological soil contact.

The following were the locations where there were exceedances for Residential land use:

- 2018-10-SS4 – Arsenic for human soil ingestion; and
- 2018-10-SS6 – Copper for ecological contact.

**Table A: Parameters of Concern and Available Pathways for Soil at Old Landfill**

Contaminant of Concern	Sample ID	Site Concentration (mg/kg)	Sampling Depth (mbg)	Agricultural Land Use Guidelines <sup>(4)</sup>			Residential Land Use Guidelines <sup>(4)</sup>		
				Applicable Guideline (mg/kg)	Soil Ingestion (mg/kg)	Soil Contact (mg/kg)	Applicable Guideline (mg/kg)	Soil Ingestion (mg/kg)	Soil Contact (mg/kg)
Se	08MW04B	<u>1.58</u>	7.6	1	NA	NA	1	NA	NA
As	2018-10SS-4	<u>16</u>	0.75	12	12	17	12	12	17
B	2018-10SS-4	<u>3.2</u>	0.75	2	NA	NA	NA	NA	NA
B	2018-10SS-5	<u>4.3</u>	0.9						
B	2018-10SS-6	<u>3.7</u>	0.8						
Cd	2018-10SS-6	<u>5</u>	0.8	1.4	1.4	3.8	10	14	10
Cu	2018-10SS-6	<u>409</u>	0.8	63	1100	63	63	1100	63
Pb	2018-10SS-6	<u>95</u>	0.8	70	140	70	140	140	300
Sn	2018-10SS-6	<u>140</u>	0.8	5	NA	NA	50	NA	NA
Zn	2018-10SS-6	<u>3950</u>	0.8	200	NA	200	200	NA	NA
Naphthalene	2018-10SS-5	<u>0.024</u>	0.8	0.013	NA	NA	0.013	NA	NA
Phenanthrene	2018-10SS-5	<u>0.09</u>	0.8	0.046	NA	NA	0.046	NA	NA
<b>Notes:</b> 1. NA = Not available 2. mbg = metres below grade 3. <b><u>Bold and underlined</u></b> = exceeds guideline 4. CCME, 2007. <i>Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (CSQG)</i> , Agricultural and Residential land use (coarse-grained soils) 5. Se=selenium; As=arsenic; B=Boron; Cd=cadmium; Cu=Copper; Pb=lead; Sn=Tin; Zn=zinc									

### 3.3.2 Groundwater

Federal Interim Groundwater Quality Guidelines (CCME, 2010) were used for comparison of groundwater analytical results. Table B outlines the identified parameters of concern, available pathways, and guidelines for Agricultural and Residential land uses. It should be noted that as per EBA's consultation with PCA, drinking water use is not expected at the Old Landfill site and therefore was excluded from the groundwater pathway analysis.

The analytical results indicated that the irrigation groundwater use guideline values were exceeded for iron and manganese at most monitoring well locations.

The analytical results indicated that the freshwater aquatic life guideline values were exceeded at all monitoring well locations (indicated in Table B) for one or more of the following parameters: aluminium (Al), arsenic (As), cadmium (Cd), copper (Cu), fluoride (Fl), iron (Fe) and selenium(Se).

Sulfate concentrations exceeded the freshwater life guideline value at 08MW05B.

It should be noted that aquatic life guidelines are applied to groundwater assuming that the groundwater discharges to surface water 10 m away from the sampling location. At this site, the nearest surface water receptor is 250 m down gradient and therefore may not necessarily impact aquatic life at the receptor. Attenuation processes in the subsurface may reduce concentrations down gradient.

Based upon the local hydrogeological conditions, it is likely that some of the parameters exceeding guideline values are naturally occurring. This is discussed further in Section 5.2. Columbia-Franz (2011) states that the metals in groundwater are not attributable to the Old Landfill.

**Table B: Parameters Exceeding Guidelines and Available Pathways for Groundwater at Old Landfill**

Parameters of Concern (µg/L)	08MW04B	08MW05B	08MW06B	2018-10BH-1M	2018-10BH-2M	2018-10BH-3M	2018-10BH-4M	2018-10BH-5M	2018-10BH-6M	2018-10BH-7M	Agricultural Land Use Guidelines <sup>(4)</sup>				Residential/Parkland Guidelines <sup>(4)</sup>	
											Applicable Guideline (µg/L)	Freshwater Life	Irrigation	Livestock	Applicable Guideline (µg/L)	Freshwater Life
Al	-	-	-	<u>338</u>	-	-	-	-	<u>534</u>	-	100	100	5,000	5,000	100	100
As	<u>6</u>	<u>10</u>	-	<u>10</u>	<u>7</u>	<u>8</u>	<u>7</u>	<u>14</u>	<u>8</u>	<u>12</u>	5	5	100	25	5	5
Cd	-	-	<u>2</u>	<u>0.033</u>	<u>0.03</u>	<u>0.02</u>	-	-	<u>0.09</u>	-	0.017	0.017	5.1	80	0.017	0.017
Cu	-	<u>18</u>	<u>9</u>	-	-	-	-	-	-	-	4	4	200	500	4	4
F	<u>200</u>	<u>220</u>	-	<u>200</u>	<u>190</u>	<u>180</u>	<u>250</u>	<u>180</u>	-	<u>190</u>	120	120	1,000	1,000	120	120
Fe	<u>2,900</u>	<u>6,300</u>	-	<u>8,000</u>	<u>6,200</u>	<u>6,800</u>	-	<u>7,400</u>	<u>51,000</u>	<u>8,000</u>	300	300	5,000	NA	300	300
Mn	<u>538</u>	<u>639</u>	<u>226</u>	<u>600</u>	<u>428</u>	<u>462</u>	<u>641</u>	<u>444</u>	<u>737</u>	<u>334</u>	200	NA	200	NA	NA	NA
Se	<u>10.8</u>	<u>2</u>	-	-	<u>3</u>	<u>3</u>	-	-	-	-	1	1	20	50	1	1
Zn	<u>93.8</u>	<u>61</u>	<u>39</u>	-	-	-	-	-	-	-	30	30	1,000	50,000	30	30
SO4	-	<u>111,000</u>	-	-	-	-	-	-	-	-	100,000	100,000	NA	1,000,000	100,000	100,000

**Notes:**

- 1- **Inhalation, soil organism direct contact and wildlife watering pathways** were not available for these parameters.
- 2 - **Marine Life pathway** is excluded as there is no marine/salty water in the area.
- 3 - "-" means did not exceed guidelines
- 4 - **CCME**, 2010. *Federal Interim Groundwater Quality Guidelines*, Agricultural and Residential land use (coarse-grained soils)
5. Al=aluminum; As=arsenic; Cd=cadmium; Cu=copper; F=fluoride; Fe=iron; Mn=manganese; Se=selenium; Z=zinc; SO<sub>4</sub>=sulfate;

## 4.0 SUMMARY OF HISTORICAL REPORT FINDINGS

A summary of the key findings of the four reports reviewed (discussed in Section 1.2) are summarized in the following sections.

### 4.1 Community Airstrip

The following tables (C and D) summarize guideline exceedances found in the soil and groundwater. Soil sampling locations (surface soil samples) and groundwater monitoring well locations are shown on Figures 3a and 3b.

**Table C: Summary of Soil Guideline Exceedances and Estimated Volume at Community Airstrip**

Areas	Area of Concern	Identified Contaminants Exceeding Guidelines	Surface Soil ID and Exceeding Parameters	Estimated Area of Impacts (m <sup>2</sup> )	Estimated Depth of Impacts (m)	Estimated Volume (m <sup>3</sup> )
1	Stained Area 1	BTEX, F1, F2 <sup>(1)</sup>	Drum Storage (@ 0.3 mbg)	100 <sup>(1)</sup>	0.5 <sup>(1)</sup>	50
2	Stained Area 2	F1, F2 <sup>(1)</sup>	08-SS36 (@ 0 – 0.6 mbg)	200 <sup>(2)</sup>	1.0 <sup>(2)</sup>	200
<b>Total Estimated Impacted Soil</b>						250 m <sup>3</sup>
<p>(1) = Hydrocarbons, area and depth identified in EBA, 2006  (2) = Hydrocarbons, area and depth identified in EBA, 2009  B=benzene; T=toluene; E=ethylbenzene; X=xylene; F1= hydrocarbon fraction C<sub>6</sub>-C<sub>10</sub>;  F2= hydrocarbon fraction &gt;C<sub>10</sub>-C<sub>16</sub></p>						

**Table D: Summary of Groundwater Guidelines Exceedances at Community Airstrip**

No	Monitoring Well ID	Identified Parameters Exceeding Guidelines	Depth of Groundwater (mbg)
1	08MW10	<u>Cd</u> , Mn, Se, Zn <sup>(1)</sup>	8.92 <sup>(1)</sup>
2	08MW11	<u>Cd</u> , Se, Zn <sup>(1)</sup>	9.08 <sup>(1)</sup>
3	08MW12	<u>Cd</u> , Mn, Se, Zn <sup>(1)</sup>	8.76 <sup>(1)</sup>
<p>(1) = Identified in EBA, 2009  <b>Highlighted and Underlined</b> parameters were below laboratory detection limits but the detection limits were above the applicable guidelines.  (2) = Cd=cadmium; Mn=manganese; Se=selenium; Z=zinc</p>			

## 4.2 Old Landfill

The following tables (E and F) summarize guideline exceedances found in the soil and groundwater. Soil sampling locations (surface soil samples/boreholes) and groundwater monitoring well locations are shown on Figures 4a and 4b.

**Table E: Summary of Soil Guideline Exceedances and Estimated Volume at Old Landfill**

Areas	Area of Concern	Identified Contaminants	Borehole/Surface Soil ID and Exceeding Parameters	Estimated Area of Impacts (m <sup>2</sup> )	Estimated Depth of Impacts (m)	Estimated Volume (m <sup>3</sup> )
1	North Debris Area	Not defined	Not defined	1,350	0.3 <sup>(3)</sup>	405
2	Old Landfill	As, B, Cd, Cu, Pb, Se <sup>(2)</sup> , Sn, Zn, naphthalene, phenanthrene, EC and SAR <sup>(1)</sup>	08MW04B = Se <sup>(2)</sup> (@ 7.6 mbg) 2018-10BH-6M = As, naphthalene, phenanthrene (@ 9 – 10.7 mbg) 2018-10SS-4 = As, B (@ 0 – 0.75 mbg) 2018-10SS-5 = B, naphthalene, phenanthrene (@ 0 – 0.9 mbg) 2018-10SS-6 = B, Cd, Cu, Pb, Sn, Zn, SAR, EC (@ 0 – 0.8 mbg)	3,600	1.5 <sup>(4)</sup>	5,400
				400	3 <sup>(5)</sup>	1,200
3	Scattered Surface Debris	Not defined	Not defined	250	0.3 <sup>(3)</sup>	75
4	South Debris Area	Not defined	Not defined	450	0.3 <sup>(3)</sup>	135
<b>Total Estimated Impacted Soil</b>						≈7,200 m <sup>3</sup>
(1) = Parameters identified in Columbia - Franz, 2011 (2) = Parameters identified in EBA, 2009 (3) = Assumed depth (4) = Estimated impacted depth identified in Columbia - Franz, 2011 (5) = 10% contingency for impacted depth exceeding 1.5 m; Columbia – Franz, 2011 indicated that there could be areas where impacts exceed 1.5 m. (6) = As=arsenic; B=boron; Cd=cadmium; Cu=copper; Pb=lead; Se=selenium; Sn=tin; Zn=zinc; Ec=electric conductivity; SAR=sodium absorption ratio						

**Table F: Summary of Groundwater Guideline Exceedances at Old Landfill**

No.	Monitoring Well ID	Identified Parameters Exceeding Guidelines	Depth of Groundwater (mbg)
1	08MW04B	As, <u>Cd</u> , F, Fe, <u>Hg</u> , Mn, Se, Zn <sup>(1 &amp; 2)</sup>	8.02 <sup>(2)</sup>
2	08MW05B	F, As, <u>Cd</u> , Cu, Fe, <u>Hg</u> , Mn, Se, Zn <sup>(1&amp;2)</sup>	8.16 <sup>(2)</sup>
3	08MW06B	Cd, Cu, <u>Hg</u> , Mn, Se, Zn <sup>(2)</sup>	7.95 <sup>(2)</sup>
4	2018-10BH-1M	F, Al, As, Cd, Fe, Mn <sup>(1)</sup>	9.31 <sup>(1)</sup>
5	2018-10BH-2M	F, As, Cd, Fe, Mn, Se <sup>(1)</sup>	9.51 <sup>(1)</sup>
6	2018-10BH-3M	F, As, Cd, Fe, Mn, Se <sup>(1)</sup>	9.85 <sup>(1)</sup>
7	2018-10BH-4M	F, As, Mn <sup>(1)</sup>	9.49 <sup>(1)</sup>
8	2018-10BH-5M	F, SO <sub>4</sub> , As, Fe, Mn <sup>(1)</sup>	9.52 <sup>(1)</sup>

**Table F: Summary of Groundwater Guideline Exceedances at Old Landfill**

No.	Monitoring Well ID	Identified Parameters Exceeding Guidelines	Depth of Groundwater (mbg)
9	2018-10BH-6M	TDS, Al, As, Cd, Fe, Mn <sup>(1)</sup>	Not Available
10	2018-10BH-7M	F, As, Fe, Mn <sup>(1)</sup>	9.67 <sup>(1)</sup>

(1) = Identified in Columbia - Franz, 2011  
(2) = Identified in EBA, 2009  
**Highlighted and underlined** parameters were below laboratory detection limits but the detection limits were above the applicable guidelines.  
Al=aluminum; As=arsenic; Cd= cadmium; F=fluoride; Fe=iron; Hg=mercury; Mn=manganese; Se=selenium; Zn=zinc;  
SO<sub>4</sub>=sulfate;  
TDS=total dissolved solids

## 5.0 DISCUSSION ON FINDINGS

### 5.1 Community Airstrip

As referenced in Table C, approximately 250 m<sup>3</sup> of hydrocarbon impacted soils are estimated to be located on-site, including the Stained Areas 1 and 2 (Figure 3a). Remediation options of these impacted soils are discussed in detail in Section 6.1.

Concentrations of select dissolved metals (cadmium [Cd], manganese [Mn], selenium [Se], and zinc [Zn]) were reported exceeding the guidelines in groundwater (EBA, 2009). These exceedances are discussed below.

Previous consultants reported concentrations of dissolved cadmium exceeding the guideline value for groundwater at 08MW10, 08MW11 and 08MW12; however, this is not based on measured concentrations. The reported concentrations were below laboratory detection limits, which were greater than the guidelines value. Therefore, the concentrations of dissolved cadmium are not considered an environmental concern. Additional sampling could clarify this.

Concentrations of dissolved manganese exceeded the guideline value for groundwater at 08MW10 and 08MW12. Elevated concentrations of dissolved manganese are not necessarily indicative of impacts to the groundwater quality from on-site operations. Dissolved manganese occurs naturally in groundwater under anaerobic conditions (Hem, 1985). As shown on Figure 3c, soil samples collected from above and below the water table levels did not have manganese concentrations exceeding the guideline value. Therefore, the elevated concentrations of manganese in groundwater are interpreted to be naturally occurring.

Concentrations of dissolved selenium exceeded guidelines in groundwater at 08MW10, 08MW11 and 08MW12. EBA and others have observed high selenium concentrations at other sites in Alberta that have highly mineralized groundwater. As shown on Figure 3c, soil samples collected below and above the water table did not have selenium concentrations exceeding guideline values. Therefore, the selenium concentrations are interpreted to be natural and not due to on-site activities. Additional sampling could clarify this.

Concentrations of dissolved zinc exceeded the guideline value for groundwater at 08MW10, 08MW11 and 08MW12. Since there is no identified source of zinc at the site and the soil samples collected at these

locations did not have zinc concentrations exceeding the guideline value, the elevated zinc concentrations are interpreted to be naturally occurring. Additional sampling could clarify this.

## 5.2 Old Landfill

As noted in Table E, approximately 7,200 m<sup>3</sup> of metals and polycyclic aromatic hydrocarbons (PAHs) (naphthalene and phenanthrene) impacted soils are estimated to be located on-site, including the Old Landfill and adjacent debris areas. Remediation options for these soils are discussed in detail in Section 6.2.

Concentrations of select dissolved metals were reported exceeding guideline values for groundwater (Columbia - Franz, 2011). These exceedances are discussed below.

Concentrations of dissolved aluminum exceeded the guideline value for groundwater at 2018-10BH-1M. Aluminum has limited solubility at near neutral pH values. Therefore, if a sample is properly field-filtered using a 0.45 µm pore diameter filter, aluminum concentrations in groundwater will be typically reported near or below the analytical detection limit. Based on this, the elevated aluminum is likely not indicative of impacts to groundwater, but the result of inadequate filtering.

Concentrations of dissolved iron and manganese exceeded the guideline values for groundwater at most of the wells. Elevated dissolved iron and manganese are not necessarily indicative of impacts to the groundwater quality from on-site operations. Dissolved iron and manganese occur naturally in groundwater under anoxic/anaerobic conditions (Hem, 1985).

Concentrations of dissolved arsenic exceeded the guideline value for groundwater at 08MW04B, 08MW05B, and in 2018-10BH-1M to 2018-10BH-7M. Elevated concentrations of dissolved iron and manganese also exceeded the guidelines values in most of these wells. Elevated manganese and iron concentrations are likely reflecting that the redox conditions in the vicinity of these wells are anoxic. Since arsenic is known to form precipitates with iron oxides under oxic conditions (Lemay, 2003), the elevated arsenic concentration measured are likely the result of the dissolution of iron oxide precipitates due to anoxic conditions in the groundwater in the vicinity of these wells. Therefore, the elevated concentrations of arsenic are interpreted to be natural and not due to on-site activities.

Concentrations of dissolved cadmium exceeded the guideline value for groundwater at 08MW06B, 2018-10BH-1M, 2018-10BH-2M and 2018-10BH-3M. Analytical results for cadmium in the soil samples (Columbia - Franz, 2011) were below the applicable guideline values. These soil samples were collected from surface and depths ranging from 5.5 to 9.0 mbg (refer to Figure 4b). Therefore, the elevated concentrations of cadmium in groundwater are likely naturally elevated and not due to on-site activities.

Concentrations of dissolved copper exceeded the guideline value for groundwater at 08MW05B and 08MW06B. Soil analytical results (EBA, 2009) indicated that copper concentrations were below the guideline value for soil samples collected at these locations. Soil samples were collected from 0.8 and 7.6 mbg (see Figure 4c). Therefore, elevated concentrations of copper are likely indicative of natural conditions or due to unknown sources and not due to on-site activities.

Concentrations of dissolved fluoride exceeded the guideline value for groundwater at 08MW04B and at 2018-10BH-1M to 2018-10BH-7M. Monitoring wells 2018-10BH-4M and 2018-10BH-7M are located

up-gradient of the Old Landfill. Therefore, it is concluded that elevated concentrations of fluoride in groundwater is due to natural conditions.

Previous consultants reported concentrations of mercury exceeding the applicable guideline value; however, this is not based on measured concentrations. The reported values were below laboratory detection limits, which were greater than the applicable guideline value. The soil analytical results for mercury in soil at these locations (refer to Figure 4c) did not indicate any elevated mercury concentrations. Therefore, the concentrations of dissolved mercury in groundwater are not considered an issue.

Concentrations of dissolved selenium exceeded the guideline value for groundwater at 08MW04B, 08MW05B, 08MW06B, 2018-10BH-2M and 2018-10BH-3M. Analytical results for the soil samples (Columbia - Franz, 2011) collected at these locations did not indicate any concentrations exceeding the guideline value. These soil samples were collected from surface and at depths ranging from 5.5 to 9.0 mbg (see Figure 4c). EBA and others have observed high selenium concentrations at other sites in Alberta that have highly mineralized groundwater. Therefore, the selenium concentrations are interpreted to be naturally occurring and not due to on-site activities.

Concentrations of dissolved zinc exceeded the guideline value for groundwater at 08MW04B, 08MW05B and 08MW06B. As shown on Figure 4c, soil samples collected from depths above the groundwater level did had concentrations of zinc that were below the guideline value. Therefore, elevated concentrations of zinc are not considered to be due to on-site activities and are likely naturally occurring and/or due to unknown sources. Additional sampling could clarify this.

Based on the foregoing, there is compelling information and data suggesting the groundwater at the monitoring well locations has not been impacted with the above-referenced metals of concern and the metals are likely naturally occurring. Further, Columbia-Franz (2011) stated metals in groundwater are not attributable to the Old Landfill.

## **6.0 REMEDIAL OPTIONS ANALYSIS**

### **6.1 Community Airstrip**

Potential remediation options available for remediation of hydrocarbon impacted soils at this site are summarized in Table G:

**Table G: Summary of Potential Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>1. Aerobic Treatment (landfarming)</b>	<ul style="list-style-type: none"> <li>Remediation of hydrocarbon contaminated soils by landfarming</li> </ul>	\$50-300/m <sup>3</sup>	Years	In-situ. On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Monitoring</li> <li>Organic nutrients</li> <li>Possibly liners</li> </ul>	<ul style="list-style-type: none"> <li>Cost effective</li> <li>Can be carried out in-situ, on-site or off-site</li> </ul>	<ul style="list-style-type: none"> <li>Time involved to remediate soils could be substantial.</li> <li>Toxic by-products may be produced.</li> <li>Microbial action may be impacted by salts, metals, and trace organic compounds.</li> </ul>	<ul style="list-style-type: none"> <li>Feasible due to site conditions and estimated quantity of impacted soils (250 m<sup>3</sup>)</li> </ul>
<b>2. Excavation and Landfill Disposal at Rainbow Lake Landfill</b>	<ul style="list-style-type: none"> <li>Simplest method to remove contaminated soils</li> <li>Used for soils with high level of contaminants</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>Transportation</li> <li>Remediation success monitoring required</li> </ul>	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions on landfill location</li> <li>May be expensive transportation costs</li> <li>Regulatory liaison delays</li> <li>Very expensive if large volumes of soil requires remediation</li> <li>Impacts to roads</li> <li>Greenhouse gas emissions from trucks</li> <li>Accidental spills</li> </ul>	<ul style="list-style-type: none"> <li>Feasible due to site conditions and estimated quantity of impacted soils (250 m<sup>3</sup>)</li> </ul>
<b>3. Excavate and Deposit in New Landfill Construct at Old Landfill Location</b>	<ul style="list-style-type: none"> <li>Simplest method to remove contaminated soils</li> </ul>	\$50-300/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>Transportation</li> <li>Remediation success monitoring required</li> </ul>	<ul style="list-style-type: none"> <li>Please see Option 3 of Table H</li> </ul>		

**Table G: Summary of Potential Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
4. Excavate and Deposit in New Landfill construct 3 Km west of community of Garden River	<ul style="list-style-type: none"><li>Simplest method to remove contaminated soils</li></ul>	\$50-300/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"><li>Transportation</li><li>Remediation success monitoring required</li></ul>	<ul style="list-style-type: none"><li>Please see Option 4 of Table H</li></ul>		
5. Thermal Stripping	<ul style="list-style-type: none"><li>Removal of VOCs from soils using heat</li><li>Low concentrations of VOCs</li><li>Where VOC's are insoluble in water</li><li>Where air emissions will not be unacceptable</li></ul>	\$150-500/m <sup>3</sup>	Days to weeks	On/Off-site	<ul style="list-style-type: none"><li>Excavators</li><li>Tank</li><li>Heat Source</li></ul>	<ul style="list-style-type: none"><li>Removal of highly volatile organic compounds</li><li>Can reduce air emissions through use of incineration or condensing to recover hydrocarbon products.</li></ul>	<ul style="list-style-type: none"><li>May be restrictions on air emissions, does not remove non-volatile organics.</li><li>Increase cost.</li></ul>	<ul style="list-style-type: none"><li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li></ul>
6. Soils Washing	<ul style="list-style-type: none"><li>Removal of contaminants by water washing.</li><li>Ideal for salt contaminated soils</li></ul>	\$50-150/m <sup>3</sup>	Days to months	In-situ, On/Off-site	<ul style="list-style-type: none"><li>Excavators</li><li>Soil and water monitoring probes</li><li>Tanks</li><li>Water</li><li>Tile Drain</li><li>Pumps</li></ul>	<ul style="list-style-type: none"><li>Can be carried out on-site or off-site.</li><li>Suitable for organic and inorganic contamination.</li></ul>	<ul style="list-style-type: none"><li>Water supply</li><li>Water treatment</li><li>Water disposal</li><li>Less effective in silts and clays</li></ul>	<ul style="list-style-type: none"><li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li></ul>

**Table G: Summary of Potential Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>7. Vacuum Extraction</b>	<ul style="list-style-type: none"> <li>Removal of VOCs from soils by vapour extractions</li> <li>In homogeneous isotropic soils</li> </ul>	\$150-1,000/m <sup>3</sup>	Months to years	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Extraction wells</li> <li>Soil and air HC monitoring probes</li> <li>Vacuum Pump and Piping</li> </ul>	<ul style="list-style-type: none"> <li>Can be performed in-situ without excavation of soils.</li> <li>Removal of VOCs</li> </ul>	<ul style="list-style-type: none"> <li>Can take months to years to remediate</li> <li>Air emissions and monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>
<b>8. Neutralization</b>	<ul style="list-style-type: none"> <li>Chemical neutralization</li> <li>Suitable for acid or alkali contaminated soils</li> </ul>	\$150-250/m <sup>3</sup>	Days to weeks	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Soil and water monitoring probes</li> <li>Tanks</li> </ul>	<ul style="list-style-type: none"> <li>Contaminants transformed into harmless chemicals</li> </ul>	<ul style="list-style-type: none"> <li>Chemical reaction between treatment chemicals and waste to form additional toxic or hazardous contaminants</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>) and as impacts are shallow</li> </ul>
<b>9. Oxidation /Reduction</b>	<ul style="list-style-type: none"> <li>Adding chemicals to oxidize or reduce contaminants in soils.</li> <li>Oxidation can be used to remove cyanide and organic chemicals while reduction can be used to remove chromium, silver and mercury.</li> </ul>	\$150-500/m <sup>3</sup>	Days to weeks	In-situ. On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Chemicals</li> <li>Tanks</li> <li>Soil monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Contaminants transformed into harmless chemicals.</li> </ul>	<ul style="list-style-type: none"> <li>Chemical reactions between waste and oxidants/reductants can form explosive reactions, and produce additional toxic or hazardous contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>
<b>10. Incineration</b>	<ul style="list-style-type: none"> <li>Removal of severely hydrocarbon contaminated soil and PCBs by incineration</li> </ul>	\$500/m <sup>3</sup>	Days to weeks	Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Transportation</li> <li>Incineration facility</li> </ul>	<ul style="list-style-type: none"> <li>Complete removal of contamination from site</li> </ul>	<ul style="list-style-type: none"> <li>Costly capital and operating expenses</li> <li>Disposal of ash and air emissions</li> <li>Incomplete combustion</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>

**Table G: Summary of Potential Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>11. Pyrolysis</b>	<ul style="list-style-type: none"> <li>Slow addition of heat for organic recovery</li> </ul>	\$500/m <sup>3</sup>	Days to weeks	In-situ, On-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Soil monitoring</li> <li>Contamination tanks</li> </ul>	<ul style="list-style-type: none"> <li>Carried out in-situ or off-site</li> <li>Removal and recovery of products</li> </ul>	<ul style="list-style-type: none"> <li>Costly</li> <li>Disposal of product</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>) and as impacts are shallow</li> </ul>
<b>12. Anaerobic Treatment</b>	<ul style="list-style-type: none"> <li>Remediation of hydrocarbon in anaerobic environment</li> <li>Remediation of hydrocarbon contaminated soils</li> </ul>	\$150-300/m <sup>3</sup>	Years	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Monitoring</li> <li>Organic nutrients</li> </ul>	<ul style="list-style-type: none"> <li>Can be carried out, in-situ on-site or off-site</li> <li>Cost effective</li> </ul>	<ul style="list-style-type: none"> <li>Remediation may be incomplete</li> <li>Toxic by-products may be produced.</li> <li>Microbial action may be impacted by salts, metals, and trace organic compounds</li> <li>Odor problems such as hydrogen sulphide gas</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>

**Table G: Summary of Potential Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>13. Capping and Monitoring</b>	<ul style="list-style-type: none"> <li>▪ Risk management approach.</li> <li>▪ Used for old landfill final closure</li> <li>▪ Can be used where metals are primarily contaminants of concern.</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	On -site	<ul style="list-style-type: none"> <li>▪ Excavators</li> <li>▪ Compactors</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lower cost</li> <li>▪ Less time period</li> <li>▪ Potential land uses – pasture, recreational, cultivation, and forestry</li> </ul>	<ul style="list-style-type: none"> <li>▪ Contaminated soils remains on-site</li> <li>▪ Future monitoring (groundwater monitoring) required to verify soil leaching to groundwater and groundwater transport not occurring)</li> <li>▪ Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>▪ Soil cap must be maintained in perpetuity.</li> <li>▪ Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>▪ Lack of feasibility for residential development</li> <li>▪ AENV may not approve this approach</li> </ul>	<ul style="list-style-type: none"> <li>▪ Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>
<b>14. Fixation / Encapsulating</b>	<ul style="list-style-type: none"> <li>▪ Removal and encapsulation of contaminants.</li> <li>▪ Contaminants may be used as construction materials.</li> <li>▪ Ideal where landfill disposal is not available.</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>▪ Excavators</li> <li>▪ Encapsulation fixations</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fixated waste may be placed in landfill or used as construction material.</li> </ul>	<ul style="list-style-type: none"> <li>▪ May be costly</li> <li>▪ May not be appropriate due to incomparability of other associated contaminants/chemical species</li> </ul>	<ul style="list-style-type: none"> <li>▪ Not feasible due to low quantity of hydrocarbon impacted soils (250 m<sup>3</sup>)</li> </ul>

Due to the location of the Community Airstrip and volume of impacted soils, EBA considers Options 1 to 4 as the most feasible options for remediation of hydrocarbon impacted soils. The key activities involved with these options are discussed below.

#### **6.1.1 Option 1 - Excavation and Landfarming**

In this method, impacted soils are excavated and placed as a layer (0.3 m) on a liner. The impacted soils are subsequently periodically aerated via mechanical mixing to promote biodegradation. Nutrients may be added to promote growth of hydrocarbon degrading bacteria. The landfarming area may require run-off and run-on control to prevent potential release of runoff from the landfarm. Landfarming is a common remediation option in the environmental industry.

The key activities will include the following:

- Regulatory approvals from the local municipality and Alberta Environment;
- Tender preparation for excavating, backfilling, compacting the backfill soils, landfarm preparation and periodic aeration for two to three years;
- Project management and site visits;
- Landfarm construction per provincial standards, including placement of liner (approximately 1,000 m<sup>2</sup> area);
- Excavating and landfarming contaminated soils (approximately 250 m<sup>3</sup>);
- Conduct a confirmatory soil sampling program of approximately 300 m<sup>2</sup> area for contaminants of concern (BTEX, F1 and F2) reported for this site. Approximately 20 samples will be collected from the walls and bases of Areas 1 and 2;
- Backfill and compact backfill soils (approximately 300 m<sup>3</sup>).
- Placing top soil (approximately 60 m<sup>3</sup>), seeding and re-contouring;
- Preparing a report of the work conducted;
- Annual monitoring of landfarmed soils and reporting (assuming four years). This will include collection of 10 confirmatory soil samples and analyzing them for BTEX, F1 to F4; and
- No groundwater monitoring is recommended at this time.

The cost for conducting this option is estimated at \$210,000. The Class C cost estimate for this option is provided in Table 1.

#### **Assumptions for Cost Estimation**

- Excavation mass of 2000 kg per cubic metre (2 tonnes/m<sup>3</sup>)
- Suitable backfill material is available on site or within 5 km radius
- Backfill material required for excavation includes 20% swell factor

- Suitable landfarm area available on site (Possible suitable locations are on runway approaches)
- Parks Canada to maintain seeded areas until complete grass germination
- CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction

### 6.1.2 Option 2 - Excavation and Landfill Disposal at Rainbow Lake

This option involves excavation and landfilling of soils exceeding the applicable guidelines and backfilling the excavation with clean soils. Prior to backfilling the excavation, confirmatory soil samples are collected from the base and walls of the excavation to assess if the excavation boundaries are clean (i.e., concentrations are below guidelines) and the contaminated soils are removed.

The key activities include the following:

- Conduct soil sampling for landfill disposal characterization analysis (5 samples);
- Tender preparation for excavating, backfilling and compacting backfill soils;
- Project management and meetings, including: site visit; trucking routes; potential crossing agreements; local road bans; safety requirements; and landfill hours;
- Field work preparation, line locates, ground disturbance;
- Excavate and landfill disposal of approximately 250 m<sup>3</sup> of impacted soils from Community Strip to the Rainbow Lake landfill;
- Conduct a confirmatory soil sampling program of approximately 300 m<sup>2</sup> area for contaminants of concern (BTEX, F1 and F2) reported for this site. Approximately 20 samples will be collected from the walls and bases of Areas 1 and 2;
- Backfill excavations with source fill material and compact;
- Placing topsoil (approximately 60 m<sup>3</sup>), seeding and re-contouring; and
- Complete a post remediation report including the findings of the confirmatory soil sampling.

The cost for conducting this option is estimated at \$200,000. The Class C cost estimate for this option is provided in Table 2.

#### Assumptions for Cost Estimation

- Excavation mass of 2,000 kg per cubic metre (2 tonnes/m<sup>3</sup>)
- Suitable backfill material is available on site or within 5 km radius
- Backfill material required for excavation includes 20% swell factor
- Parks Canada to maintain seeded areas until complete grass germination
- All materials hauled to Rainbow Lake landfill are accepted.

- CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction.

### **6.1.3 Option 3 - Excavate and Deposit in New Landfill Constructed at Old Landfill Site**

Please refer to Section 6.2.3 for details.

The cost for conducting this option is estimated at \$150,000. The Class C cost estimate for this option is provided in Table 3.

### **6.1.4 Option 4 - Excavate and Deposit in New Landfill Constructed West of Garden River**

Please refer to Section 6.2.4 for details.

The cost for conducting this option is estimated at \$250,000. The Class C cost estimate for this option is provided in Table 4.

## **6.2 Old Landfill**

Potential remediation options available for remediation of impacted soils at the Old Landfill site are summarized in Table H:

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>1. Capping and Monitoring</b>	<ul style="list-style-type: none"> <li>▪ Risk management approach.</li> <li>▪ Used for old landfill final closure</li> <li>▪ Can be used where metals are primarily contaminants of concern.</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	On -site	<ul style="list-style-type: none"> <li>▪ Excavators</li> <li>▪ Compactors</li> </ul>	<ul style="list-style-type: none"> <li>▪ Lower cost</li> <li>▪ Less time period</li> <li>▪ Potential land uses – pasture, recreational, cultivation, and forestry</li> <li>▪ Is an accepted practice</li> </ul>	<ul style="list-style-type: none"> <li>▪ Contaminated soils remains on-site</li> <li>▪ Future monitoring (groundwater monitoring) required to verify soil leaching to groundwater and groundwater transport not occurring)</li> <li>▪ Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>▪ Soil cap must be maintained in perpetuity.</li> <li>▪ Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>▪ Lack of feasibility for residential development</li> <li>▪ AENV may not approve this approach</li> </ul>	<ul style="list-style-type: none"> <li>▪ Feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>2. Excavation and Landfill Disposal at Rainbow Lake</b>	<ul style="list-style-type: none"> <li>Simplest method to remove contaminated soils</li> <li>Used for soils with high level of contaminants</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>Transportation</li> <li>Remediation success monitoring required</li> </ul>	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions on landfill location</li> <li>May be expensive transportation costs</li> <li>Potential human and ecological risks in the event of an accident during transportation.</li> <li>Regulatory liaison delays</li> <li>Very expensive if large volumes of soil require remediation</li> <li>Impact to roads</li> <li>Greenhouse gas emissions from trucks</li> <li>Accidental spills</li> </ul>	<ul style="list-style-type: none"> <li>Feasible as metals are the major contaminants of concern</li> </ul>
<b>3. Excavate and Deposit in New Landfill Construct at Old Landfill Site</b>	<ul style="list-style-type: none"> <li>Simplest method to remove contaminated soils</li> <li>Used for soils with high level of contaminants</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>Transportation</li> <li>Remediation success monitoring required</li> </ul>	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants</li> </ul>	<ul style="list-style-type: none"> <li>AENV may not approve the location of the new landfill</li> <li>Additional cost for constructing new landfill</li> <li>Additional cost for capping impacted soils at new landfill</li> <li>Continued groundwater monitoring required</li> <li>Regulatory liaison delays</li> <li>Contaminated soils remain on-site</li> <li>Soil cap thickness and design must ensure no human or</li> </ul>	<ul style="list-style-type: none"> <li>Feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
							<ul style="list-style-type: none"> <li>ecological access to soils.</li> <li>▪ Soil cap must be maintained in perpetuity.</li> <li>▪ Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>▪ Lack of feasibility for residential development</li> </ul>	
<b>4. Excavate and Deposit in New Landfill Construct 3 km West of Community of Garden River</b>	<ul style="list-style-type: none"> <li>▪ Simplest method to remove contaminated soils</li> <li>▪ Used for soils with high level of contaminants</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>▪ Transportation</li> <li>▪ Remediation success monitoring required</li> </ul>	<ul style="list-style-type: none"> <li>▪ Simplest remediation method</li> <li>▪ Appropriate for soils with high levels of contaminants</li> <li>▪ Could be sited at old Lagoon east of community if conditions are favourable</li> </ul>	<ul style="list-style-type: none"> <li>▪ AENV may not approve the location of the new landfill</li> <li>▪ The proposed site has not been seen if it is suitable place for new landfill</li> <li>▪ Additional cost for constructing new landfill</li> <li>▪ Additional cost for capping impacted soils at new landfill</li> <li>▪ Continued groundwater monitoring required</li> <li>▪ Potential human and ecological risks in the event of an accident during transportation.</li> <li>▪ Regulatory liaison delays</li> <li>▪ Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>▪ Soil cap must be maintained in perpetuity.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
							<ul style="list-style-type: none"> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> </ul>	
<b>5. Thermal Stripping</b>	<ul style="list-style-type: none"> <li>Removal of VOCs from soils using heat</li> <li>Low concentrations of VOCs.</li> <li>Where VOCs are insoluble in water</li> <li>Where air emissions will not be unacceptable</li> </ul>	\$150-500/m <sup>3</sup>	Days to weeks	On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Tank</li> <li>Heat Source</li> </ul>	<ul style="list-style-type: none"> <li>Removal of highly volatile organic compounds</li> <li>Can reduce air emissions through use of incineration or condensing to recover hydrocarbon products.</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions on air emissions, does not remove non-volatile organics.</li> <li>Need to develop risk management plan for emissions to protect workers on site and public off site.</li> <li>Increase cost.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>6. Soils Washing</b>	<ul style="list-style-type: none"> <li>Removal of contaminants by water washing.</li> <li>Ideal for salt contaminated soils</li> </ul>	\$50-150/m <sup>3</sup>	Days to months	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Soil and water monitoring probes</li> <li>Tanks</li> <li>Water</li> <li>Tile Drain</li> <li>Pumps</li> </ul>	<ul style="list-style-type: none"> <li>Can be carried out on-site or off-site.</li> <li>Suitable for organic and inorganic contamination.</li> </ul>	<ul style="list-style-type: none"> <li>Water supply</li> <li>Water treatment</li> <li>Water disposal</li> <li>Potential for chemical releases in wash water. Need to develop a risk management plan.</li> <li>Less effective in silts and clays</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>7. Vacuum Extraction</b>	<ul style="list-style-type: none"> <li>Removal of VOCs from soils by vapour extraction</li> <li>In homogeneous isotropic soils</li> </ul>	\$150-1,000/m <sup>3</sup>	Months to years	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Extraction wells</li> <li>Soil and air HC monitoring probes</li> <li>Vacuum Pump and Piping</li> </ul>	<ul style="list-style-type: none"> <li>Can be performed in-situ without excavation of soils.</li> <li>Removal of VOCs</li> </ul>	<ul style="list-style-type: none"> <li>Can take months to years to remediate</li> <li>Air emissions and monitoring</li> <li>Need to develop risk management plan for emissions to protect workers on site and public off site.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>8. Neutralization</b>	<ul style="list-style-type: none"> <li>Chemical neutralization</li> <li>Suitable for acid or alkali contaminated soils</li> </ul>	\$150-250/m <sup>3</sup>	Days to weeks	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Soil and water monitoring probes</li> <li>Tanks</li> </ul>	<ul style="list-style-type: none"> <li>Contaminants transformed into harmless chemicals.</li> </ul>	<ul style="list-style-type: none"> <li>Chemical reaction between treatment chemicals and waste to form additional toxic or hazardous contaminants</li> <li>Potential for chemical releases.</li> <li>Need to risk assess and/or develop risk management plan for chemicals.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>9. Oxidation /Reduction</b>	<ul style="list-style-type: none"> <li>Adding chemicals to oxidize or reduce contaminants in soils.</li> <li>Oxidation can be used to remove cyanide and organic chemicals while reduction can be used to remove chromium, silver and mercury.</li> </ul>	\$150-500/m <sup>3</sup>	Days to weeks	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Chemicals</li> <li>Tanks</li> <li>Soil monitoring</li> </ul>	<ul style="list-style-type: none"> <li>Contaminants transformed into harmless chemicals.</li> </ul>	<ul style="list-style-type: none"> <li>Chemical reactions between waste and oxidants/reductants can form explosive reactions, and produce additional toxic or hazardous contaminants.</li> <li>Need to risk assess and/or develop risk management plan for chemicals.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>10. Incineration</b>	<ul style="list-style-type: none"> <li>Removal of severely hydrocarbon contaminated soil and PCBs by incineration</li> </ul>	\$500/m <sup>3</sup>	Days to weeks	Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Transportation</li> <li>Incineration facility</li> </ul>	<ul style="list-style-type: none"> <li>Complete removal of contamination from site</li> </ul>	<ul style="list-style-type: none"> <li>Costly capital and operating expenses</li> <li>Disposal of ash and air emissions</li> <li>Need to develop a risk management plan for workers on site and public off site from emissions.</li> <li>Incomplete combustion</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>11. Pyrolysis</b>	<ul style="list-style-type: none"> <li>Slow addition of heat for organic recovery</li> </ul>	\$500/m <sup>3</sup>	Days to weeks	In-situ, On-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Soil monitoring</li> <li>Contamination tanks</li> </ul>	<ul style="list-style-type: none"> <li>Carried out in-situ or off-site</li> <li>Removal and recovery of products</li> </ul>	<ul style="list-style-type: none"> <li>Costly</li> <li>Disposal of product</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>12. Aerobic Treatment (landfarming)</b>	<ul style="list-style-type: none"> <li>Remediation of hydrocarbon contaminated soils.</li> </ul>	\$50-300/m <sup>3</sup>	Years	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Monitoring</li> <li>Organic nutrients</li> </ul>	<ul style="list-style-type: none"> <li>Cost effective</li> <li>Can be carried out in-situ, on-site or off-site</li> </ul>	<ul style="list-style-type: none"> <li>Time involved to remediate soils could be substantial.</li> <li>Toxic by-products may be produced and are accessible for human and ecological exposure by direct contact or dust inhalation.</li> <li>Microbial action may be impacted by salts, metals, and trace organic compounds.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>

**Table H: Summary of Potential Remediation Options for Impacted Soils at Old Landfill**

Option	Principle and Application	Typical Costs	Time	Location	Equipment Requirements	Flexibility		EBA Evaluation
						Pros	Cons	
<b>13. Anaerobic Treatment</b>	<ul style="list-style-type: none"> <li>-Remediation of hydrocarbon contaminated soils in anaerobic environment</li> </ul>	\$150-300/m <sup>3</sup>	Years	In-situ, On/Off-site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Monitoring</li> <li>Organic nutrients</li> </ul>	<ul style="list-style-type: none"> <li>Can be carried out, in-situ on-site or off-site</li> <li>Cost effective</li> </ul>	<ul style="list-style-type: none"> <li>Remediation may be incomplete</li> <li>Toxic by-products may be produced.</li> <li>Microbial action may be impacted by salts, metals, and trace organic compounds</li> <li>Odor problems such as hydrogen sulphide gas</li> <li>Need to develop risk management plan for vapours for workers on site a public off site.</li> </ul>	<ul style="list-style-type: none"> <li>Not feasible as metals are the major contaminants of concern</li> </ul>
<b>14. Fixation / Encapsulating</b>	<ul style="list-style-type: none"> <li>Removal and encapsulation (eg: in concrete) of contaminants.</li> <li>Contaminants may be used as construction materials.</li> <li>Ideal where landfill disposal is not available.</li> </ul>	\$50-500/m <sup>3</sup>	Days to weeks	Off-Site	<ul style="list-style-type: none"> <li>Excavators</li> <li>Encapsulation fixations</li> </ul>	<ul style="list-style-type: none"> <li>Fixated waste may be placed in landfill or used as construction material.</li> </ul>	<ul style="list-style-type: none"> <li>High cost</li> <li>May not be appropriate due to incompatibility of other associated contaminants/chemical species</li> </ul>	<ul style="list-style-type: none"> <li>Feasible as metals are the major contaminants of concern</li> </ul>

Based on the location of the Old Landfill and estimated volume of impacted soils, EBA considers Options 1 to 4 as the most feasible options for remediation of impacted soils. The key activities involved with these options are discussed below.

### 6.2.1 Option 1 - Capping and Monitoring

This option involves capping the old landfill area and each of the adjacent debris areas separately with an impermeable liner or cap. The liner acts to prevent infiltration of rainwater and consequent leading of contaminants downward to underlying groundwater. The cap or liner also acts as a barrier to potential human or environmental exposure to the landfill materials. Key activities include the following:

- Tender preparation for capping and compacting borrow soils;
- Project management and meetings, including site visit with contractors to discuss the final project scope, trucking routes, potential crossing agreements, local road bans, safety requirements;
- Fieldwork preparation, field area preparation, line locates, ground disturbance, temporary storage area construction;
- Decommissioning of three monitoring wells in the Old Landfill area;
- Placement and compaction of borrow soils at Old Landfill and adjacent debris areas. The borrow soils will include:
  - **Area 1 – North Debris Area:**
    - 0.6 m of a clay layer (approximately 810 m<sup>3</sup>)
    - 0.8 m of subsoil for cultivated land use or forestry (approximately 1,080 m<sup>3</sup>)
    - 0.2 m topsoil (approximately 270 m<sup>3</sup>)
  - **Area 2 – Old Landfill:**
    - 0.6 m of a clay layer (approximately 2,400 m<sup>3</sup>)
    - 0.8 m of subsoil for cultivated land use or forestry (approximately 3,200 m<sup>3</sup>)
    - 0.2 m topsoil (approximately 800 m<sup>3</sup>)
  - **Area 3 – Scattered Surface Debris:**
    - 0.6 m of a clay layer (approximately 150 m<sup>3</sup>)
    - 0.8 m of subsoil for cultivated land use or forestry (approximately 200 m<sup>3</sup>)
    - 0.2 m topsoil (approximately 50 m<sup>3</sup>)
  - **Area 4 – South Debris Area:**
    - 0.6 m of a clay layer (approximately 270 m<sup>3</sup>)
    - 0.8 m of subsoil for cultivated land use or forestry (approximately 360 m<sup>3</sup>)

- 0.2 m topsoil (approximately 90 m<sup>3</sup>)

- Complete a post closure report for the site;
- A post closure groundwater monitoring program including preparation, implementation and reporting. This will include groundwater monitoring at the existing wells and installing an additional eight groundwater monitoring wells; and
- Continued groundwater monitoring and reporting (assume five years). The cost for conducting this option is estimated at \$1,570,000. The Class C cost estimate for this option is provided in Table 5.

### **Assumptions for Cost Estimation**

- Excavation mass of 2,000 kg per cubic metre (2 tonnes/m<sup>3</sup>)
- Suitable backfill material is available on site or within 5 km radius
- Backfill material includes 20% swell factor
- Parks Canada to maintain seeded areas until complete grass germination

### **Discussion**

Former landfill sites have frequently been capped and closed in place even when they did not previously have a liner (clay or geosynthetic) as they are historic facilities. Examples that EBA is directly familiar with include capped and closed landfill sites at Ermineskin and Alexander First Nations and Enoch Cree Nation in Alberta. The City of Edmonton also has old landfill sites in Rundle Park and former ravines that have been capped to minimize infiltration but in each case, domestic waste was consolidated in one location, compacted and covered with up to 1 m of clay fill and topsoil and sloped to promote runoff and minimize infiltration. The waste materials do not generate significant leachate in this situation as infiltration is minimized and the waste does not come in contact with the water table. Regular inspections are required to ensure that the cap has good grass cover and is not eroding and groundwater monitoring wells are sampled and tested annually for landfill indicator parameters. Typical ones include chloride, phenol, metals, sulphates, etc. but are specific to each site. This monitoring is carried out to ensure that there is no migration of impacts.

### **End Use Alternatives**

There are many examples of former landfill sites that have been closed and utilized for a range of new land uses. Closed and capped landfill sites have been developed as golf courses (Millwoods Golf Course, Edmonton), active recreational areas (Rundle Park, Edmonton), and passive open space. In all cases, the capped waste needs to be well above the fluctuation zone for the water table and graded to promote runoff (no flat areas where water can pond and infiltrate). One issue to consider with Class II waste (domestic waste including organics) is the generation of methane gas. Where levels are high, passive or active venting is provided as gas can build up in the ground (and adjacent basements of dwellings) and potentially be explosive. This happened at a landfill in Ontario about 20 years ago. As a result, residential and commercial development is usually set back from the edge of the waste by at least 100 m, depending on the site particulars. In the case of Garden River, there are no residences near the site and if it is capped, there should be stipulations that no new development be allowed nearby. That should not be difficult to

regulate in this case. A reasonable end use for the Old Landfill Site at Garden River if capped in place would be for passive recreational use. In general, grass and low shrub growth on the cap could be promoted to prevent erosion but large tree growth would result in root systems that could penetrate the cap and open pathways for the infiltration of runoff. Therefore, tree growth should be discouraged. There would be no apparent need to fence off the closed site but this could be done. Groundwater monitors should be protected (locked) and clearly marked from ATV's and snowmobiles for safety reasons and vandalism if the area is left open for public access.

### **6.2.2 Option 2 - Excavation and Landfill Disposal at Rainbow Lake**

This option involves excavation and landfilling of soils exceeding the applicable guidelines and backfilling the excavation with clean soils. Prior to backfilling the excavation, confirmatory soil samples are collected from the base and walls of the excavation to assess if the excavation boundaries are clean and the contaminated soils are removed. In addition, EBA would recommend the completion of at least one groundwater monitoring and sampling event following remediation to confirm that subsurface conditions have not been affected, followed by the decommissioning of the existing monitoring wells.

The key activities will include the following:

- Conduct soil sampling for landfill disposal characterization analysis (five samples);
- Tender preparation for excavating, backfilling and compacting backfill soils;
- Project management and meetings, including: site visit with contractors to discuss the final project scope; trucking routes; potential crossing agreements; local road bans; safety requirements; and landfill hours;
- Fieldwork preparation, field area preparation, line locates, ground disturbance;
- Decommissioning of three groundwater monitoring wells in the Old Landfill area;
- Construction of temporary storage area may be required to stockpile excavated soils;
- Excavate and landfill disposal of approximately 7,200 m<sup>3</sup> of impacted soils from Old Landfill and adjacent debris areas to the Rainbow Lake landfill;
- Conduct a confirmatory soil sampling program of approximately 6,000 m<sup>2</sup> area for contaminants of concern reported for this site. Approximately 90 samples will be collected from the walls and bases of the excavations;
- Backfilling the excavations with source fill material and compacting backfill;
- Placing top soil (approximately 1,200 m<sup>3</sup>), seeding and re-contouring;
- Complete a post remediation report including the findings of the confirmatory soil sampling; and
- Complete a post-remediation groundwater monitoring and sampling program. This will include groundwater monitoring from the existing wells on-site (six wells). Prepare a report of the post-treatment groundwater monitoring.

The cost for conducting this option is estimated at \$3,920,000. The Class C cost estimate for this option is provided in Table 6.

### **Assumptions for Cost Estimation**

- Excavation mass of 2,000 kg per cubic metre (2 tonne/m<sup>3</sup>)
- Suitable backfill material is available on site or within 5 km radius
- Backfill material required for excavation includes 20% swell factor
- Parks Canada to maintain seeded areas until complete grass germination
- All materials hauled to Rainbow Lake landfill are accepted by the Mackenzie Regional Waste Management Commission

### **6.2.3 Option 3 - Excavate and Disposal in New Landfill Constructed at Old Landfill Site**

This option involves excavation of impacted soils and stockpiling them in a separate area, followed by construction of a new landfill at the Old Landfill location and then placing the stockpiled soils at the new landfill, followed by capping and annual monitoring as discussed in Section 6.2.1.

It should be noted that hydrocarbon impacted soils from the Community Airstrip (discussed in Section 6.1.3) will also be deposited in the new landfill, if constructed.

The key activities will include the following:

- Conduct soil sampling for landfill disposal characterization analysis (five samples);
- Obtain approval from AESRD for construction of a new landfill;
- Tender preparation for excavating, landfill construction at Old Landfill location, backfilling with impacted soils, and capping;
- Project management and meetings, including: site visit with contractors to discuss the final project scope; trucking routes; potential crossing agreements; local road bans; and safety requirements;
- Fieldwork preparation, field area preparation, line locates, ground disturbance;
- Decommissioning of three groundwater monitoring wells in the Old Landfill area;
- Construction of temporary storage area to stockpile excavated soils;
- Excavate and stockpile impacted soils (approximately 7,200 m<sup>3</sup>) at the temporary storage area;
- Conduct a confirmatory soil sampling program of approximately 6,000 m<sup>2</sup> area for parameters of concern reported for this site. Approximately 90 samples will be collected from the walls and bases of the excavations;
- Construct a new landfill at the Old Landfill location once confirmatory sampling results show that clean boundaries have been reached;
- Deposit stockpiled soil in the new landfill followed by capping, which will include:

- 0.6 m of a clay layer (approximately 2,400 m<sup>3</sup>)
- 0.8 m of subsoil for cultivated land use or forestry (approximately 3,200 m<sup>3</sup>)
- 0.2 m topsoil (approximately 800 m<sup>3</sup>)
- Backfilling debris areas with topsoil (approximately 600 m<sup>3</sup>), seeding and re-contouring;
- Complete a landfill construction and post closure report for the site;
- Conduct a post closure groundwater monitoring program including preparation, implementation and reporting. This will include groundwater monitoring at the existing wells and installing an additional eight groundwater monitoring wells; and
- Continued groundwater monitoring and reporting (assume ten years).

The cost for conducting this option is estimated at \$1,960,000. The Class C cost estimate for this option is provided in Table 7.

#### **Assumptions for Cost Estimation**

- Excavation mass of 2,000 kg per cubic metre (2 tonne/m<sup>3</sup>)
- Suitable backfill material (top soil) is available on site or within 5 km radius
- Backfill material required for excavation includes 20% swell factor
- Parks Canada to maintain seeded areas until complete grass germination

#### **6.2.4 Option 4 - Excavate and Deposit in New Landfill Constructed West of Garden River**

This option involves excavating and landfilling of soils exceeding the applicable guidelines to a new landfill to be constructed at approximately 3 km west of the community of Garden River. The approximate location of the proposed landfill is shown on Figure 5, included in Appendix A. The landfill could also be sited at the old lagoon east of the community, if conditions are favourable.

It should be noted that hydrocarbon impacted soils from the Community Airstrip (discussed in Section 6.1.3) will also be deposited in this new landfill, if constructed.

The key activities will include the following:

- Conduct soil sampling for landfill disposal characterization analysis (five samples);
- Obtain approval from AESRD for construction of a new landfill;
- Tender preparation for construction of the new landfill, new landfill capping, excavating impacted soils from the Old Landfill and hauling to the new landfill, and backfilling excavations at the Old Landfill;
- Project management and meetings, including: site visits with contractors to discuss the final project scope; trucking routes; potential crossing agreements; local road bans; and safety requirements;
- Fieldwork preparation, field area preparation, line locates, ground disturbance;

- Construct a new landfill at the proposed location approximately 3 km west of the community of Garden River;
- Decommissioning of three groundwater monitoring wells in the Old Landfill area;
- Construction of temporary storage area may be required to stockpile excavated soils;
- Excavate and landfill disposal of approximately 7,200 m<sup>3</sup> of impacted soils from the Old Landfill and adjacent debris areas to the new landfill;
- Conduct a confirmatory soil sampling program of approximately 6,000 m<sup>2</sup> area for contaminants of concern reported for this site. Approximately 90 samples will be collected from the walls and bases of the excavations;
- Backfilling the excavations with source fill material and compacting backfill;
- Placing top soil (approximately 1,200 m<sup>3</sup>), seeding and re-contouring;
- Capping new landfill with 0.6 m of a clay layer, 0.8 m of subsoil, and 0.2 m of topsoil. The quantities of clay, subsoil and top soil will depend upon the depth of the impacted soils in the new landfill. However, for this cost estimate, it is assumed that a 4,000 m<sup>2</sup> area of the new landfill will be capped. The capping will then include:
  - 0.6 m of a clay layer (approximately 2,400 m<sup>3</sup>)
  - 0.8 m of subsoil for cultivated land use or forestry (approximately 3,200 m<sup>3</sup>)
  - 0.2 m topsoil (approximately 800 m<sup>3</sup>)
- Complete a post remediation report for the Old Landfill including the findings of the confirmatory soil sampling;
- Complete a post-remediation groundwater monitoring and sampling program at the Old Landfill. This will include groundwater monitoring from the existing wells on-site (six wells). Prepare a report of the post-treatment groundwater monitoring;
- Complete a landfill construction and capping report;
- Conduct a post closure groundwater monitoring program for the new landfill, including preparation, implementation and reporting. This will include installation of 12 groundwater monitoring wells around the new landfill; and
- Continued groundwater monitoring and reporting for the new landfill (assume 10 years).

The cost for conducting this option is estimated at \$3,270,000. The Class C cost estimate for this option is provided in Table 8.

#### **Assumptions for Cost Estimation**

- Excavation mass of 2,000 kg per cubic metre (2 tonnes/m<sup>3</sup>)
- Suitable backfill material (top soil) is available on site or within 5 km radius

- Backfill material required for excavation includes 20% swell factor
- Parks Canada to maintain seeded areas until complete grass germination

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the reports review, the volume of impacted soils at the Community Airstrip is estimated to be 250 m<sup>3</sup> where identified parameters of concerns were BTEX, F1 and F2. Hydrocarbon impacts are limited to surface soils to a maximum depth of 1 mbg. At the Old Landfill site, the volume of impacted soils is estimated to be 7,200 m<sup>3</sup> where metals were the main parameters of concern. The impacted soils are generally limited to the surface soils to a maximum depth of 1.5 mbg. It is noted that there may be impacts to 3 m in some areas (Columbia – Franz, 2011) and a 10% contingency has been applied to account for this possibility.

Based on the remediation options analysis, EBA provides four feasible options for remediation of impacted soils at each site which are presented to PCA for their consideration. The remedial options are summarized in the following tables.

**Table I: Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 1 - Excavation and Landfarming (estimated 250 m <sup>3</sup> of impacted soils)	\$210,000	Years	On/Off-site	<ul style="list-style-type: none"> <li>▪ Cost effective</li> <li>▪ Can be carried out on-site or off-site</li> </ul>	<ul style="list-style-type: none"> <li>▪ Time involved to remediate soils could be substantial.</li> <li>▪ Toxic by-products may be produced.</li> <li>▪ Microbial action may be impacted by salts, metals, and trace organic compounds</li> </ul>
Option 2 - Excavation and Landfill Disposal at Rainbow Lake (estimated 250 m <sup>3</sup> of impacted soils)	\$200,000	Days to weeks	Off-site	<ul style="list-style-type: none"> <li>▪ Simplest remediation method</li> <li>▪ Appropriate for soils with high levels of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>▪ May be restrictions at landfill location</li> <li>▪ Expensive transportation costs</li> <li>▪ Potential human and ecological risks in the event of an accident during transportation</li> <li>▪ Regulatory liaison delays</li> <li>▪ Impact to roads</li> <li>▪ Greenhouse gas emissions by trucks</li> <li>▪ Accidental spills</li> </ul>
Option 3 - Excavate and Disposal in New Landfill Construct at Old Landfill Site (estimated 250 m <sup>3</sup> of impacted soils)	\$150,000	Days	Off-site	<ul style="list-style-type: none"> <li>▪ Please, see Option 3 in Table J</li> </ul>	

**Table I: Remediation Options for Hydrocarbon Impacted Soils at Community Airstrip**

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 4 - Excavate and Disposal in New Landfill Construct 3 Km West of Community (estimated 250 m <sup>3</sup> of impacted soils)	\$250,000	Days	Off-site	<ul style="list-style-type: none"> <li>Please, see Option 4 in Table J</li> </ul>	

**Table J: Remediation Options for Impacted Soils at Old Landfill**

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 1 - Capping and Monitoring	\$1,570,000	Weeks	On-site	<ul style="list-style-type: none"> <li>Lower cost</li> <li>Less time period possible</li> <li>Potential end land uses – pasture, recreational, cultivation, and forestry</li> </ul>	<ul style="list-style-type: none"> <li>Contaminated soils remains on-site</li> <li>Future monitoring (groundwater monitoring) required to verify soil leaching to groundwater and groundwater transport not occurring</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>Restricts nearby for residential development</li> </ul>
Option 2 - Excavation and Landfill Disposal at Rainbow Lake	\$3,920,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> <li>Could be sited at old lagoon east of community if conditions are favourable</li> </ul>	<ul style="list-style-type: none"> <li>May be restrictions at landfill location</li> <li>Expensive transportation costs</li> <li>Potential human and ecological risks in the event of an accident during transportation</li> <li>Regulatory liaison delays</li> <li>Overall costs are high</li> </ul>

**Table J: Remediation Options for Impacted Soils at Old Landfill**

Options	Class C Cost Estimate	Time	Location	Flexibility	
				Pros	Cons
Option 3 - Excavate and Disposal in New Landfill Construct at Old Landfill site	\$1,960,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>AESRD may not approve the location of the new landfill</li> <li>Additional cost for constructing and capping new landfill</li> <li>Continued groundwater monitoring required</li> <li>Regulatory liaison delays</li> <li>Contaminated soils remain on-site</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> <li>Lack of feasibility for residential development</li> </ul>
Option 4 - Excavate and Disposal in New Landfill Construct 3 km West of Community of Garden River	\$3,270,000	Weeks	Off-site	<ul style="list-style-type: none"> <li>Simplest remediation method</li> <li>Appropriate for soils with high levels of contaminants.</li> </ul>	<ul style="list-style-type: none"> <li>AESRD may not approve the location of the new landfill</li> <li>The proposed site has not been seen if it is suitable place for new landfill</li> <li>Additional cost for constructing and capping new landfill</li> <li>Continued groundwater monitoring required</li> <li>Potential human and ecological risks in the event of an accident during transportation.</li> <li>Regulatory liaison delays</li> <li>Soil cap thickness and design must ensure no human or ecological access to soils.</li> <li>Soil cap must be maintained in perpetuity.</li> <li>Clay cap may increase the build-up of landfill gas and venting may be required.</li> </ul>

Findings of the previous reports review identified that select metal concentrations in groundwater exceeded the applicable guidelines. Figures 3b and 4b show the monitoring well locations at the Community Airstrip and Old Landfill, respectively, where those exceedances were observed. Columbia - Franz, 2011 concluded that there were exceedances of metal concentrations but were not due to the Old Landfill site. In addition, by considering the soil and groundwater analytical results (discussed in detail in Section 5.0 of the report), elevated concentrations of select metals were considered to be naturally occurring and/or not due to on-site activities. Therefore, a remediation option analysis and action plan was not considered applicable for groundwater at either the Community Airstrip or at the Old Landfill.

## **8.0 LIMITATIONS OF LIABILITY**

This report and its contents are intended for the sole use of PCA and their agents. EBA Engineering Consultants Ltd. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than PCA, or for any project other than the remediation of the sites. Any such unauthorized use of this letter report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in EBA's Services Agreement. EBA's General Conditions are provided in Appendix B of this report.

## 9.0 CLOSURE

We trust this report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

EBA Engineering Consultants Ltd.

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<p><b>PERMIT TO PRACTICE</b> EBA ENGINEERING CONSULTANTS LTD.</p> <p>Signature _____</p> <p>Date _____</p> <p><b>PERMIT NUMBER: P245</b> The Association of Professional Engineers and Geoscientists of Alberta</p>
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## REFERENCES

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## TABLES

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Table 1	Community Airstrip Option 1: Class C Cost Estimate for Excavation and Landfarming
Table 2	Community Airstrip Option 2: Class C Cost Estimate for Excavation and Landfill Disposal at Rainbow Lake
Table 3	Community Airstrip Option 3: Class C Cost Estimate for Excavation and Disposal in New Landfill at Old Landfill Site
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**Table 1: Option 1 Community Airstrip: Class C Cost Estimate for Excavation and Landfarming**

	<b>Garden River Community Airport Stained Area 1 and Stained Area 2 at East End of Rwy 07-25</b>	<b>Unit of Measure</b>	<b>Approx. Quantity</b>	<b>Unit Price</b>	<b>Total Cost</b>
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Land farm construction including liner (1,000 m <sup>2</sup> )	m <sup>2</sup>	1000	\$10	\$10,000
3	Excavate soils from Areas 1 and 2 and place on landfarm area in 0.3 m lift	m <sup>3</sup>	250	\$20	\$5,000
4	Construct 0.3 m high berm around perimeter of land farm	lin m	120	\$25	\$3,000
5	Backfill with common & compact - Area 1 [(0.3 m x 100 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	40	\$75	\$3,000
6	Backfill with common & compact - Area 2 [(0.8 m x 200 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	200	\$75	\$15,000
7	Regrade Sites 1 and 2	m <sup>2</sup>	300	\$10	\$3,000
8	Supply and place 0.2 m thick topsoil	m <sup>2</sup>	300	\$50	\$15,000
9	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	300	\$5	\$1,500
10	Mob and demob from site (+/- 20 %)	lump sum			\$11,600
<b>Subtotal - Estimated Construction Cost</b>					<b>\$69,600.00</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$10,440.00</b>
Additional Costs	Engineering fee and reporting		1	\$50,000	\$50,000.00
Additional Costs	Annual Monitoring of Land farmed Soils (Cost Table AC)	Year	4	\$19,115	\$76,460
<b>Total Estimated Cost</b>					<b>\$206,500</b>
<b>Class C Estimated Cost</b>					<b>\$210,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Suitable landfarm area available on site (Possible suitable locations are on runway approaches) Parks Canada to maintain seeded areas until complete grass germination CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction					

**Table 2: Option 2 Community Airstrip: Class C Cost Estimate for Excavation and Landfill Disposal at Rainbow Lake**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community Airport Stained Area 1 and Stained Area 2 at East End of Rwy 07-25</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Excavate and haul to the Tervita landfill, 40km east of Rainbow Lake (Site 1 - 0.5 m depth; Site 2 - 1.0 m depth) Using 15 m <sup>3</sup> per load trucks	m <sup>3</sup>	250	\$200	\$50,000
3	Backfill with common & compact - Area 1 [(0.3 m x 100 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	40	\$75	\$3,000
4	Backfill with common & compact - Area 2 [(0.8 m x 200 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	200	\$75	\$15,000
5	Regrade Sites 1 and 2	m <sup>2</sup>	300	\$10	\$3,000
6	Supply and place 0.2 m thick topsoil	m <sup>2</sup>	300	\$50	\$15,000
7	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	300	\$5	\$1,500
8	Mob and demob from site (+/- 20 %)	lump sum			\$18,000
<b>Subtotal - Estimated Construction Cost</b>					\$108,000
<b>Estimated Construction Cost Contingency (15%)</b>					\$16,200
Additional Costs	Engineering fee and reporting		1	\$50,000.00	\$50,000
Additional Costs	Class 2 Soil Samples Collection (Cost Table AA)				\$21,595
<b>Total Estimated Cost</b>					\$195,795
<b>Class C Estimated Cost</b>					<b>\$200,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination All materials hauled to the Tervita Landfill site east of Rainbow Lake are accepted CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction					

**Table 3: Community Airstrip Option 3: Class C Cost Estimate for Excavation of Community Airstrip Soils and Disposal in New Landfill at Old Landfill Site**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community Airport Stained Area 1 and Stained Area 2 at East End of Rwy 07-25</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Excavate and haul contaminated material to the Old Landfill Site (Old Landfill Site has previously been remediated to a New Landfill Site - See Table 7)	m <sup>3</sup>	250	\$50	\$12,500
3	Backfill with common & compact - Area 1 [(0.3 m x 100 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	40	\$75	\$3,000
4	Backfill with common & compact - Area 2 [(0.8 m x 200 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	200	\$75	\$15,000
5	Regrade Sites 1 and 2	m <sup>2</sup>	300	\$10	\$3,000
6	Supply and place 0.2 m thick topsoil	m <sup>2</sup>	300	\$50	\$15,000
7	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	300	\$5	\$1,500
8	Mob and demob from site (+/- 20 %)	lump sum			\$10,500
<b>Subtotal - Estimated Construction Cost</b>					<b>\$63,000</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$9,450</b>
Additional Costs	Engineering fee and reporting		1	\$50,000.00	\$50,000
Additional Costs	Class 2 Soil Samples Collection (Cost Table AA)				\$21,595
<b>Total Estimated Cost</b>					<b>\$144,045</b>
<b>Class C Estimated Cost</b>					<b>\$150,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination Remediation of the Airstrip is done at the same time as the construction of the New Landfill at the Old landfill Site. CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction					

**Table 4: Community Airstrip Option 4: Class C Cost Estimate for Excavation and Disposal in New Landfill 3 km West of Community**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community Airport Stained Area 1 and Stained Area 2 at East End of Rwy 07-25</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Excavate and haul contaminated material to a New Landfill 3 Km west of Village (New Landfill Site has previously been constructed - See Table 8)	m <sup>3</sup>	250	\$50	\$12,500
3	Backfill with common & compact - Area 1 [(0.3 m x 100 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	40	\$75	\$3,000
4	Backfill with common & compact - Area 2 [(0.8 m x 200 m <sup>2</sup> ) x1.2]	m <sup>3</sup>	200	\$75	\$15,000
5	Regrade Sites 1 and 2	m <sup>2</sup>	300	\$10	\$3,000
6	Supply and place 0.2 m thick topsoil	m <sup>2</sup>	300	\$50	\$15,000
7	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	300	\$5	\$1,500
8	Mob and demob from site (+/- 20 %)	lump sum			\$10,500
<b>Subtotal - Estimated Construction Cost</b>					<b>\$63,000</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$9,450</b>
Additional Costs	Engineering costs for new landfill design and reporting		1	\$150,000.00	\$150,000
Additional Costs	Class 2 Soil Samples Collection (Cost Table AA)				\$21,595
<b>Total Estimated Cost</b>					<b>\$244,045</b>
<b>Class C Estimated Cost</b>					<b>\$250,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination Remediation of the Airstrip is done at the same time as the construction of the New Landfill 3 KM west of Village CFU4 Airport Operator (Little Red River Cree Nation) to provide NOTAM communications to CYOJ FSS (High Level Airport Flight Service Station) during construction					

**Table 5: Old Landfill Option 1: Class C Cost Estimate for Capping and Monitoring**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community - Old Landfill</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Area 1 - Load, place and compact borrow materials				
2.1	0.6 m layer of clay	m <sup>3</sup>	810	\$75	\$60,750
2.2	0.8 m subsoil	m <sup>3</sup>	1080	\$75	\$81,000
2.3	0.2 m topsoil	m <sup>2</sup>	1350	\$50	\$67,500
3	Area 2 - Load, place and compact borrow materials				
3.1	0.6 m layer of clay	m <sup>3</sup>	2400	\$75	\$180,000
3.2	0.8 m subsoil	m <sup>3</sup>	3200	\$75	\$240,000
3.3	0.2 m topsoil	m <sup>2</sup>	4000	\$50	\$200,000
4	Area 3 - Load, place and compact borrow materials				
4.1	0.6 m layer of clay	m <sup>3</sup>	150	\$75	\$11,250
4.2	0.8 m subsoil	m <sup>3</sup>	200	\$75	\$15,000
4.3	0.2 m topsoil	m <sup>2</sup>	250	\$50	\$12,500
5	Area 4 - Load, place and compact borrow materials				
5.1	0.6 m layer of clay	m <sup>3</sup>	270	\$75	\$20,250
5.2	0.8 m subsoil	m <sup>3</sup>	360	\$75	\$27,000
5.3	0.2 m topsoil	m <sup>2</sup>	450	\$50	\$22,500
6	Mob and demob from site (+/- 20 %)	lump sum			\$188,050
<b>Subtotal - Estimated Construction Cost</b>					<b>\$1,128,300</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$169,245</b>
Additional Costs	Additional cost and reporting		1	\$100,000.00	\$100,000
	Decommissioning of 3 monitoring wells (Cost Table AG)				\$20,968
	Post Remediation Groundwater Monitoring and Adding 8 New Wells (Cost Table AE)				\$38,551
	Continued Groundwater Monitoring (Cost Table AF)	Year	5	\$21,775	\$108,875
<b>Total Estimated Cost</b>					<b>\$1,565,939</b>
<b>Class C Estimated Cost</b>					<b>\$1,570,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination					

**Table 6: Old Landfill Option 2: Class C Cost Estimate for Excavation and Landfill Disposal at Rainbow Lake**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community - Old Landfill</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Construct temporary stockpile site (clearing & grading)	m <sup>2</sup>	1000	\$5	\$5,000
3	Excavate, separate and stockpile contaminated soils and other debris	m <sup>3</sup>	7200	\$40	\$288,000
4	Load, Haul and disposal to Tervita Landfill east of Rainbow Lake (Contaminated Soil approved for Daily Cover; Tipping Fee - \$30/tonne)	m <sup>3</sup>	1800	\$200	\$360,000
5	Load, Haul and disposal to High River Landfill (Assorted Metals, Debris etc. Tipping Fee - \$140/tonne)	m <sup>3</sup>	5400	\$250	\$1,350,000
6	Backfill with common native material ; compact and regrade	m <sup>3</sup>	8640	\$75	\$648,000
7	Supply and place 0.2 m thick topsoil	m <sup>2</sup>	1200	\$50	\$60,000
8	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	1200	\$5	\$6,000
9	Mob and demob from site (+/- 20 %)	lump sum			\$543,900
<b>Subtotal - Estimated Construction Cost</b>					<b>\$3,263,400</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$489,510</b>
Additional Costs	Engineering cost and reporting		1	\$100,000.00	\$100,000
	Class 2 Landfill Soil Samples Collection (Cost Table AB)				\$21,595
	Well Decommissioning and Monitoring in Old landfill area (Cost Table AG)				\$20,968
	Post Remediation GW Monitoring/Sampling (Cost Table AD)				\$20,000
<b>Total Estimated Cost</b>					<b>\$3,915,473</b>
<b>Class C Estimated Cost</b>					<b>\$3,920,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination All materials hauled to the Tervita landfill site east of Rainbow Lake are accepted All materials hauled to High Level landfill are accepted by the Mackenzie Regional Waste Management Commission					

**Table 7: Old Landfill Option 3: Class C Cost Estimate for Excavation of Landfill Material and Disposal in New Landfill at Existing Site**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
	<b>Garden River Community - Old Landfill</b>				
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Construct temporary stockpile site (clearing & grading)	m <sup>2</sup>	1000	\$5	\$5,000
3	Excavate, separate and stockpile contaminated soils and other debris from Old Landfill Areas 1,2,3 and 4	m <sup>3</sup>	7200	\$35	\$252,000
4	Prepare base of Old Landfill site for clay liner	m <sup>2</sup>	6050	\$3	\$18,150
5	Load, haul, place and compact 1.0m clay liner sub-grade	m <sup>3</sup>	6050	\$25	\$151,250
6	Install geomembrane liner	m <sup>2</sup>	6050	\$15	\$90,750
7	Load, haul, and place contaminated soils and other debris from adjacent stockpiles to New Landfill cells in Old Landfill site (Contaminated materials from Airport to be placed in New Landfill cell at the same time)	m <sup>3</sup>	7200	\$25	\$180,000
	<b>Cap New Landfill:</b>				
8	Load, haul, place and compact 0.6 m clay layer from borrow area	m <sup>3</sup>	3630	\$25	\$90,750
9	Load, haul, place and compact 0.8 m sub-soil layer from borrow area	m <sup>3</sup>	4840	\$25	\$121,000
10	Supply and place 0.2 m thick topsoil Layer	m <sup>2</sup>	6050	\$50	\$302,500
11	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	6050	\$5	\$30,250
12	Mob and demob from site (+/- 20 %)	lump sum			\$248,830
<b>Subtotal - Estimated Construction Cost</b>					<b>\$1,492,980</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$223,947</b>
Additional Costs	Engineering costs for new landfill development and siting including construction monitoring and reporting				\$150,000
	Final Landfill Closure and Post-Closure Engineering				\$50,000
	Well Decommissioning and Monitoring in Old landfill area (Cost Table AG)				\$20,968
	Post Remediation GW Monitoring/Sampling (Cost Table AD)				\$20,000
<b>Total Estimated Cost</b>					<b>\$1,957,895</b>
<b>Class C Estimated Cost</b>					<b>\$1,960,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination New Landfill development and closure meets development and siting criteria as per Standards For Landfills in Alberta					

**Table 8: Old Landfill Option 4: Class C Cost Estimate for Excavation of Old Landfill Material and Disposal in New Landfill 3 km West of Community**

Item No.	Description	Unit of Measure	Approx. Quantity	Unit Price	Total Cost
<b>Garden River Community - Old Landfill</b>					
1	Locates - Alberta One-Call	lump sum	1	\$2,500	\$2,500
2	Construct temporary stockpile site (clearing & grading)	m <sup>2</sup>	1000	\$5	\$5,000
3	Excavate, separate and stockpile contaminated soils and other debris from Old Landfill Areas 1, 2, 3 and 4	m <sup>3</sup>	7200	\$35	\$252,000
4	Load, haul, and place contaminated soils and other debris from adjacent stockpiles to New Landfill cells in New Landfill 3 Km west of Village	m <sup>3</sup>	7200	\$40	\$288,000
Prepare New Landfill Site:					
5	Prepare base of New Landfill site for clay liner	m <sup>2</sup>	6050	\$3	\$18,150
6	Load, haul, place and compact 1.0 m clay liner sub-grade	m <sup>3</sup>	6050	\$25	\$151,250
7	Install geomembrane liner	m <sup>2</sup>	6050	\$15	\$90,750
Cap Old Landfill:					
8	Area 1 - Load, place and compact borrow materials				
8.1	0.6 m layer of clay	m <sup>3</sup>	810	\$75	\$60,750
8.2	0.8 m subsoil	m <sup>3</sup>	1080	\$75	\$81,000
8.3	0.2 m topsoil	m <sup>2</sup>	1350	\$50	\$67,500
9	Area 2 - Load, place and compact borrow materials				
9.1	0.6 m layer of clay	m <sup>3</sup>	2400	\$75	\$180,000
9.2	0.8 m subsoil	m <sup>3</sup>	3200	\$75	\$240,000
9.3	0.2 m topsoil	m <sup>2</sup>	4000	\$50	\$200,000
10	Area 3 - Load, place and compact borrow materials				
10.1	0.6 m layer of clay	m <sup>3</sup>	150	\$75	\$11,250
10.2	0.8 m subsoil	m <sup>3</sup>	200	\$75	\$15,000
10.3	0.2 m topsoil	m <sup>2</sup>	250	\$50	\$12,500
11	Area 4 - Load, place and compact borrow materials				
11.1	0.6 m layer of clay	m <sup>3</sup>	270	\$75	\$20,250
11.2	0.8 m subsoil	m <sup>3</sup>	360	\$75	\$27,000
11.3	0.2 m topsoil	m <sup>2</sup>	450	\$50	\$22,500
14	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	1200	\$5	\$6,000
Cap New Landfill:					
15	Load, haul, place and compact 0.6 m clay layer at New Landfill site	m <sup>3</sup>	3630	\$25	\$90,750
16	Load, haul, place and compact 0.8 m sub-soil layer at New Landfill site	m <sup>3</sup>	4840	\$25	\$121,000
17	Load, haul, and place 0.2 m topsoil layer at New Landfill site	m <sup>2</sup>	6050	\$50	\$302,500
18	Seeding (Parks Canada to water and maintain)	m <sup>2</sup>	6050	\$5	\$30,250
19	Mob and demob from site (+/- 20 %)	lump sum			\$350,280
<b>Subtotal - Estimated Construction Cost</b>					<b>\$2,646,180</b>
<b>Estimated Construction Cost Contingency (15%)</b>					<b>\$396,927</b>
Additional Costs	Engineering costs for new landfill development and siting including construction monitoring and reporting				\$150,000
	Final Landfill Closure and Post-Closure Engineering				\$50,000
	Post Remediation GW Monitoring/Sampling (Cost Table AD)				\$20,000
<b>Total Estimated Cost</b>					<b>\$3,263,107</b>
<b>Class C Estimated Cost</b>					<b>\$3,270,000</b>
<b>Assumptions:</b> Excavation mass of 2,000 kg per cubic metre (2 tonnes/m <sup>3</sup> ) Suitable backfill material is available on site or within 5 km radius Backfill material required for excavation includes 20% swell factor Parks Canada to maintain seeded areas until complete grass germination New Landfill development and closure meets development and siting criteria as per Standards For Landfills in Alberta					

**Table 9: Comparison of Applicable Environmental Management Options Community Airstrip**

Assessment Criteria	Excavation and Landfarming	Excavation and Landfill Disposal at Rainbow Lake	Excavate and Disposal at Reconstructed Landfill Site	Excavate and Disposal at New Landfill 3 km West
Liability Reduction	High	High	High	High
Impact on Site Operations	Limited if landfarm is located on site	Limited (during excavation)	Limited (during excavation)	Limited (during excavation)
Complexity	Low to Moderate	Low	Low	Low
Public/ Stakeholder Perception	unknown	unknown	unknown	unknown
Risk to Human Health and the Environment	Low	Low	Low	Low
Timeframe	Years	Days to weeks	Days to weeks	Days to weeks
Relative cost	\$210,000	\$200,000	\$150,000	\$250,000
Land Use Restrictions	High <ul style="list-style-type: none"> <li>Landfarm area cannot be used until soil has been remediated</li> </ul>	None	None	None
Regulatory Compliance	Yes	Yes	Yes – if new landfill is approved	Yes – if new landfill is approved
Local Economic Benefit	Minimal	Minimal	Minimal	Minimal
Sustainability of Approach	Moderate <ul style="list-style-type: none"> <li>Few resources used</li> <li>Low risk to environment during remediation</li> <li>Land cannot be used during remediation</li> </ul>	High <ul style="list-style-type: none"> <li>Few resources used</li> <li>Low risk to environment during remediation</li> </ul>	High <ul style="list-style-type: none"> <li>Few resources used</li> <li>Low risk to environment during remediation</li> </ul>	High <ul style="list-style-type: none"> <li>Few resources used</li> <li>Low risk to environment during remediation</li> </ul>
Implementation Risks	Low to Moderate <ul style="list-style-type: none"> <li>Soil remediation may not progress as expected</li> <li>Potential for long term (years) to remediate soil</li> </ul>	Low <ul style="list-style-type: none"> <li>Spills during transportation</li> </ul>	Moderate <ul style="list-style-type: none"> <li>Landfill may not be approved</li> </ul>	Moderate <ul style="list-style-type: none"> <li>Landfill may not be approved</li> </ul>
Other Advantages	Low cost	Low cost	Low cost	Low cost
Other Disadvantages	Time to remediate soil	None	None	None

**Table 10: Comparison of Applicable Environmental Management Options Old Landfill**

<b>Assessment Criteria</b>	<b>Capping and Monitoring</b>	<b>Excavation and Landfill Disposal at Rainbow Lake</b>	<b>Excavate and Disposal at Reconstructed Landfill Site</b>	<b>Excavate and Disposal at New Landfill 3 km West</b>
Liability Reduction	High	High	High	High
Impact on Site Operations	High	High	High	High
Complexity	Moderate	Low	Moderate to high	Moderate to high
Public/ Stakeholder Perception	May be unacceptable	Likely acceptable	May be unacceptable	Likely acceptable
Risk to Human Health and the Environment	Low Monitoring required	Low	Low Monitoring required	Low Monitoring required
Timeframe	Day to weeks	Days to weeks	Months	Months
Relative cost	\$1,570,000	\$3,920,000	\$1,960,000	\$3,270,000
Land Use Restrictions	Moderate ▪ No housing within setbacks	none	Moderate ▪ No housing within setbacks	None
Regulatory Compliance	Yes	Yes	Yes – if new landfill is approved	Yes – if new landfill is approved
Local Economic Benefit	Minimal	Minimal	Minimal	Minimal
Sustainability of Approach	Moderate ▪ Few resources used ▪ Low risk to environment during remediation ▪ Land use restrictions	High ▪ No land use restrictions	Moderate ▪ Few resources used ▪ Low risk to environment during remediation ▪ Land use restrictions	High ▪ No land use restrictions
Implementation Risks	Moderate Monitoring required Land use restrictions	Low	Moderate Land use restrictions May not be approved	Moderate Landfill may not be approved
Other Advantages	Lower relative cost	Impact removed from site	Convenience of local landfill	Convenience of local landfill
Other Disadvantages	May not be acceptable	Higher relative cost	May not be acceptable	Higher relative cost

# FIGURES

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Figure 1	Site Location Plan
Figure 2	Site Plan Showing Community Airstrip and Old Landfill Locations
Figure 3a	Community Airstrip Site Plan Showing Soil Exceedances
Figure 3b	Community Airstrip Site Plan Showing Groundwater Exceedances
Figure 3c	Details of Groundwater Monitoring Well Profile Showing Soil and Groundwater Exceedances (Community Airstrip)
Figure 4a	Old Landfill Site Plan Showing Soil Exceedances
Figure 4b	Old Landfill Site Plan Showing Groundwater Exceedances
Figure 4c	Details of Groundwater Monitoring Well Profile Showing Soil and Groundwater Exceedances (Old Landfill)

Q:\Edmonton\Drafting\PROJECTS\E22103088-01\101\Report Components\Phase 001\AutoCad\E22103088-01\_FIG 1.dwg [FIGURE 1] January 25, 2013 - 12:07:39 pm (BY: KIROS, TIGIST)



**NOTES**

Background imagery courtesy of Google Earth and is shown for visual presentation purposes only.

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**GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB**

**SITE LOCATION PLAN**

PROJECT NO.  
E22103088-01

DWN  
TK

CKD  
JM

REV  
0

OFFICE  
EDM

DATE  
January 2013

**Figure 1**



0 250 m  
Scale: 1: 7 500

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GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD  
LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB

**SITE PLAN SHOWING COMMUNITY AIRSTRIP  
AND OLD LANDFILL SITES**

PROJECT NO.  
E22103088-01

DWN  
TK

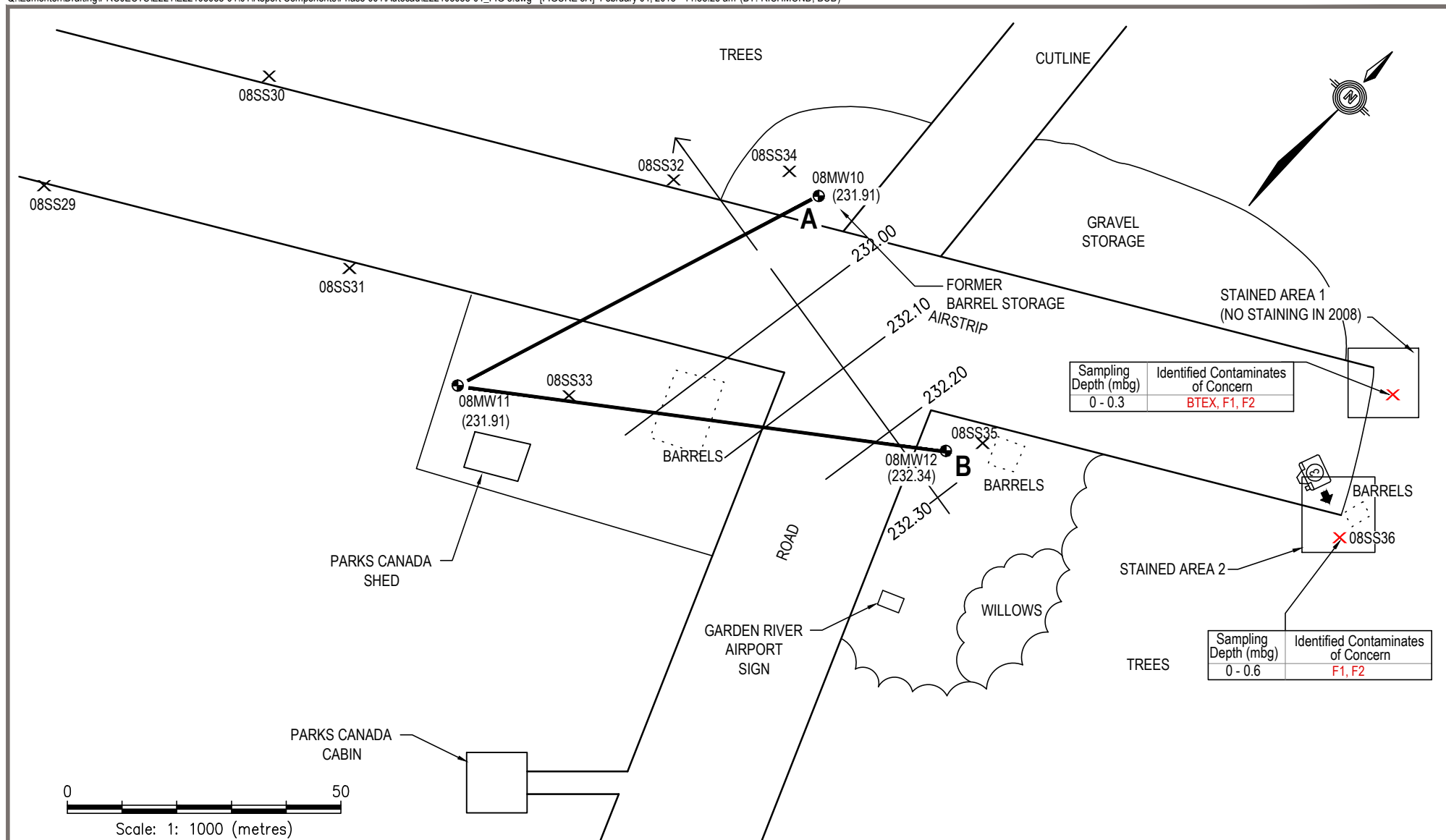
CKD  
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EDM

DATE  
January 2013

**Figure 2**



#### LEGEND:

- 08MW## - MONITORING WELL LOCATION
- × 08SS## - SHALLOW SOIL SAMPLE LOCATION
- (###.##) - GROUNDWATER ELEVATION
- ###.## - GROUNDWATER ELEVATION CONTOUR
- - INTERPRETED LOCAL GROUNDWATER FLOW DIRECTION



- PHOTO DIRECTION AND NUMBER



- RED INDICATES SOIL EXCEEDED THE APPLICABLE GUIDELINE

#### NOTES

MONITORING WELL LOCATIONS ARE ON SCALE AND OTHER FEATURES ON THE DRAWING ARE NOT TO SCALE  
ALL INFORMATION FROM EBA, 2009

CLIENT

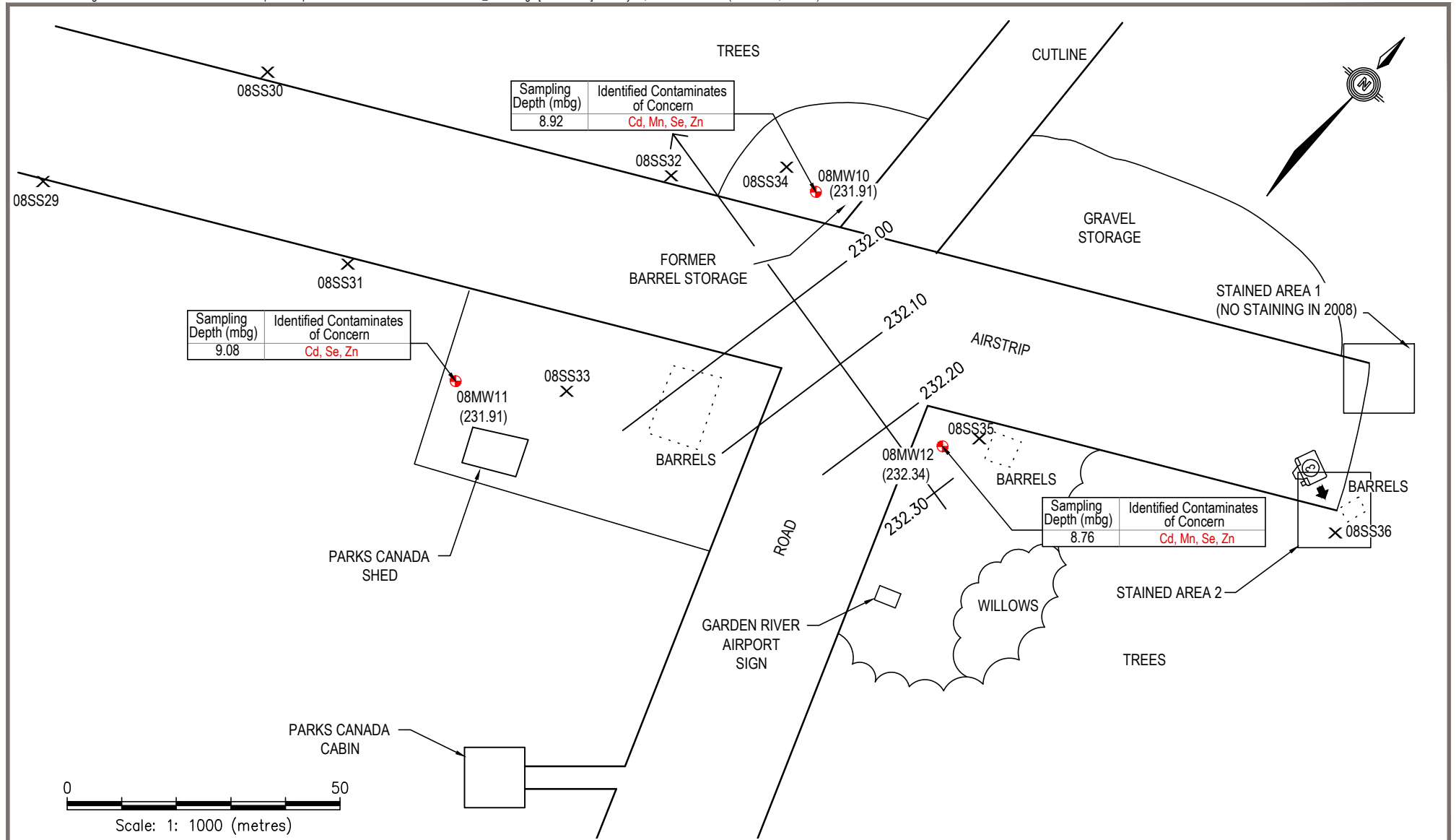
Parks Canada Agency



GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB

#### COMMUNITY AIRSTRIP SITE PLAN SHOWING SOIL EXCEEDANCES

PROJECT NO. E22103088-01	DWN TK	CKD JM	REV 0	Figure 3a
OFFICE EDM	DATE February 2013			



**LEGEND:**

- 08MW## - MONITORING WELL LOCATION
- × 08SS## - SHALLOW SOIL SAMPLE LOCATION
- (###.##) - GROUNDWATER ELEVATION
- ###.##— - GROUNDWATER ELEVATION CONTOUR
- - INTERPRETED LOCAL GROUNDWATER FLOW DIRECTION



- PHOTO DIRECTION AND NUMBER



- RED INDICATES GROUNDWATER EXCEEDED THE APPLICABLE GUIDELINE

**NOTES**

MONITORING WELL LOCATIONS ARE ON SCALE AND OTHER FEATURES ON THE DRAWING ARE NOT TO SCALE

CLIENT

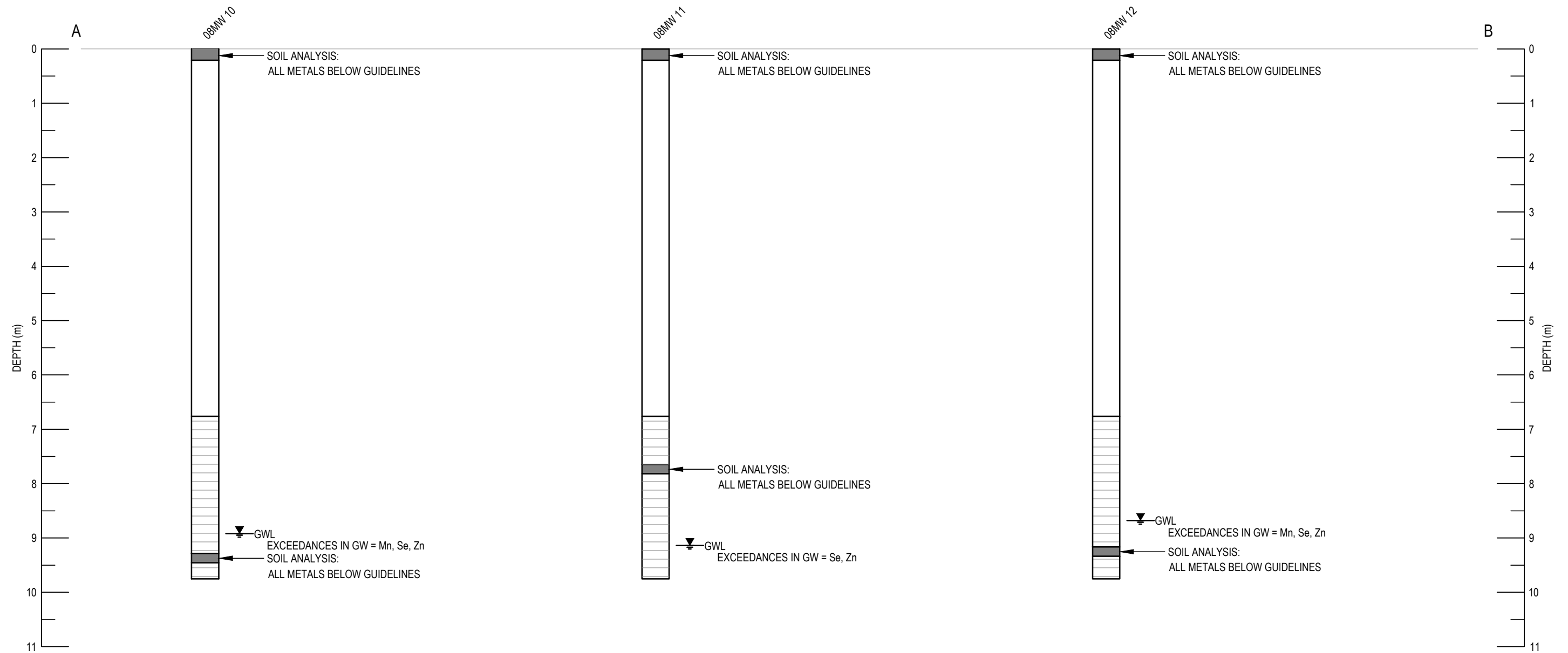
**Parks Canada Agency**





**GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB**

**COMMUNITY AIRSTRIP SITE PLAN SHOWING  
GROUNDWATER EXCEEDANCES**

PROJECT NO. E22103088-01	DWN TK	CKD JM	REV 0	<b>Figure 3b</b>
OFFICE EDM	DATE January 2013			



LEGEND:

-  - SOIL SAMPLE  
 - MONITORING WELL SCREEN

DRAWING NOT TO SCALE

	CLIENT
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Parks Canada Agency



**GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD  
LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB**

**DETAILS OF GROUNDWATER MONITORING WELL PROFILE  
SHOWING SOIL AND GROUNDWATER EXCEEDANCES  
(COMMUNITY AIRSTRIP)**

PROJECT NO.	E22103088-01
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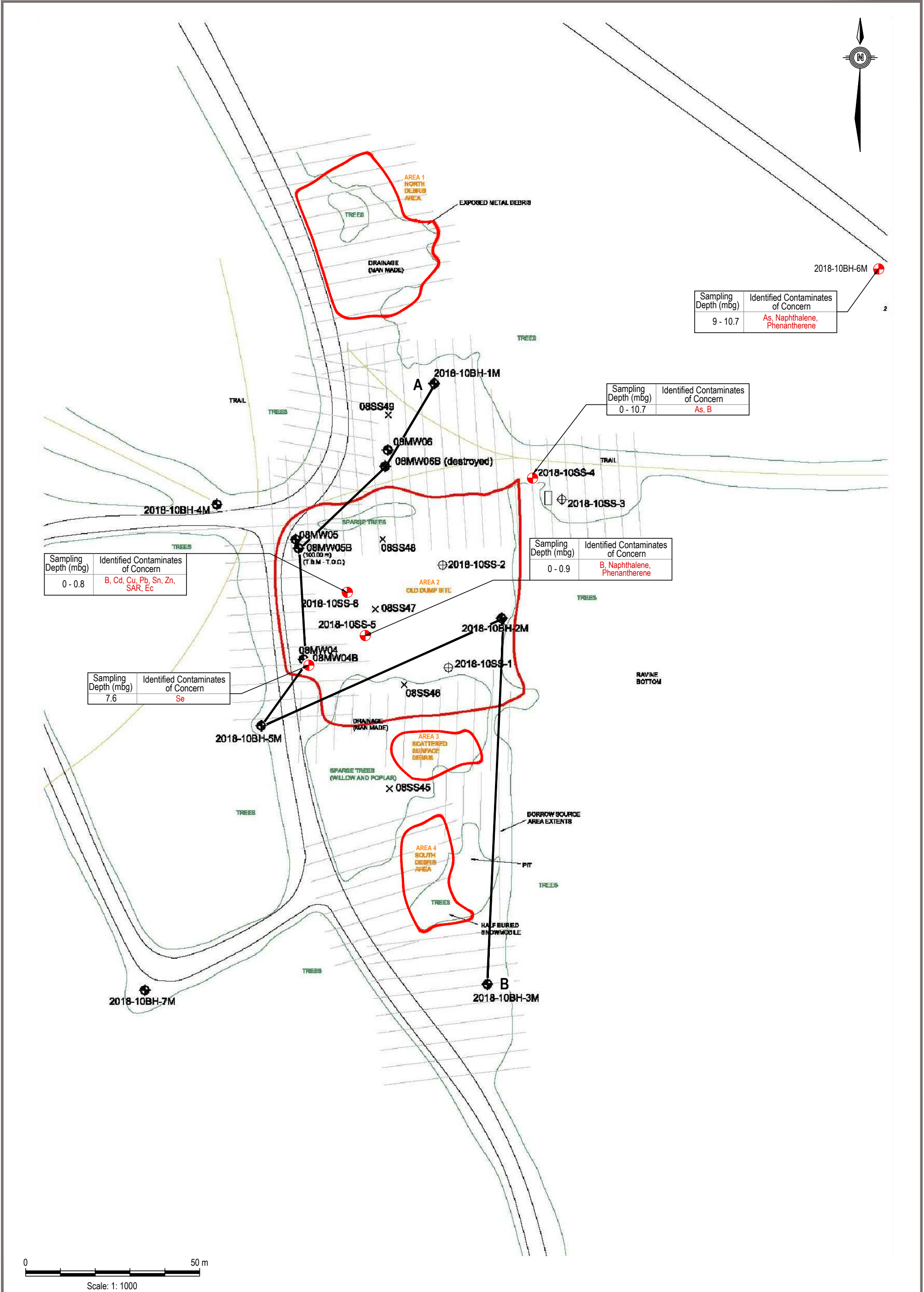
	DWN
	BR/TK

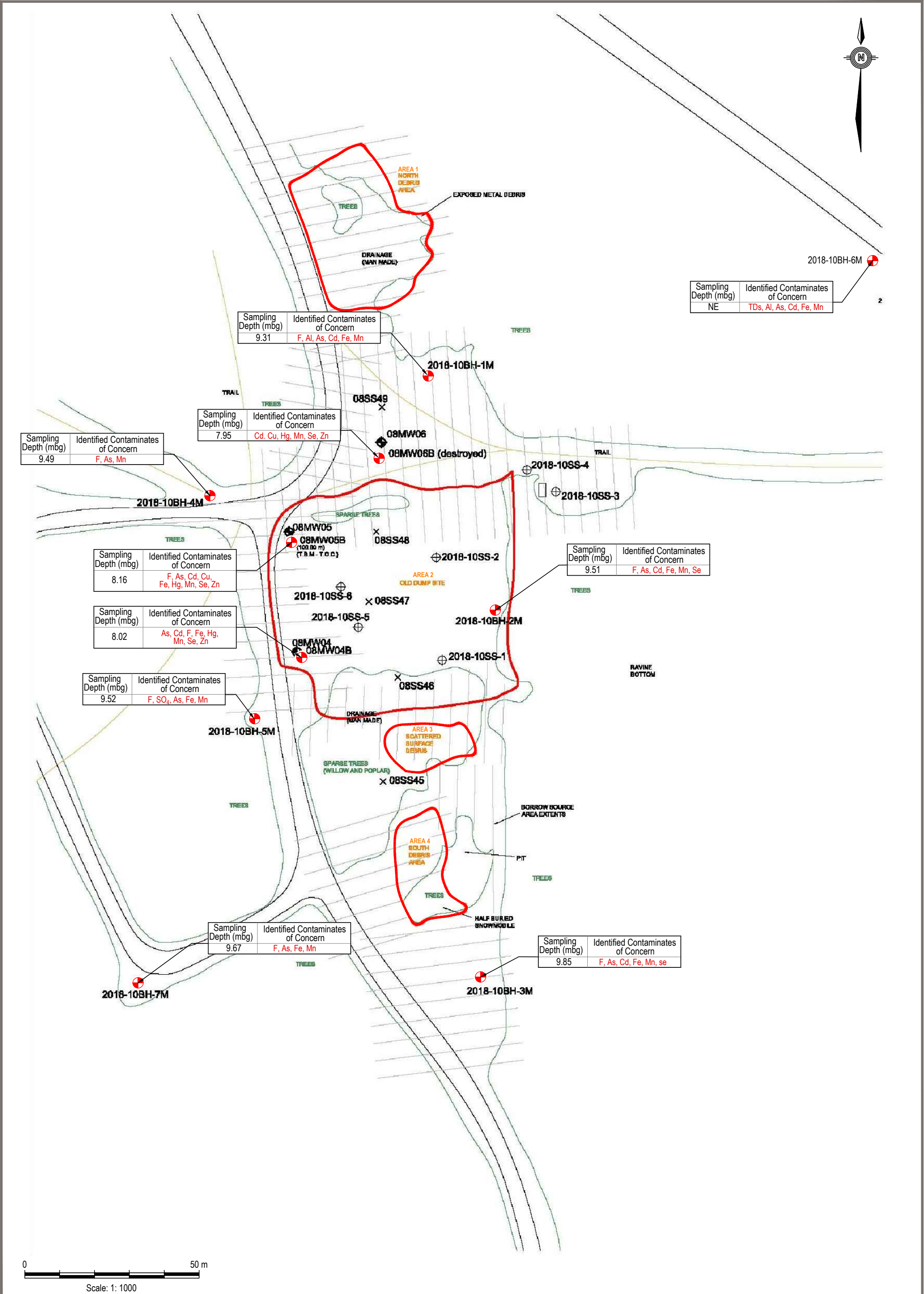
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JM

OFFICE  
EDM

DATE	February 2013
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**Figure 3c**





Sampling Depth (mbg)	Identified Contaminates of Concern
NE	TDs, Al, As, Cd, Fe, Mn

Sampling Depth (mbg)	Identified Contaminates of Concern
9.49	F, As, Mn

Sampling Depth (mbg)	Identified Contaminates of Concern
7.95	Cd, Cu, Hg, Mn, Se, Zn

Sampling Depth (mbg)	Identified Contaminates of Concern
8.16	F, As, Cd, Cu, Fe, Hg, Mn, Se, Zn

Sampling Depth (mbg)	Identified Contaminates of Concern
8.02	As, Cd, F, Fe, Hg, Mn, Se, Zn


Sampling Depth (mbg)	Identified Contaminates of Concern
9.52	F, SO <sub>4</sub> , As, Fe, Mn

Sampling Depth (mbg)	Identified Contaminates of Concern
9.51	F, As, Cd, Fe, Mn, Se

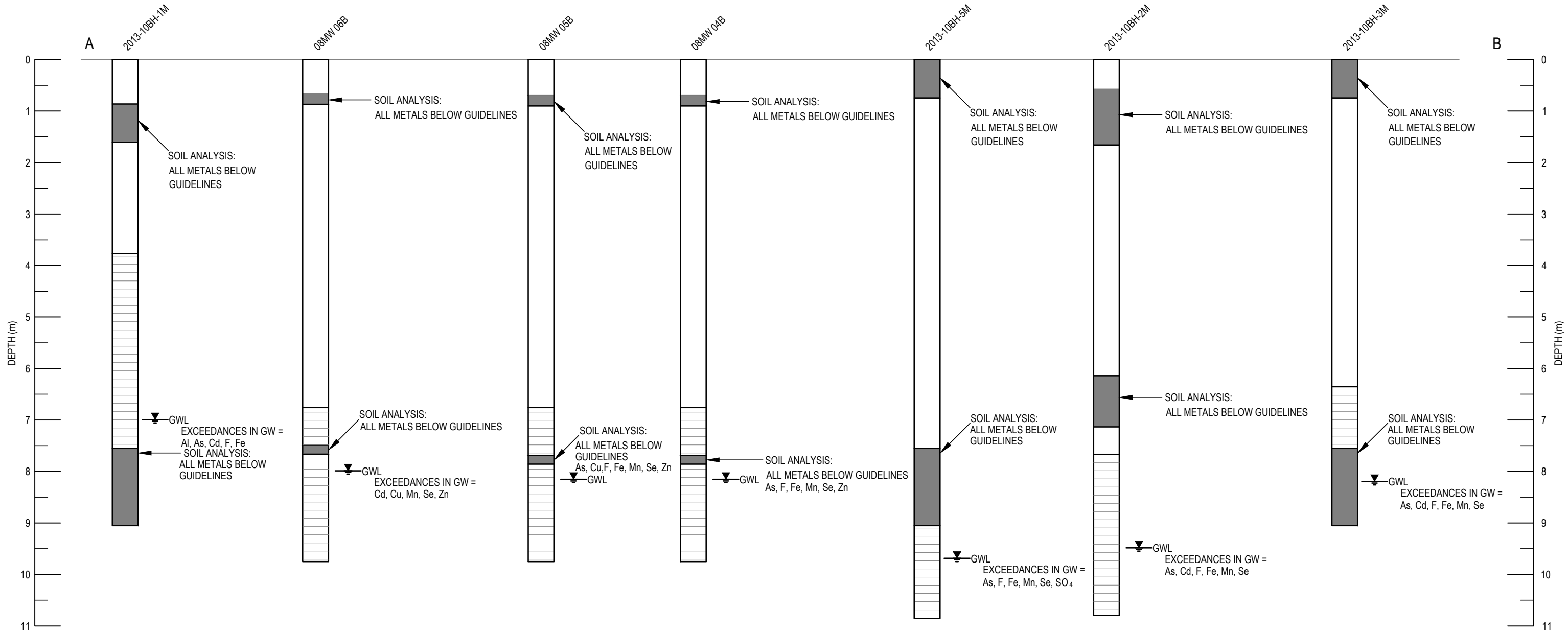
Sampling Depth (mbg)	Identified Contaminates of Concern
9.67	F, As, Fe, Mn

Sampling Depth (mbg)	Identified Contaminates of Concern
9.85	F, As, Cd, Fe, Mn, se

- LEGEND:
- AREA OF CONCERN
  - TREE LINE
  - TRAILS
  - RED INDICATES GROUNDWATER EXCEEDED THE APPLICABLE GUIDELINE
  - INCINERATOR
  - MONITORING WELL
  - BOREHOLE
  - SURFACE SOIL SAMPLE

CLIENT		GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS GARDEN RIVER, AB				
Parks Canada Agency		OLD LANDFILL SITE PLAN SHOWING GROUNDWATER EXCEEDANCES				
		PROJECT NO. E22103088-01	DWN TK	CKD JM	REV 0	Figure 4b
		OFFICE EDM	DATE January 2013			

Q:\Edmonton\Drafting\PROJECTS\E221\E22103088-01\Report Components\Phase 001\Autocad\E22103088-01\_FIG 4.dwg [FIGURE 4C] February 04, 2013 - 11:58:52 am (BY: RICHMOND, BOB)



LEGEND:  
- SOIL SAMPLE  
- MONITORING WELL SCREEN

DRAWING NOT TO SCALE

CLIENT  
**Parks Canada Agency**



**GARDEN RIVER, ALBERTA COMMUNITY AIRSTRIP AND OLD LANDFILL REPORTS REVIEW AND REMEDIAL OPTIONS ANALYSIS  
GARDEN RIVER, AB**  
**DETAILS OF GROUNDWATER MONITORING WELL PROFILE  
SHOWING SOIL AND GROUNDWATER EXCEEDANCES  
(OLD LANDFILL)**

PROJECT NO. E22103088-01	DWN BR/TK	CKD JM	REV 0
OFFICE EDM	DATE January 2013		

Figure 4c

# APPENDIX A

## INFORMATION FROM THE PREVIOUS REPORTS

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Parameter <sup>a</sup>	Material Type			
	Topsoil (A horizon)		Subsoil (B horizon)	
Value	Random	Value	Random	
EC (dS/m)	<4	<3	Good	
SR	<4	<4	Good	

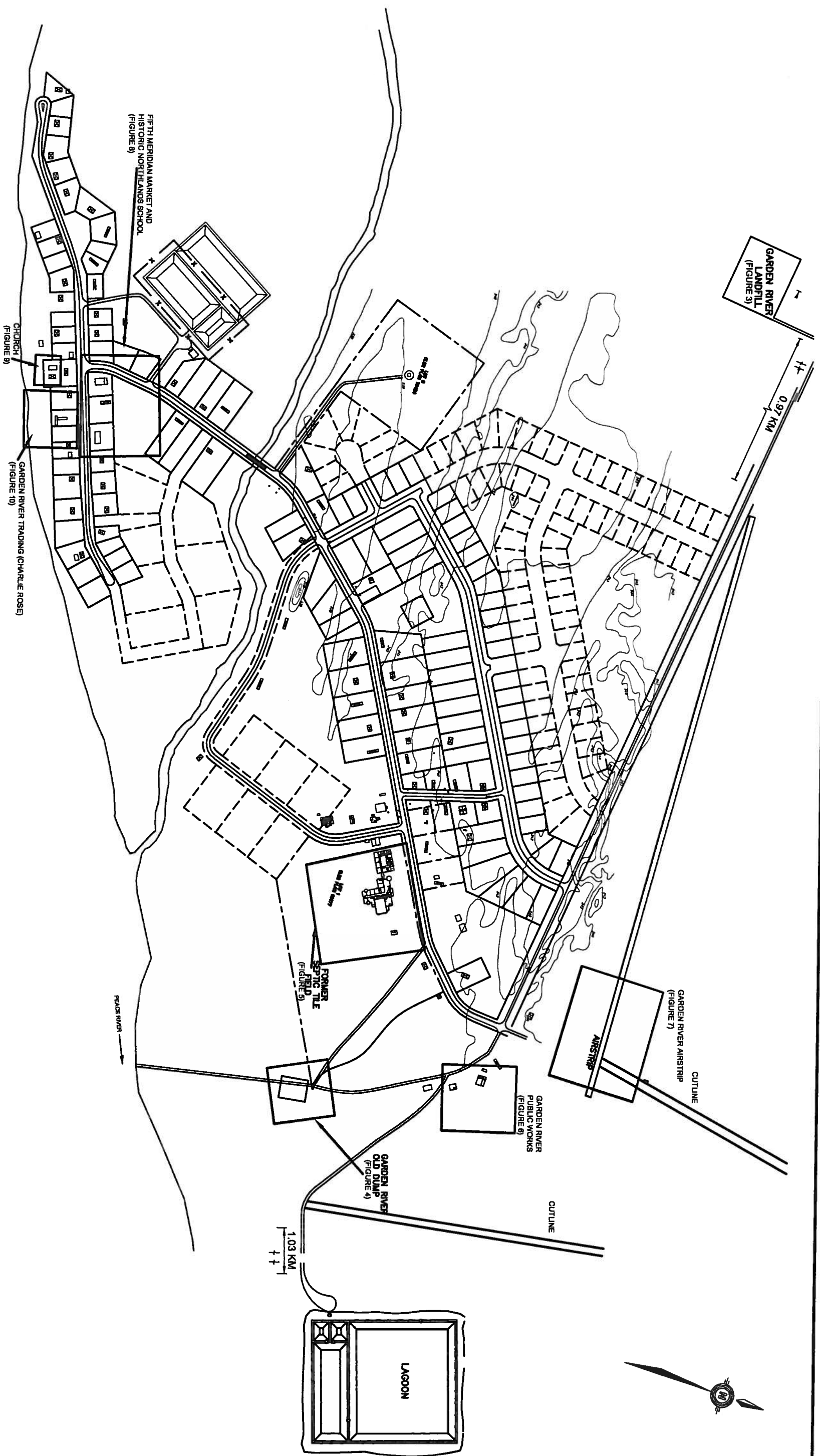
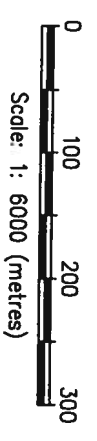
TABLE 2: GROUNDWATER MONITORING RESULTS														
Monitoring Well ID	Borehole Depth (mbg)	Ground Surface Elevation (m)	Top of Casing (TOC) Elevation (m)	Height of Stickup (m)	Slotted Interval (mBG)		Groundwater levels (mBTOC)	Groundwater levels (mbg)	Groundwater levels (mBTOC)	Groundwater levels (mbg)	Slotted Interval Elevation		Groundwater Elevation* (m)	Groundwater Elevation* (m)
					Top (m)	Bottom (m)	21-Mar-08		29-Aug-08		Top (m)	Bottom (m)	21-Mar-08	29-Aug-08
Garden River Landfill														
08MW01	11.3	241.37	242.29	0.92	8.2	11.3	10.06	9.14	10.58	9.66	233.17	230.07	232.23	231.71
08MW02	6.7	240.73	241.87	1.14	3.7	6.7	7.01	5.87	7.01	5.87	237.03	234.03	234.86	234.86
08MW03	11.3	241.38	242.47	1.09		11.3	10.68	9.59	10.66	9.57			231.79	231.81
Garden River Old Dump														
08MW04	6.1	238.84	240.03	1.19	3.1	6.1	dry	dry	dry	dry	235.74	232.74	dry	dry
08MW04B	9.8	238.88	240.16	1.29	6.7	9.8	9.28	8.00	9.31	8.02	232.18	229.08	230.88	230.85
08MW05	6.1	239.09	240.31	1.22	3.1	6.1	dry	dry	dry	dry	235.99	232.99	dry	dry
08MW05B	9.8	239.07	240.27	1.20	6.7	9.8	9.34	8.14	9.35	8.16	232.37	229.27	230.93	230.92
08MW06	8.4	239.06	240.34	1.28	6.4	8.4	dry	dry	9.27	7.99	232.66	230.66	dry	dry
08MW06B	9.8	238.95	240.29	1.34	6.7	9.8	9.32	7.98	9.29	7.95	232.25	229.15	230.97	231.00
Former Septic Tile Field														
08MW07	6.1	239.12	239.00	-0.12	3.1	6.1	dry	dry	5.87	5.99	236.02	233.02	dry	dry
08MW07B	9.2	239.21	239.04	-0.17	6.1	9.2	7.85	8.03	7.85	8.02	233.11	230.01	231.19	231.19
08MW08	9.8	239.33	239.22	-0.11	6.7	9.8	8.10	8.21	8.01	8.13	232.63	229.53	231.12	231.20
08MW09	9.2	239.14	239.03	-0.11	6.1	9.2	7.89	8.00	damaged	damaged	233.04	229.94	231.14	#VALUE!
Garden River Airstrip														
08MW10	9.8	240.87	242.08	1.20	6.7	9.8	10.16	8.96	10.12	8.92	234.17	231.07	231.91	231.95
08MW11	9.8	240.98	242.26	1.27	6.7	9.8	10.35	9.08	10.35	9.08	234.28	231.18	231.91	231.90
08MW12	9.8	241.33	242.57	1.24	6.7	9.8	10.23	8.99	10.00	8.76	234.63	231.53	232.34	232.57
Garden River Trading (Charlie Rose)														
08MW14	10.1	235.73	235.62	-0.11	6.9	9.9			9.07	9.19	228.83	225.83		226.55
Fifth Meridian Market														
08MW16	9.9	236.50	236.39	-0.10	6.9	9.9			9.21	9.31	229.60	226.60		227.18
08MW18	9.9	235.99	235.91	-0.08	6.9	9.9			8.96	9.04	229.09	226.09		226.94
Garden River Public Works														
08MW20	11.4	240.72	240.66	-0.06	8.4	11.4			9.16	9.22	232.32	229.32		231.50
08MW21	9.8	240.19	240.13	-0.06	6.9	9.9			8.60	8.67	233.29	230.29		231.52
08MW22	9.7	240.17	240.06	-0.10	6.9	9.9			8.54	8.64	233.27	230.27		231.52
08MW23	9.9	239.82	239.76	-0.06	6.9	9.9			8.41	8.47	232.92	229.92		231.34
Notes:														
mbg - Metres beneath ground level.														
mBTOC - Metres below top of casing.														
Blank cell - No data.														
<b>Bold</b> - Groundwater elevation is above the screen elevation.														







LEGEND:  
--- FENCE  
--- ROAD



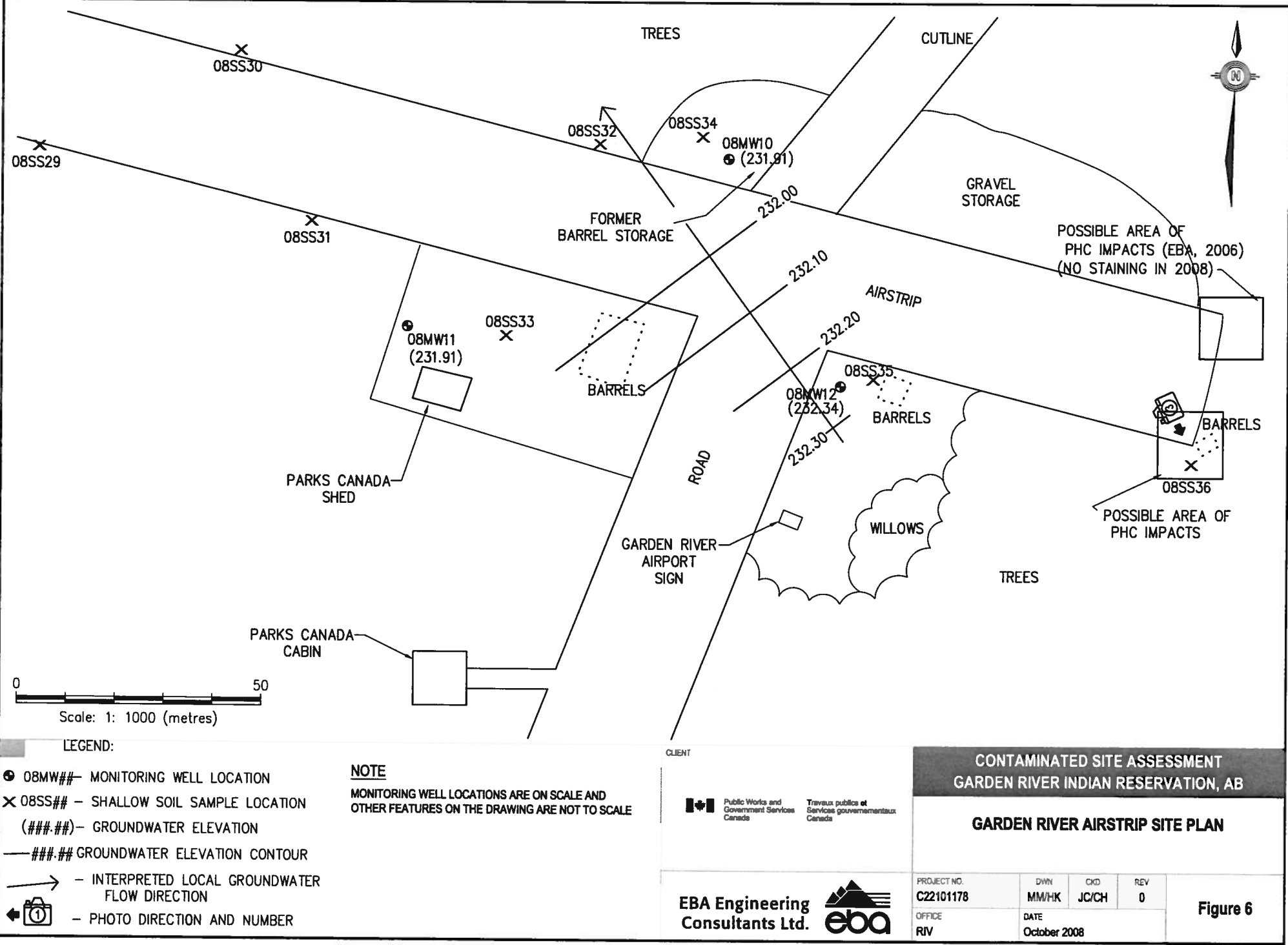
CLIENT  
Public Works and  
Government Services  
Canada  
Territorial Public and  
Service Government  
Canada

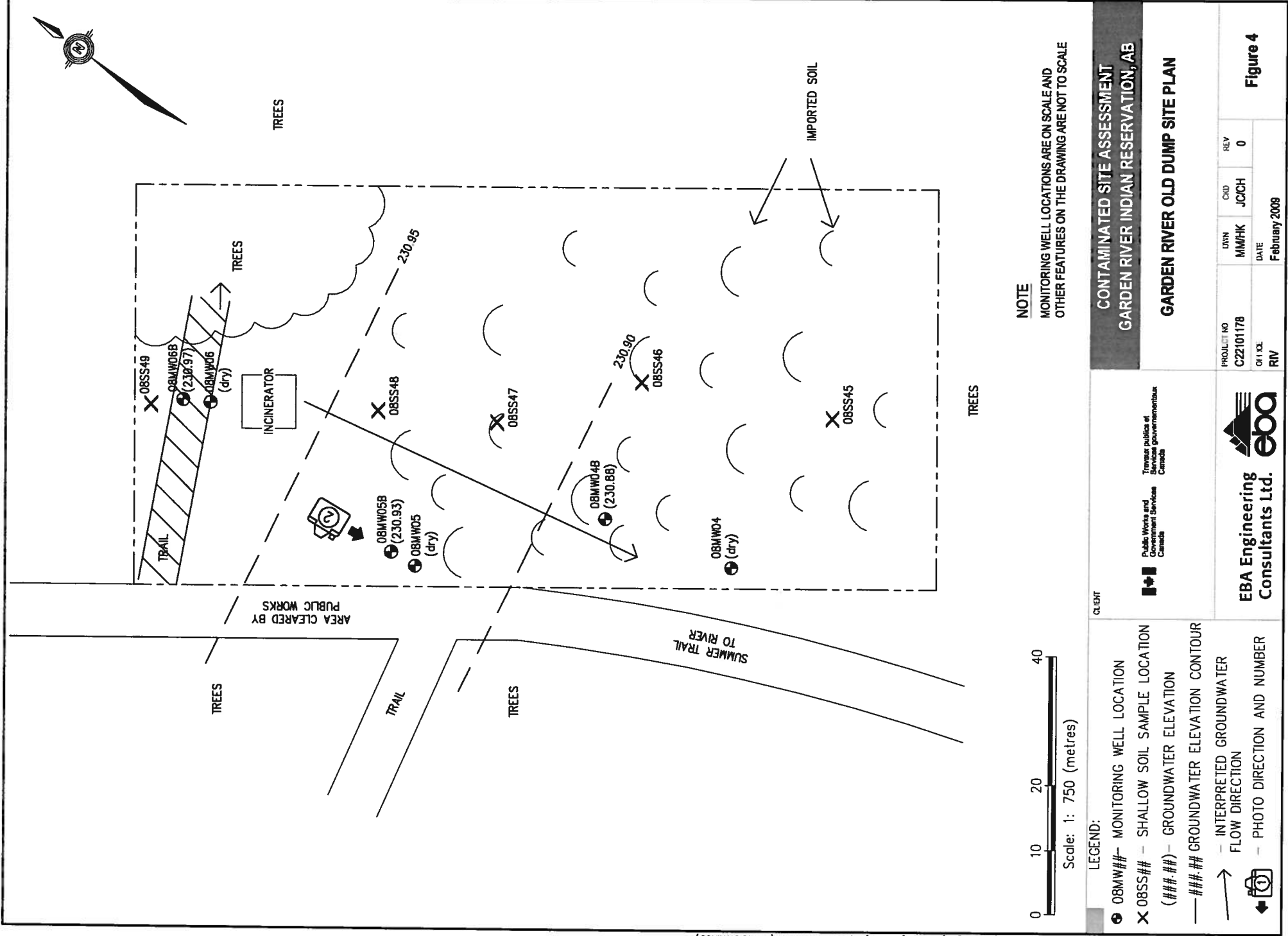
EBA Engineering  
Consultants Ltd.  
EBO

CONTAMINATED SITE ASSESSMENT  
GARDEN RIVER INDIAN RESERVATION, AB

SITE PLAN SHOWING ASSESSMENT AREAS

PROJECT NO	DWN	CHK	REV	Figure 2
C22101178	RH/K	JCH	0	
DATE				
RV	February 2009			





\\eba.local\corp\fr\riverend\Drawings\C221178\BA\06\CAD\C221178-Figs-3-10.dwg [FIGURE 4] February 13, 2009 - 10:40:00 am (BY: TKGSTTKIRIOS)



**Photo 1**  
Garden River Landfill looking northeast from 08SS26 (August 26, 2008).



**Photo 2**  
Garden River Old Dump looking south towards 08MW05 area (August 26, 2008)





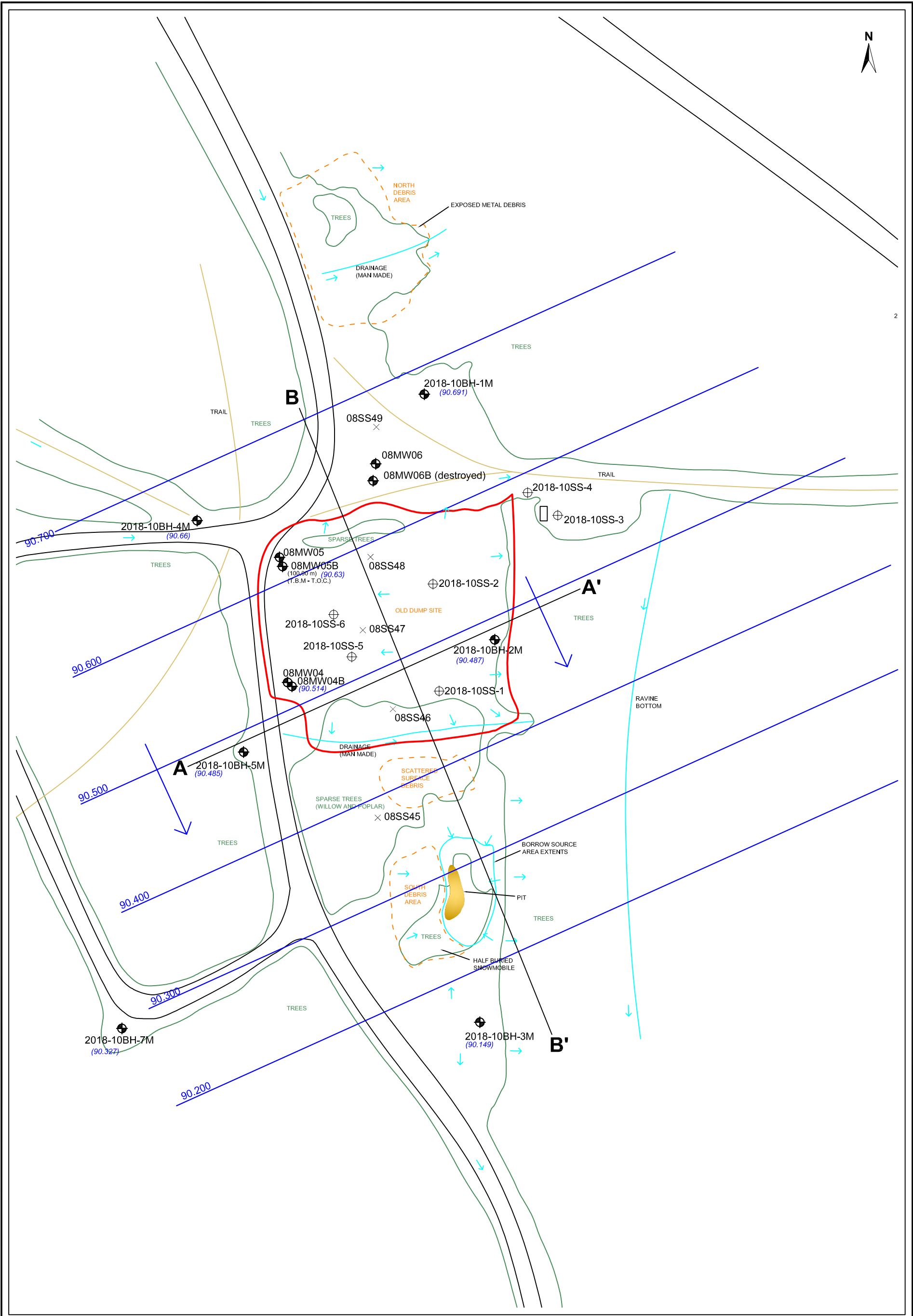
**Photo 3**  
Garden River Airstrip looking east-southeast at 08SS36 (August 26, 2008).



**Photo 4**  
Garden River Public Works yard looking northeast from 08MW20 (August 26, 2008)



Title:		<b>SITE LOCATION</b>	
Project:		DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP	
Client:		PARKS CANADA AGENCY	
 		Date:	JANUARY 2011
		<b>FIGURE 1</b>	



**LEGEND**

Site Boundary

Treeline

Trails

Area of Debris

Incinerator

Monitoring Well

Borehole

Surface Soil Sample

Inferred Groundwater Equipotential Line

Inferred Groundwater Flow Direction

322.0

Groundwater Elevation \*

Surfacewater Flow Direction

Drainage Ditch

A — A'

Cross Section Line

Note:

\* Units relative to a temporary bench mark (TBM) of 100m for 08MW05B. All other elevations are relative to this.

Scale 1:1,000

20

15

10

0

10

20

metres

Title:	<b>INVESTIGATION LOCATIONS AND SITE FEATURES</b>	
Project:	<b>DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP</b>	
Client:	<b>PARKS CANADA AGENCY</b>	
Date:	<b>FEBRUARY 2011</b>	
<b>FIGURE 2</b>		

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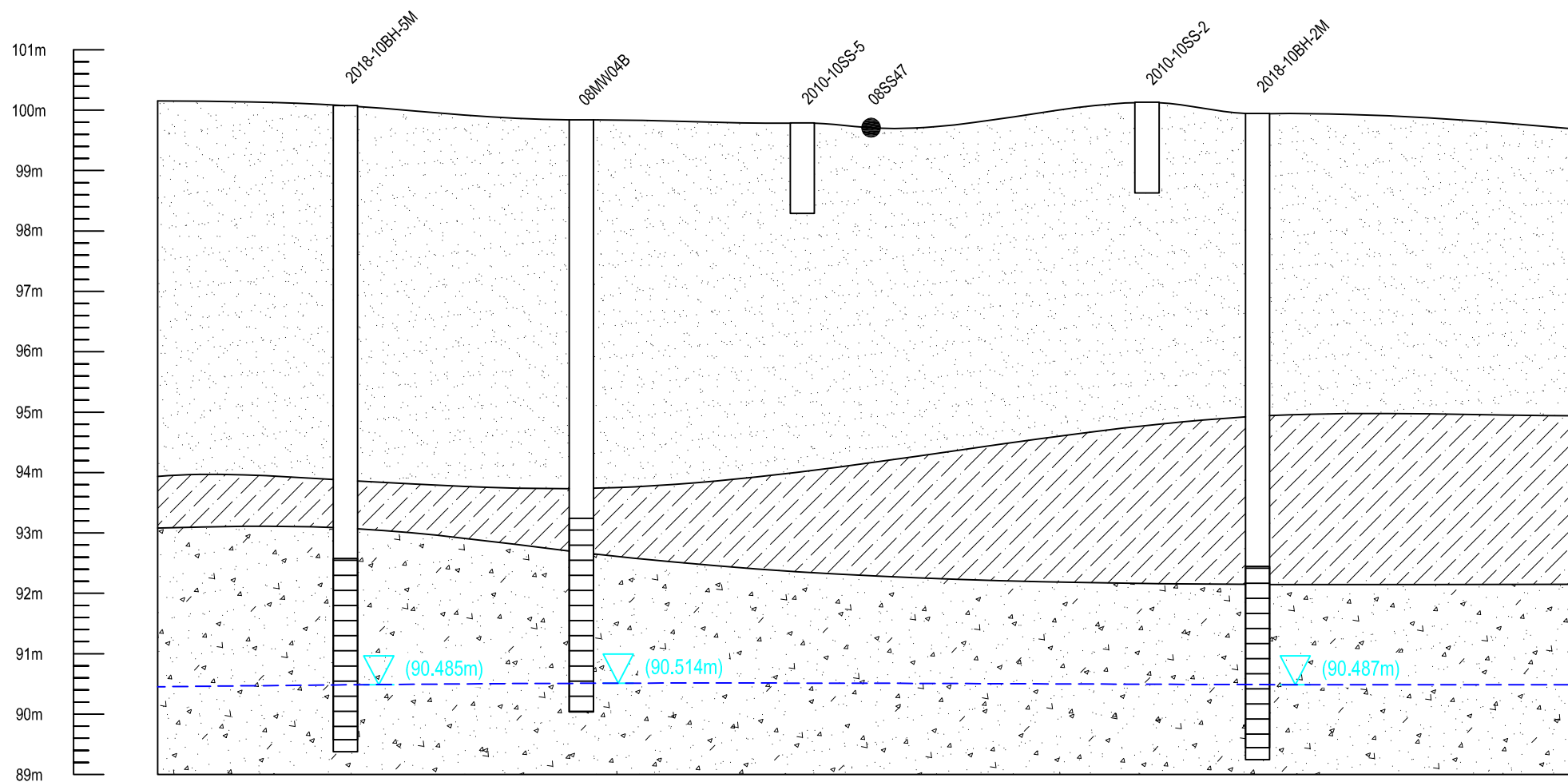
2018-1001 ParksCanada - Garden River Old Dump/CAD/NR/Garden River.dwg

A Southwest

A' Northeast

Vertical Scale 1:100

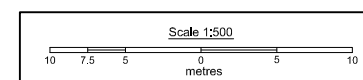
Exaggeration = 5



LEGEND

- Sandy Silt
- Clayey Silt
- Sand and Gravel
- Groundwater Table
- Water Level
- Screen
- Surface Soil Sample

Note:  
\* Units relative to a temporary bench mark (TBM) of 100m for 08MW05B. All other elevations are relative to this.

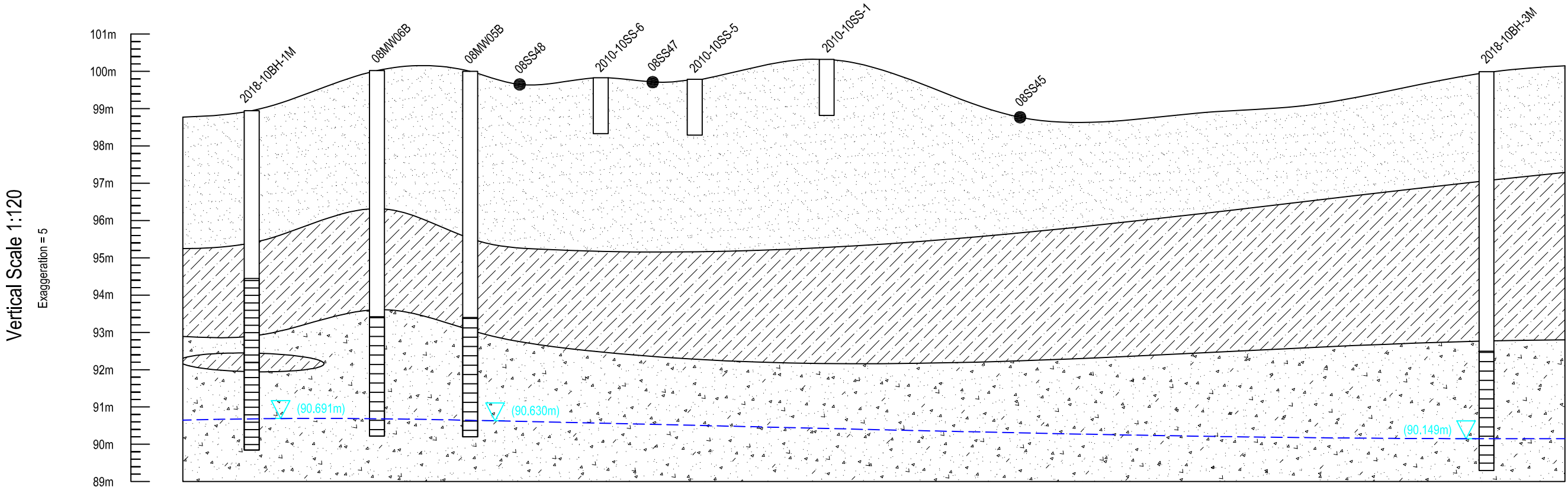


Title:	CROSS SECTION A - A'
Project:	DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP
Client:	PARKS CANADA AGENCY
Date:	FEBRUARY 2011
	FIGURE 3



B Northwest

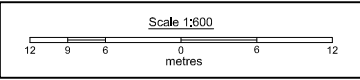
B' Southeast





LEGEND

- Sandy Silt
- Clayey Silt
- Sand and Gravel
- Groundwater Table
- Water Level
- Screen
- Surface Soil Sample

Note:  
\* Units relative to a temporary bench mark (TBM)  
of 100m for 08MW05B. All other elevations are  
relative to this.



Title:	<b>CROSS SECTION B - B'</b>	
Project:	<b>DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP</b>	
Client:	<b>PARKS CANADA AGENCY</b>	
 		Date: <b>FEBRUARY 2011</b>
		<b>FIGURE 4</b>



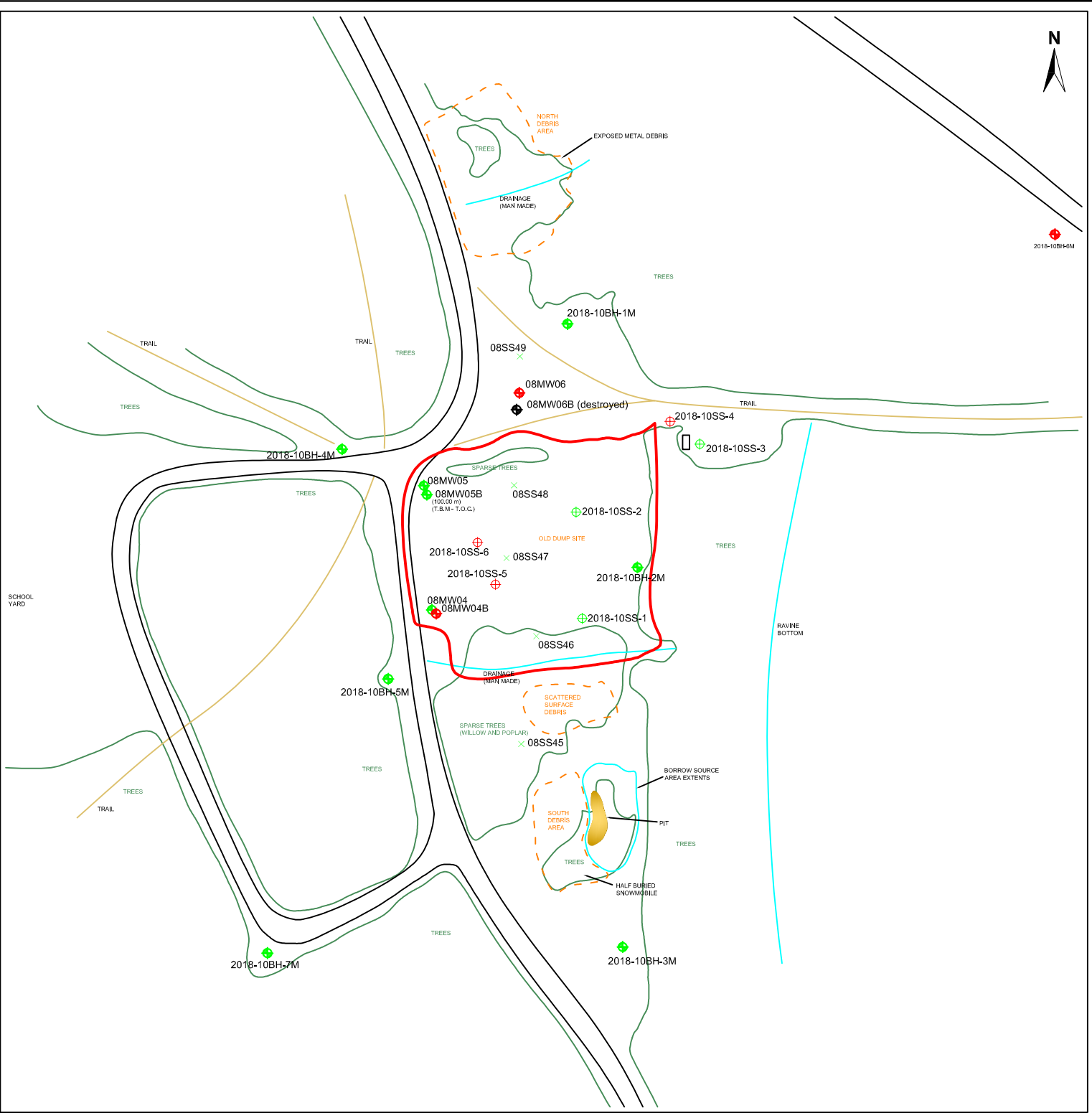




Station ID	Units	CCME AL Coarse	2018-10BH-5M		2018-10BH-6M		2018-10BH-7M		2018-10SS-1	2018-10SS-2	2018-10SS-3
Field label			2018-10BH-5M-1	2018-10BH-5M-7	2018-10BH-6M-1	2018-10BH-6M-8	2018-10BH-7M-1	2018-10BH-7M-7	2018-10SS-1	2018-10SS-2	2018-10SS-3
Duplicate ID											
Date			19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10
Consultant			Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz
Lab report ID			10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661
Depth (m)					0 - 0.5	7.7 - 9.0	0 - 0.5	9.0 - 10.7	0 - 0.5	7.7 - 9.0	0 - 0.75
Conventional											
Moisture content	%	-	6.30	10	23	18	14	18	11	12	14
pH		6 to 8	7.30	7.20	7.10	7.50	7.40	7.30	7.40	7.30	7.10
Metals											
Antimony	ug/g	20	0.80	1	1	1	1	1	1	1	1
Arsenic	ug/g	12	9.40	2	10	13	6	3	8	8	11
Barium	ug/g	750	165.00	79	272	56	228	79	241	222	204
Boron (Hot water extraction)	ug/g	2	0.50	0.50	0.60	0.50	0.50	0.50	0.90	0.50	0.50
Beryllium	ug/g	4	0.50	1	1	1	1	1	1	1	1
Cadmium	ug/g	1.4	0.50	1	1	1	1	1	1	1	1
Chromium	ug/g	64	17.10	4	22	7	12	7	18	29	27
Chromium (VI)	ug/g	0.4	0.30	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Cobalt	ug/g	40	7.90	2	11	6	6	4	8	7	10
Copper	ug/g	63	23.40	3	25	7	12	6	26	22	20
Lead	ug/g	70	9.40	2	12	5	6	3	14	15	12
Mercury	ug/g	6.6	0.50	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Molybdenum	ug/g	5	1.30	1	2	1	1	1	1	1	1
Nickel	ug/g	50	28.10	6	31	15	18	11	25	24	28
Selenium	ug/g	1	0.50	0.5	0.8	0.5	0.5	0.5	0.60	0.50	0.70
Silver	ug/g	20	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Thallium	ug/g	1	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Tin	ug/g	5	0.50	0.50	0.50	0.50	0.50	0.50	2.20	2.50	0.50
Uranium	ug/g	23	0.9	0.5	0.9	0.6	0.8	0.5	0.9	0.9	1.1
Vanadium	ug/g	130	30.70	7	35	13	23	12	29	29	43
Zinc	ug/g	200	86.00	17	94	47	60	31	102	99	88

Station ID	Units	CCME AL Coarse	2018-10SS-4	2018-10SS-5	2018-10SS-6
Field label			2018-10SS-4	2018-10SS-5	2018-10SS-6
Duplicate ID					
Date			19/Dec/10	19/Dec/10	19/Dec/10
Consultant			Franz	Franz	Franz
Lab report ID			0E461661	10E461661	10E461661
Depth (m)			0 - 0.75	0 - 0.9	0 - 0.8
Conventional					
Moisture content	%	-	15	19	19
pH		6 to 8	7.20	7.30	7.40
Metals					
Antimony	ug/g	20	2	2	19
Arsenic	ug/g	12	16	10	9
Barium	ug/g	750	259	343	154
Boron (Hot water extraction)	ug/g	2	3.20	4.30	3.70
Beryllium	ug/g	4	1	1	1
Cadmium	ug/g	1.4	1	1	5
Chromium	ug/g	64	23	25	47
Chromium (VI)	ug/g	0.4	0.3	0.3	0.3
Cobalt	ug/g	40	8	10	6
Copper	ug/g	63	48	38	409
Lead	ug/g	70	14	18	95
Mercury	ug/g	6.6	0.5	0.5	0.5
Molybdenum	ug/g	5	1	2	3
Nickel	ug/g	50	23	32	29
Selenium	ug/g	1	0.80	0.50	0.5
Silver	ug/g	20	0.50	0.50	0.50
Thallium	ug/g	1	0.50	0.50	0.50
Tin	ug/g	5	0.9	2.2	140
Uranium	ug/g	23	1.0	1.0	0.7
Vanadium	ug/g	130	32	40	24
Zinc	ug/g	200	190	152	3950

**Notes**  
"-" indicates that there is no applicable regulation or analyses were not performed.  
Red cells indicates parameter exceeds CCME AL Coarse.

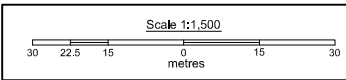




**LEGEND**

- Site Boundary
- Treeline
- Trails
- Area of Debris
- Incinerator
- Monitoring Well
- Borehole
- Surface Soil Sample
- Drainage Ditch

- One or more analytical parameters are greater than the applicable Soil Guidelines
- All analytical parameters are less than the applicable Soil Guidelines

\* Coloured stations represent most recent sampling date  
\*\*Black stations were not tested for parameters presented in current drawing



Title:	<b>ANALYTICAL RESULTS METALS IN SOIL</b>	
Project:	<b>DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP</b>	
Client:	<b>PARKS CANADA AGENCY</b>	
<div><div><div><b>FRANZ ENVIRONMENTAL INC.</b> <small>• CONSULTING • ENGINEERING • TECHNOLOGIES •</small></div><div><b>COLUMBIA ENVIRONMENTAL</b></div></div><div>Date: <b>FEBRUARY 2011</b></div><div><b>FIGURE 6-2</b></div></div>		

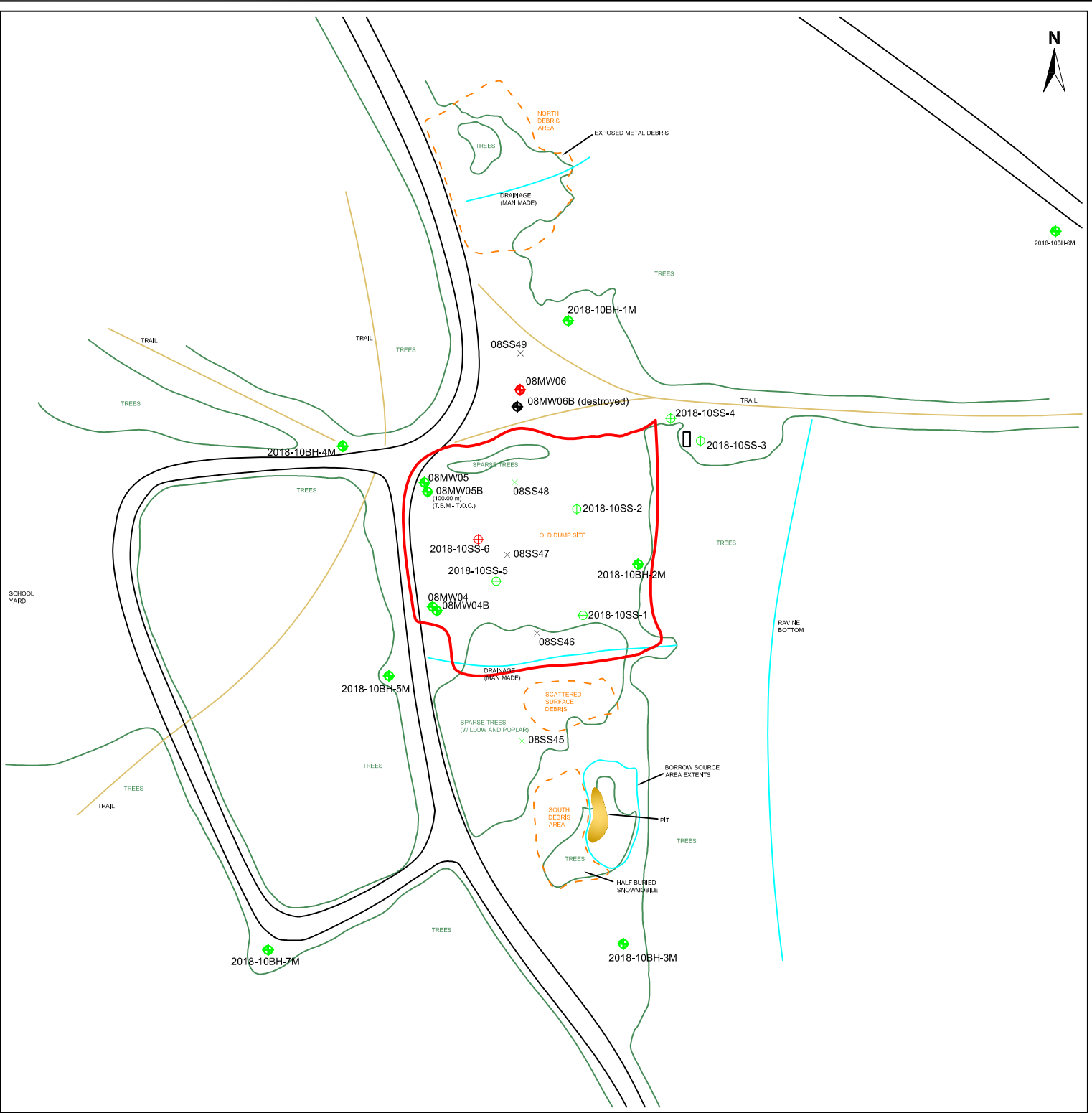






Station ID			2018-10BH-6M		2018-10BH-7M			2018-10SS-1	2018-10SS-2	2018-10SS-3	2018-10SS-4	2018-10SS-5	2018-10SS-6
Field label			2018-10BH-6M-1	2018-10BH-6M-8	2018-10BH-7M-1	2018-10BH-7M-7	2018-10BH-7M-8	2018-10SS-1	2018-10SS-2	2018-10SS-3	2018-10SS-4	2018-10SS-5	2018-10SS-6
Duplicate ID													
Date			19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10	19/Dec/10
Consultant			Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz	Franz
Lab report ID			10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661	10E461661
Depth (m)			0 - 0.5	9.0 - 10.7	0 - 0.5	7.7 - 9.0	9.0 - 10.7	0 - 0.75	0 - 0.75	0 - 0.75	0 - 0.75	0 - 0.9	0 - 0.8
Conventional													
Moisture content	%	-	23	18	14	18		11	12	14	15	19	19
Sieve Analysis <sup>1</sup> - 75 microns (wet)	%	-		84.9			98.2	20.9	13.4				29.5
Sieve Texture		-		Coarse			Coarse	Fine	Fine				Fine
Soil Salinity													
pH		6 to 8	7.10	7.50	7.40	7.30	-	7.40	7.30	7.10	7.20	7.30	7.40
Sodium Adsorption Ratio (SAR)	SAR	5	0.18	0.17	0.22	0.20	-	0.58	0.75	1.06	0.42	2.08	5.60
Elec. Cond.	dS/m	2	0.39	0.50	0.34	0.28	-	1.99	0.82	0.16	0.48	0.48	2.16
Saturation %	%	-	64.00	31.00	37.00	29.00	-	46.00	45.00	51.00	70.00	54.00	52.00
Chloride , Soluble	mg/L	-	7.00	25.00	8.00	9.00	-	231.00	60.00	7.00	29.00	49.00	1000.00
Calcium, Soluble	mg/L	-	60.00	72.00	47.00	32.00	-	295.00	94.00	140.00	66.00	366.00	641.00
Potassium, Soluble	mg/L	-	5.00	4.00	6.00	4.00	-	14.00	4.00	6.00	18.00	53.00	74.00
Magnesium, Soluble	mg/L	-	12.00	11.00	6.00	10.00	-	63.00	22.00	26.00	12.00	53.00	265.00
Sodium, Soluble	mg/L	-	6.00	6.00	6.00	5.00	-	42.00	31.00	8.00	14.00	37.00	258.00
Sulfate (S04-S), Soluble	mg/L	-	39.00	172.00	22.00	20.00	-	613.00	186.00	40.00	30.00	960.00	1780.00
Calcium, Soluble	ug/g	-	38.00	22.00	17.00	9.00	-	136.00	42.00	71.00	46.00	198.00	333.00
Chloride , Soluble (calc.)	ug/g	-	4.00	8.00	3.00	3.00	-	106.00	27.00	4.00	20.00	26.00	520.00
Magnesium, Soluble (calc.)	ug/g	-	8.00	3.00	2.00	3.00	-	29.00	10.00	13.00	8.00	29.00	138.00
Potassium, Soluble (calc.)	ug/g	-	3.00	2.00	2.00	2.00	-	6.00	2.00	3.00	13.00	29.00	38.00
Sodium, Soluble (calc.)	ug/g	-	4.00	2.00	2.00	2.00	-	19.00	14.00	4.00	10.00	20.00	134.00
Sulfate (S04-S), Soluble (calc.)	ug/g	-	25.00	53.00	8.00	6.00	-	282.00	84.00	20.00	21.00	518.00	926.00
Glycols													
Diethylene glycol	ug/g	-	10	10	10	10	-	10	10	10	10	10	10
Ethylene glycol	ug/g	960	10	10	10	10	-	10	10	10	10	10	10
Propylene glycol	ug/g	-	10	10	10	10	-	10	10	10	10	10	10
Tetraethylene glycol	ug/g	-	10	10	10	10	-	10	10	10	10	10	10
Triethylene glycol	ug/g	-	10	10	10	10	-	10	10	10	10	10	10

**Notes**  
1 Value reported is amount of sample retained on sieve after wash with water and represents proportion by weight particles larger than indicated sieve size.  
\*- indicates that there is no applicable regulation or analyses were not performed.  
Red cells indicates parameter exceeds CCME AL Coarse.

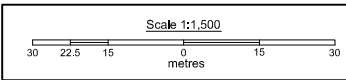


**LEGEND**

- Site Boundary
- Treeline
- Trails
- Area of Debris
- Incinerator
- Monitoring Well
- Borehole
- Surface Soil Sample
- Drainage Ditch

- One or more analytical parameters are greater than the applicable Soil Guidelines
- All analytical parameters are less than the applicable Soil Guidelines

\* Coloured stations represent most recent sampling date  
\*\*Black stations were not tested for parameters presented in current drawing



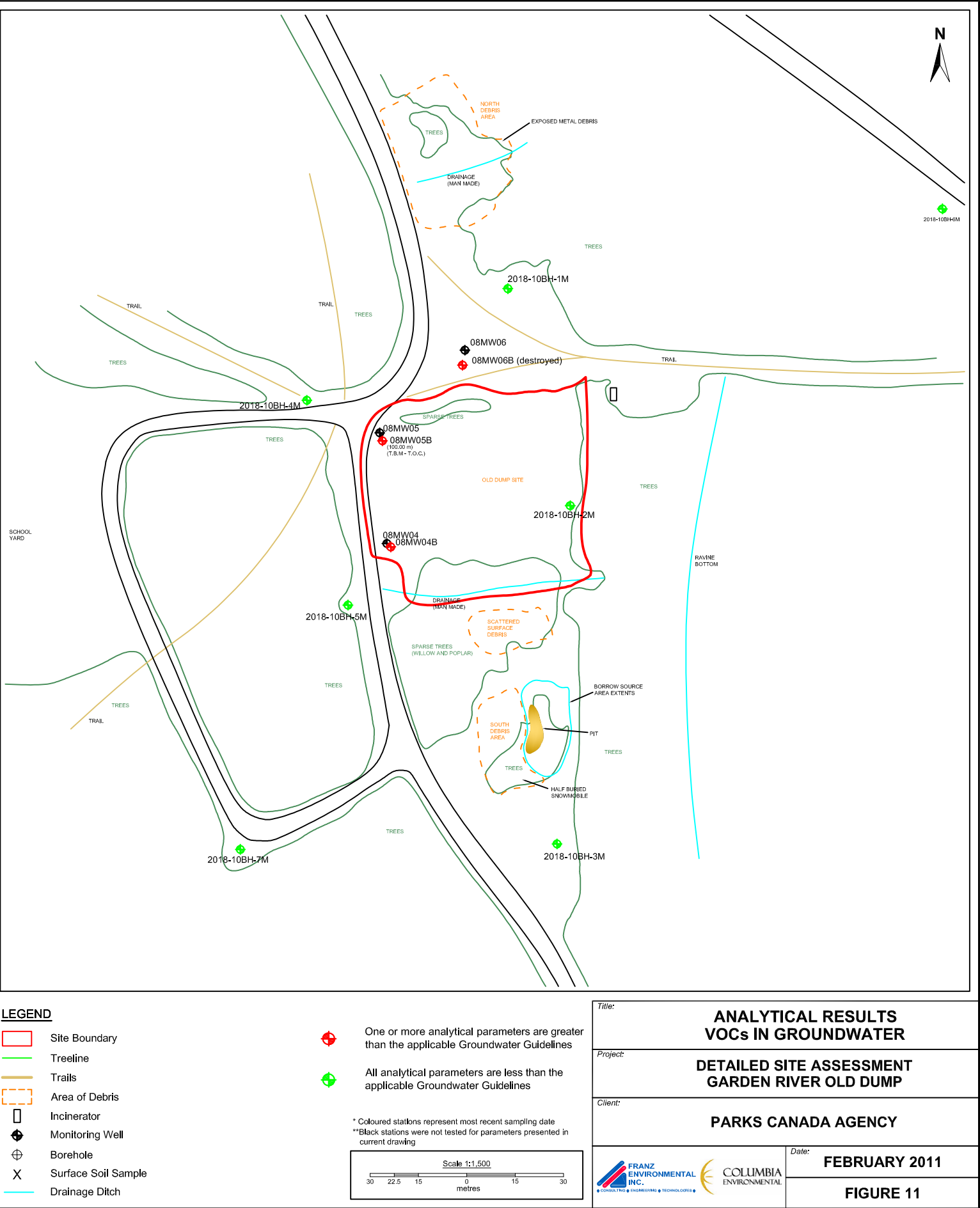
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Project:	<b>DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP</b>	
Client:	<b>PARKS CANADA AGENCY</b>	
Date:	<b>FEBRUARY 2011</b>	
	<b>FIGURE 8-2</b>	





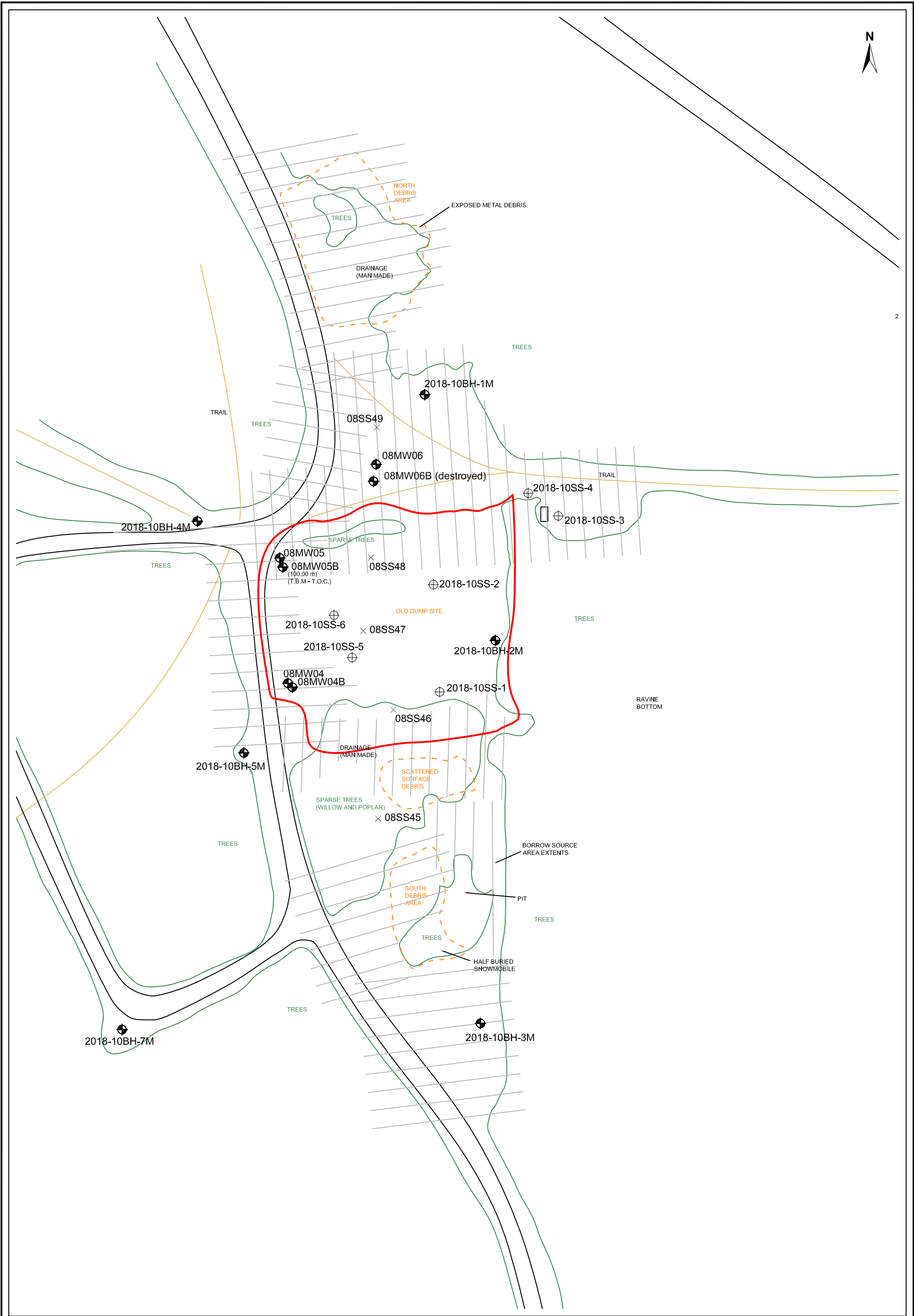


Station ID	CAS #	Units	FCSAP Tier 1 Interim GW Guidelines for AL	Health Canada Drinking Water Guidelines	08MW/04B		08MW/05B		08MW/06B	2018-10BH-1M
Field label					018 MW04B	018 MW04B	018 MW05B	018 MW05B	018MW06B	2018-10BH-1
Duplicate ID										
Date					29/Aug/08	18/Dec/10	29/Aug/08	18/Dec/10	29/Aug/08	17/Dec/10
Consultant					EBA	Franz	EBA	Franz	EBA	Franz
Lab report ID					L676397	10E 461661	L676397	10E 461661	L676397	10E 461661
<b>Volatile Organic Compounds</b>										
Bromodichlorom ethane	75-27-4	ug/L	67 000	16	-	<1	-	<1	-	<1
Bromoform	75-25-2	ug/L	840 (coarse), 5200 (fine)	100	-	<1	-	<1	-	<1
Bromom ethane	74-83-9	ug/L	2 (coarse), 16 (fine)	-	-	<1	-	<1	-	<1
Carbon tetrachloride	56-23-5	ug/L	0.56 (coarse) 5 (fine)	5	<1.0	<0.5	<1.0	<0.5	<1.0	<0.5
Chlorobenzene	108-90-7	ug/L	1.3	30	<1	<1	<1	<1	<1	<1
Chlorodibromom ethane	124-48-1	ug/L	100	100	-	<1	-	<1	-	<1
Chloroethane	75-00-3	ug/L	-	-	-	<1	-	<1	-	<1
Chloroform	67-66-3	ug/L	1.8	-	<1	<1	<1	<1	<1	<1
Chloromethane	74-87-3	ug/L	Insufficient data	-	-	<1	-	<1	-	<1
1,2-Dichlorobenzene	95-50-1	ug/L	0.7	200	<1.0	<0.5	<1.0	<0.5	<1	<0.5
1,3-Dichlorobenzene	541-73-1	ug/L	150	-	<1.0	<0.5	<1.0	<0.5	<1	<0.5
1,4-Dichlorobenzene	106-46-7	ug/L	26	5	<1.0	<0.5	<1.0	<0.5	<1	<0.5
1,1-Dichloroethane	75-34-3	ug/L	9000 (coarse), 53 000 (fine)	-	<1	<1	-	<1	<1	<1
1,2-Dichloroethane	107-06-2	ug/L	5	5	<1	<1	<1	<1	<1	<1
1,1-Dichloroethene	75-35-4	ug/L	39 (coarse), 680 (fine)	14	<1	<1	<1	<1	<1	<1
cis-1,2-Dichloroethene	156-59-2	ug/L	12000	-	-	<1	-	<1	-	<1
trans-1,2-Dichloroethene	156-60-3	ug/L	12000	-	<1	<1	<1	<1	<1	<1
Dichlorom ethane	75-09-2	ug/L	50	50	<1	<1	<1	<1	<1	<1
1,2-Dichloropropane	78-87-5	ug/L	9.3 (coarse), 58 (fine)	-	<1	<1	<1	<1	<1	<1
cis-1,3-Dichloropropene	10061-01-5	ug/L	3.8 (coarse), 24 (fine)	-	<1	<0.001	<1	<0.001	<1	<0.001
trans-1,3-Dichloropropene	10061-02-6	ug/L	3.8 (coarse), 24 (fine)	-	<1	<0.001	<1	<0.001	<1	<0.001
Ethylene dibromide	106-93-4	ug/L	3.3 (coarse), 21 (fine)	-	-	<0.001	-	<0.001	-	<0.001
Methyl tert-butyl ether	1634-04-4	ug/L	340 (coarse), 5000 (fine)	15	-	<1	-	<1	-	<1
1,1,1,2-Tetrachloroethane	630-20-5	ug/L	6 (coarse), 38 (fine)	-	<1	<1	-	<1	-	<1
1,1,2,2-Tetrachloroethane	79-34-5	ug/L	22 (coarse), 140 (fine)	-	<2	<1	<2	<1	<2	<1
Tetrachloroethene	127-18-4	ug/L	110	30	<1	<1	<1	<1	<1	<1
1,1,1-Trichloroethane	71-55-6	ug/L	4200 (coarse), 13 000 (fine)	-	<1	<1	<1	<1	<1	<1
1,1,2-Trichloroethane	79-00-5	ug/L	9400	-	<1	<1	<1	<1	<1	<1
Trichloroethene	79-01-6	ug/L	20 (coarse), 50 (fine)	5	<1	<1	<1	<1	<1	<1
Trichlorofluoromethane	75-69-4	ug/L	-	-	-	<1	-	<1	-	<1
Vinyl chloride	75-01-4	ug/L	1.1 (coarse), 0.8 (fine)	2	-	<1	-	<1	-	<1
<b>Notes</b>										
"-" indicates that there is no applicable regulation or analyses were not performed.										
Bold and Red cells indicate parameter exceeds FCSAP Tier 1 Interim GW Guidelines for AL.										



\* Original in colour : Figures should be interpreted in combination with appropriate site report.



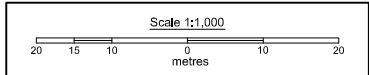


2

LEGEND

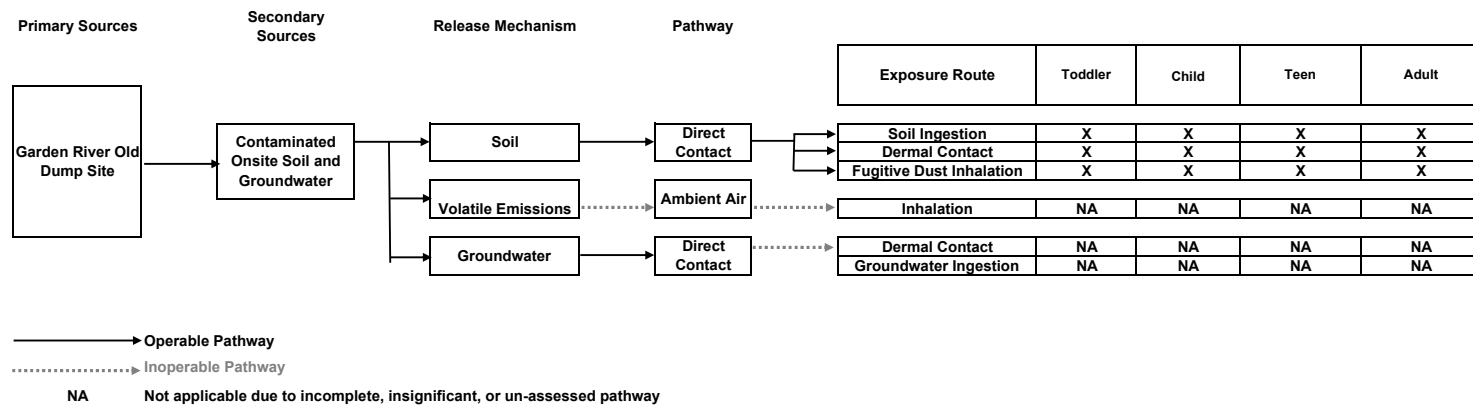
- Site Boundary
- Treeline
- Trails
- Area of Debris
- Incinerator
- Monitoring Well
- Borehole
- Surface Soil Sample
- Geophysical Transect

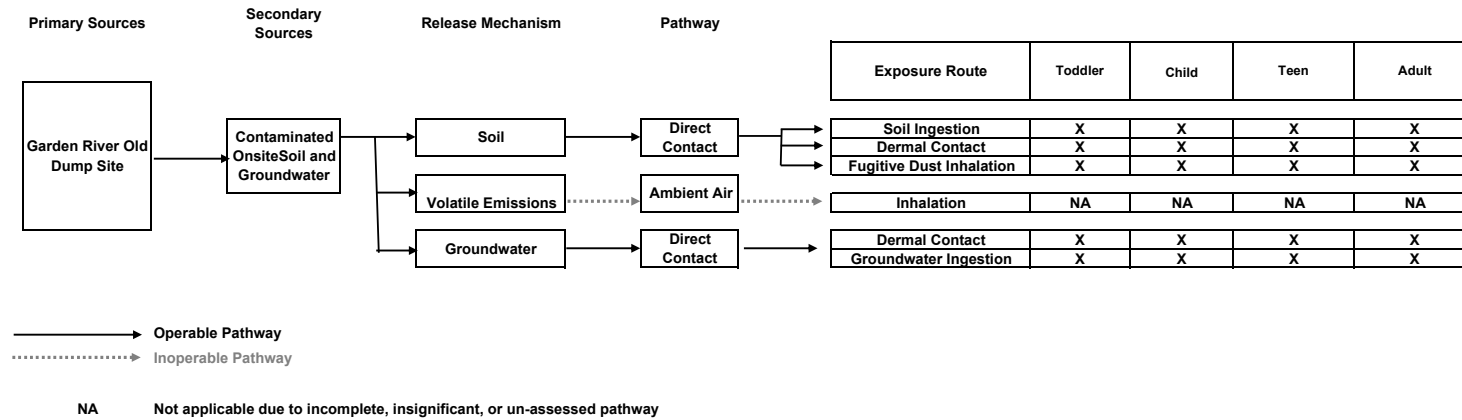
Note:  
\* Units relative to a temporary bench mark (TBM) of 100m for 08MW05B. All other elevations are relative to this.

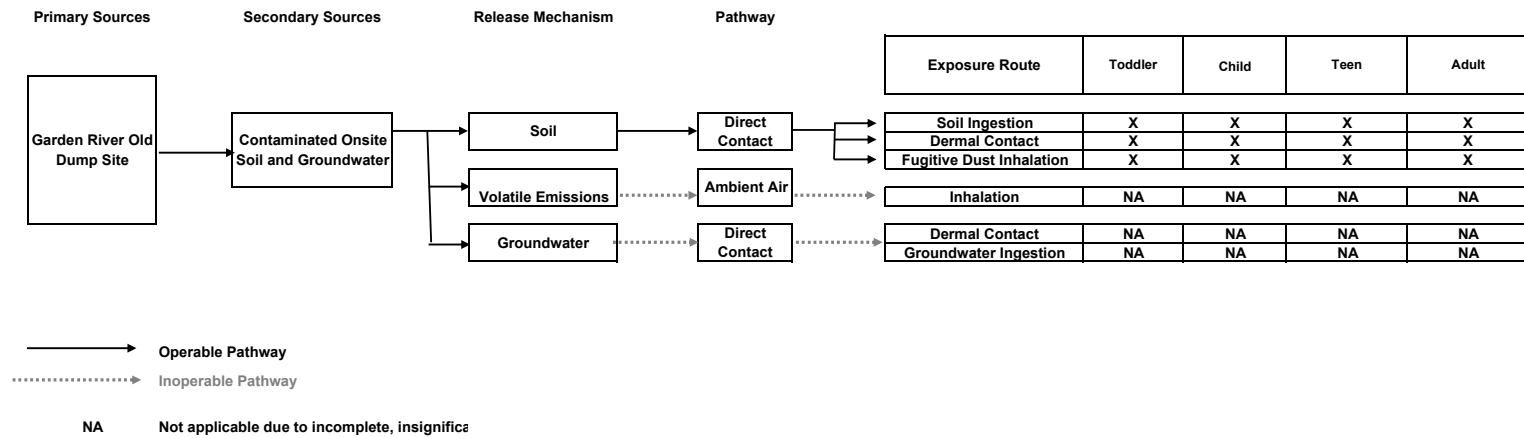


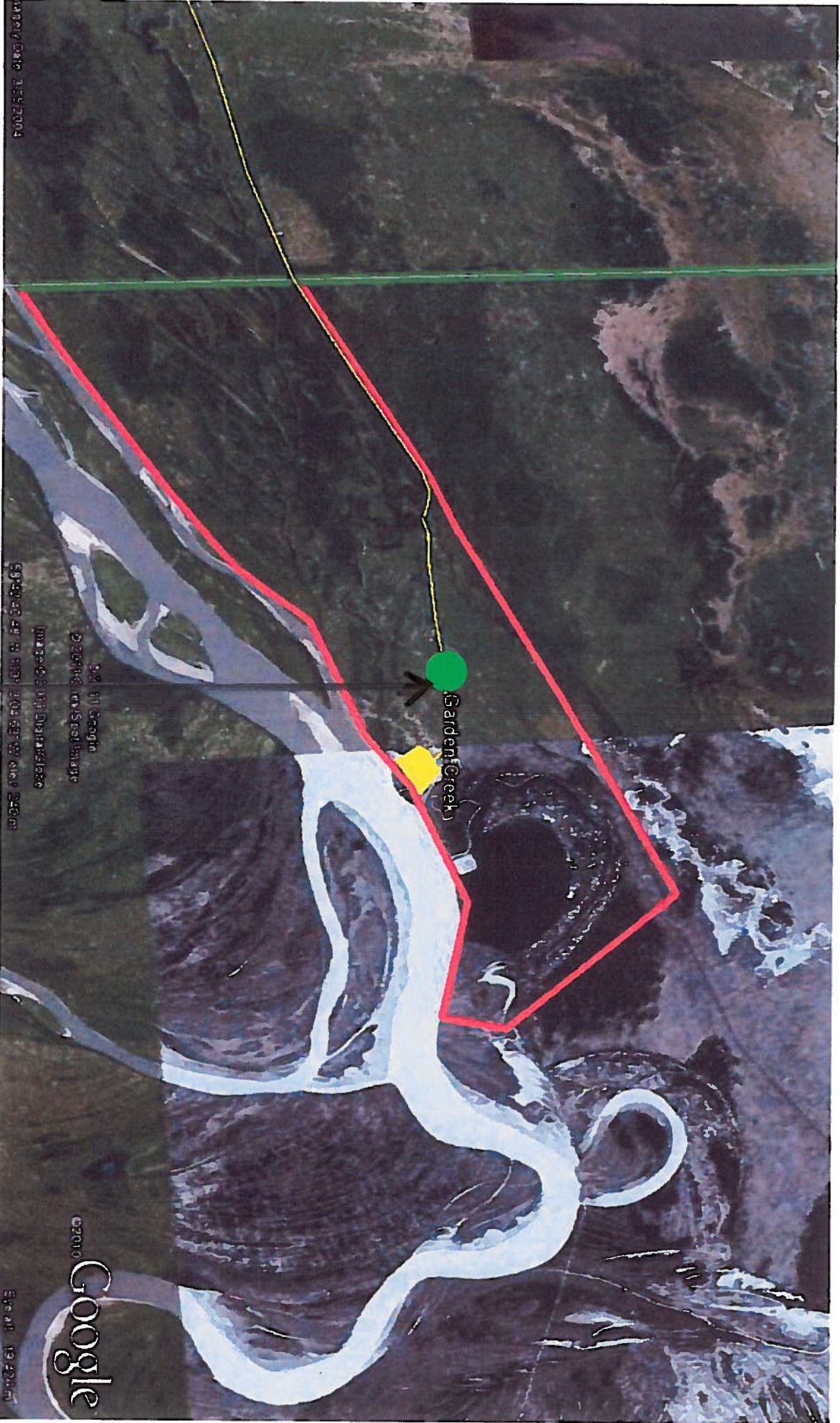
Title:	GEOPHYSICAL TRANSECTS	
Project:	DETAILED SITE ASSESSMENT GARDEN RIVER OLD DUMP	
Client:	PARKS CANADA AGENCY	
Date:	FEBRUARY 2011	
	FIGURE 13	



**SCENARIO A: CURRENT "TRANSIENT/RECREATIONAL" SITE USE**

**SCENARIO B: POTENTIAL FUTURE "HOMESTEAD, POTABLE GW" SITE USE**

**SCENARIO C: POTENTIAL FUTURE "HOMESTEAD, NON-POTABLE GW" SITE USE**



Comments/Notes:

New landfill location

Figure 5: Proposed New landfill location  
3 km West of the Community of  
Garden River

This map is used for demonstration purposes and does not represent the actual proposed reserve boundaries. Lands and Environmental Unit 2011

# APPENDIX B

## EBA'S ENVIRONMENTAL REPORT – GENERAL CONDITIONS

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# GENERAL CONDITIONS

## GEO-ENVIRONMENTAL REPORT

This report incorporates and is subject to these "General Conditions".

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### 1.0 USE OF REPORT AND OWNERSHIP

This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

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