Background Soil Assessment at Garden River in Wood Buffalo National Park, Alberta 2014

Prepared by

Environmental Sciences Group
Royal Military College
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on behalf of

Parks Canada Agency

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The Garden River 2014 Background Soil Assessment Program was commissioned by Parks Canada Agency (PCA) and was performed by the Environmental Sciences Group of the Royal Military College of Canada (ESG-RMCC) under the direction of Dr. Kela Weber. Stuart MacMillan was the project manager and primary point of contact for PCA. The draft report was reviewed by PCA.

The field program at Garden River was carried out by ESG-RMCC personnel Kathryn Eagles (Team Leader) and Jeff Donald (GIS Technician) with assistance from Tracy Blesse and Shawn Nanooch from the community of Garden River. Pre-season and off-site support was provided by Shari Reed (ESG-RMCC Project Leader) and Viviane Paquin (ESG-RMCC Project Manager). Logistical support was provided by Mike DeArruda, Kathleen Francis, Jasmine King and Candice Casucci of ESG-RMCC. Laboratory analyses were carried out by ALS Laboratories in Waterloo, ON, and the Analytical Sciences Group of RMCC, Kingston, ON.

This report was written by Kathryn Eagles, with contributions from Shari Reed, Viviane Paquin, Sonja Bissegger, Dr. Kela Weber and Dr. Daniela Loock (technical review and project management), Pat Fortin (quality assurance/quality control) and Susie Rance (editing). Bill Duffe produced the graphic design and formatted the report and Jeff Donald produced the maps.

EXECUTIVE SUMMARY

In 2014, the Environmental Sciences Group of the Royal Military College of Canada (ESG-RMCC) developed and carried out a background soil investigation program in Garden River, Alberta. The goal of the background soil assessment program was to establish the natural levels of inorganic elements in the surrounding environment. If natural levels were found to exceed the Canadian Council of Ministers of the Environment (CCME) Soil Quality Guidelines (SQGs) for Residential/Parkland land use, site-specific target levels (SSTLs) were to be established to allow for the proper assessment of the site and to provide benchmarks during any future remedial activities conducted at the site.

Soil results from previous assessments conducted at various locations throughout the community of Garden River (EBA 2006, 2009; Franz 2011) showed that concentrations of arsenic (As), boron (B), cadmium, (Cd), copper (Cu), nickel (Ni), lead (Pb), tin (Sn), selenium (Se) and zinc (Zn) exceeded the CCME SQGs for the Agricultural or the Residential/Parkland land uses. Groundwater results from those same assessments identified concentrations of As, Cd, Cu, iron (Fe), mercury (Hg), Se and Zn above the Federal Interim Groundwater Quality Guidelines for Residential/Parkland land use. If the groundwater results are compared to the Agricultural land use, then manganese was also above guideline values.

A uniform random sampling program was conducted in an area on the site that started 50 m beyond the area of current or past human activity and covered an area 500 m beyond that starting point. The purpose of defining this sampling zone was to allow sufficient distance from anthropogenically impacted areas while at the same time preventing sampling at excessive distances from the site where there may be subtle differences in geochemistry even if the soil type does not change. In total 111 surface samples (10-25 cm) and 34 depth samples (50-60 cm) were collected in areas indicative of site background but free from anthropogenic inputs. All samples were analyzed for a 31 inorganic element suite. PAHs were analyzed for a small number of soil samples in 2014 based on exceedances in groundwater in previous reports and based on potential naturally elevated occurrences from forest fires in the area.

The analytical results for all inorganic elements were reviewed and elements were carried forward to determine if SSTL calculations would be warranted if one of the following three assessment criteria was exceeded: if the 95% upper confidence limit (UCL95) on the mean exceeded the SQG; if any analytical results from the 2014 background program exceeded the SQG; and if any inorganic element exceeded the SQG in previous site assessment reports. Nine of the 31 elements, As, B, Ba, Cd, Cu, Fe, Mn, Se, and Zn, were carried forward for further

assessment. All PAH results were below CCME SQG values and also below detection in all but one sample. PAHs are not considered to be naturally elevated in the Garden River area in the top 0.7 m of soil.

Field observations of the soil characteristics and analytical results supported the presence of two geochemically different terrain units at the study site; the Sandy Glaciolacustrine (SG) terrain unit located in the north and west area of the site and Silty/Clayey Glaciolacustrine (CG) terrain unit located in the south and east area of the site. In addition differences in inorganic element concentrations were visually observed between surface (10-25cm) and depth (50-65cm) samples in both terrain unit types.

The background soil data was first investigated to identify and remove 11 extreme outliers from the data sets. Two-way ANOVAs were then completed for all inorganic elements to test if soil concentrations differed by terrain unit and depth. The ANOVA analysis identified terrain unit to be a significant defining parameter for all elements, save Mn. The same analysis identified sampling depth to be a significant defining parameter for As, B, Ba, Cu, Fe, and non-significant for Cd, Mn, Se, Zn. Based on these results, further data distribution testing and calculations were completed for the separate terrain units, with further data separation based on depth for As, B, Ba, Cu, and Fe.

A number of different approaches were reviewed in the report for calculating SSTLs for Garden River. These included, the maximum background concentration, the mean plus three standard deviations, the upper threshold limit (UTL), the upper prediction limit (UPL), the extreme outlier limit (EOL) and the upper simultaneous limit (USL). The assumptions underlying the USL best fit the Garden River data and therefore calculated USLs were selected for deriving the SSTLs.

The calculated USLs for all nine elements in the SG terrain unit and for Ba, Cd and Cu in the CG terrain unit were below the SQGs. In these cases, the SQGs should be used rather than the USLs. There is no CCME SQG for Residential/Parkland land use for B, Fe or Mn, so the USLs for these elements have been calculated for reference only in case future land use scenarios require the use of more conservative CCME SQGs. If the Agricultural land use is applied to an area at Garden River, the SSTL for B should be used as it is higher than the CCME SQG for Agricultural land use.

The USL calculations resulted in SSTLs for three elements, As, Se, and Zn in the CG terrain unit. Calculated USL based SSTLs for the CG unit are: As 14 ppm, Se 1.2 ppm and Zn 350 ppm.

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GLOSSARY AND LIST OF ABBREVIATIONS

Ag	silver
Al	aluminum
AANDC	Aboriginal Affairs and Northern Development Canada
ANOVA	analysis of variance
As	arsenic
AST	above-ground storage tank
B	boron
Ba	barium
Be	beryllium
Bi	bismuth
Ca	calcium
CCME	Canadian Council of Ministers of the Environment
Cd	cadmium
CG	Silty/Clayey Glaciolacustrine (terrain unit)
cm	centimetre
Co	cobalt
CoI	contaminant of interest
Cr	chromium
Cu	copper
DL	detection limit
EBA	EBA Engineering Consultants
EO	extreme outlier: sample with an analyte at a level that surpasses a calculated extreme outlier limit
EOL	extreme outlier limit: three times the interquartile range added to the third quartile
ESA	environmental site assessment
ESG-RMCC	Environmental Sciences Group of the Royal Military College of Canada
FCSAP	Federal Contaminated Sites Action Plan
Fe	iron
Hg	mercury
K	potassium
km	kilometre
Li	lithium
max	maximum
min	minimum
Mg	magnesium
Mn	manganese
Mo	molybdenum
MO	mild outlier: sample with an analyte at a level that surpasses a calculated mild outlier limit

MOL	mild outlier limit: 1.5 times the interquartile range of an analyte level added to the third quartile of the level
N/A	not applicable
Na	sodium
Ni	nickel
P	phosphorus
PAH	polycyclic aromatic hydrocarbon
Pb	lead
PCA	Parks Canada Agency
PHC	petroleum hydrocarbon
ppm	parts per million; equivalent to µg/g of soil
QA/QC	quality assurance/quality control
Sb	antimony
Sdev	standard deviation
Se	selenium
SG	Sandy Glaciolacustrine (terrain unit)
Sn	tin
SQG	soil quality guideline
Sr	strontium
SSTL	site-specific target level
Ti	titanium
Tl	thallium
U	uranium
UCL95	95% upper confidence limit
UPL	upper prediction limit
USL	upper simultaneous limit
UTL	upper tolerance limit
US EPA	U.S. Environmental Protection Agency
V	vanadium
WBNP	Wood Buffalo National Park
Zn	zinc

I. INTRODUCTION

Parks Canada Agency (PCA) engaged the Environmental Sciences Group of the Royal Military College of Canada (ESG-RMCC) to establish background soil and groundwater concentrations for inorganic elements at Garden River in Wood Buffalo National Park (WBNP), Alberta. Background polycyclic aromatic hydrocarbon (PAHs) concentrations in soil were also evaluated using a smaller number of samples. This report summarizes the work and findings of the background soil assessment; a similar report summarizing the work and findings of the background groundwater investigation (ESG 2015) is available under separate cover.

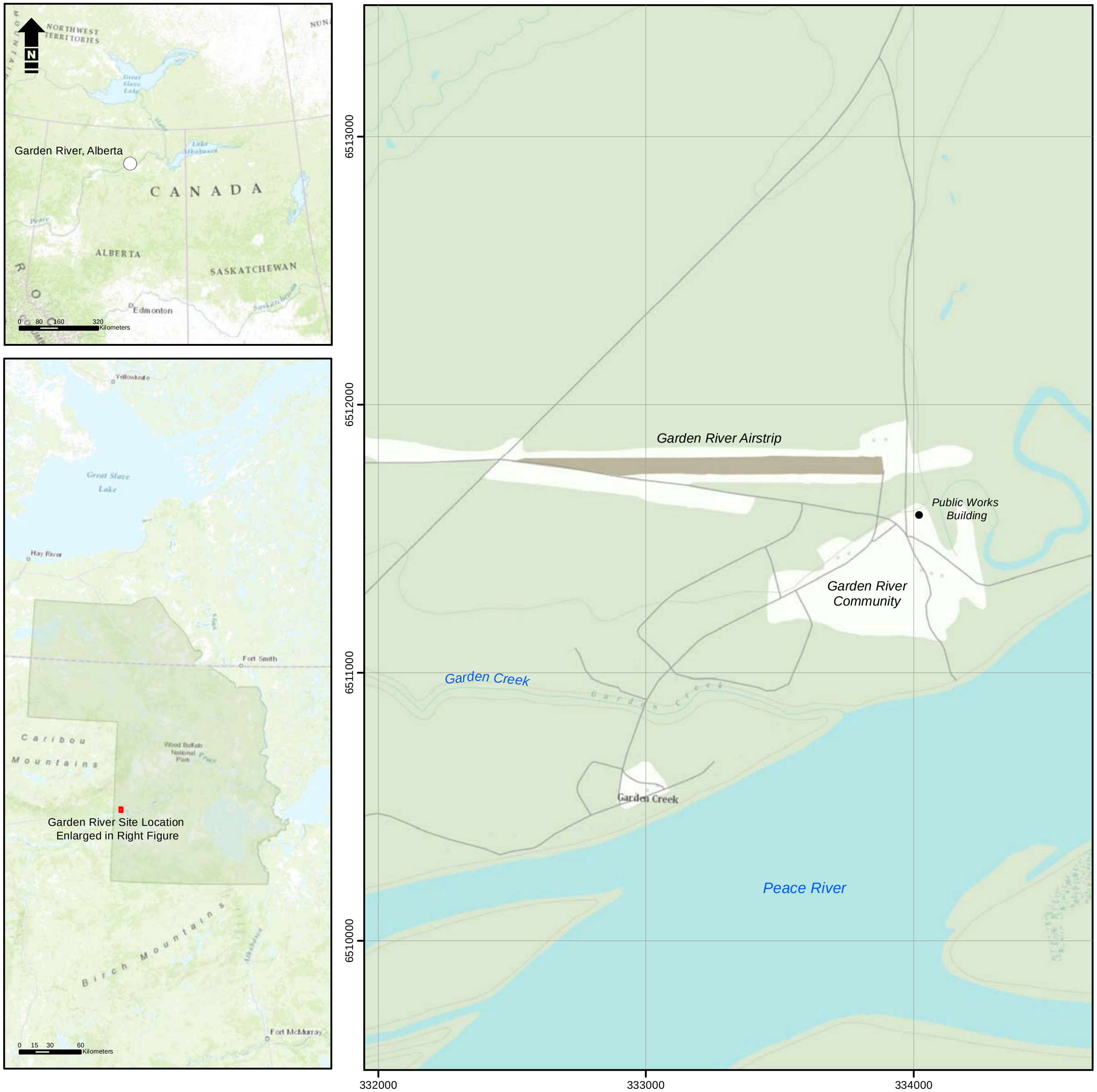
Garden River is a First Nations community of the Little Red River Cree Nation. The community is located approximately 200 km east of High Level, Alberta, on the north shore of the Peace River, and sits at the confluence of Garden Creek and the Peace River (Map I-1).

Dating back to 2006, PCA has commissioned several Phase I and II environmental site assessments (ESAs) at various locations in Garden River where potentially contaminating activities have occurred in the past (AMEC 2006; EBA 2006, 2009, 2013; Columbia and Franz 2011, ESG 2014). The work was commissioned to facilitate the transfer of lands to the Little Red River Cree Nation and Aboriginal Affairs and Northern Development Canada (AANDC; formerly Indian and Northern Affairs Canada) and excise the community from WBNP.

The ESAs conducted at Garden River identified several areas where landfills, storage tanks and airstrip activities have altered soil and groundwater quality but they also indicated that the natural geology at Garden River is such that several trace elements are likely occurring at levels approaching or exceeding applicable soil quality guidelines.

When assessing potential contamination at a site, soil concentrations must be interpreted as either natural or anthropogenic. If remediation is required, knowledge of natural background concentrations may be needed to determine the volume of soil requiring remediation, defining boundaries for excavation, and identifying site specific clean up levels for confirmatory testing. Decisions made without a thorough understanding of natural background concentrations could result in costly and unnecessary disturbance of a site.

This report describes the details of the background soil assessment program conducted by ESG-RMCC and the approach used to determine if inorganic elements in background soils naturally occur above federal guideline values. The report also describes the statistical approach used to develop site-specific target levels (SSTLs) for those inorganic elements found to be naturally elevated.



Map I-1: Location of Garden River Alberta

Legend

- Roads
- Body of Water / River System
- Cleared Area / Community
- Forrested Area
- Wetland Area

SCALE

Refer to Grid Scale and Scale Bars in Figures

DATA RESOURCES

Original Sources:
Government of Canada
Environmental Sciences Group
ESRI - Basemap Imagery

Datum:
North American Datum 1983 (NAD83)

Projection:
Universal Transverse Mercator (UTM) Zone 12N

Software:
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PHOTO: Wood Buffalo NP Photo Credit: Parks Canada

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2014 Background Soil Assessment
Garden River, Wood Buffalo National Park

A. Summary of Previous Studies

The 2006 Phase I ESA reports prepared by EBA Engineering Consultants (EBA) and AMEC Earth & Environmental (AMEC) evaluated the Garden River Land Claim Selection Areas as required by Public Works and Government Services Canada and by AANDC, respectively (EBA 2006; AMEC 2006). Both studies investigated the historical (pre-1998) and current landfills, the historical and current locations of above-ground storage tanks (ASTs) and bulk storage tanks at the airstrip, the sewage lagoon, the historical septic tile field, and the community airstrip area at which 60 jet fuel storage drums were being stored directly on the ground without secondary containment. No samples were collected as part of the AMEC Phase I ESA, but the report recommended completion of a Phase II ESA. Shallow soil samples were obtained by EBA as part of the Phase I ESA near areas of potential environmental concern for testing. A sample containing a high concentration of nickel was found in the Public Works Yard south-east of the Airstrip Area; further investigation at this area and others was recommended.

A Phase II ESA was conducted by EBA in 2008 to further investigate soil and groundwater at locations where potentially contaminating activities had been identified during the Phase I ESAs (EBA 2009). A detailed assessment was conducted at the old dump by Colombia and Franz in 2011, including soil and groundwater sampling at areas upgradient of the dump (Colombia and Franz 2011). Concentrations of inorganic elements were measured at levels above relevant environmental guidelines in both soil and groundwater in some areas within the community. Soil samples contained concentrations of arsenic (As), boron (B), cadmium, (Cd), copper (Cu), nickel (Ni), lead (Pb), tin (Sn), selenium (Se) and zinc (Zn) exceeding the Canadian Ministers of the Environment (CCME) Soil Quality Guidelines (SQGs) for the Agricultural or the Residential/Parkland land uses. Based on the location of the samples containing As, B, and Se, which were upgradient of contaminated areas, these elements have a greater likelihood of being natural and not from anthropogenic sources. Groundwater results from the assessments identified concentrations of As, barium (Ba), Cd, Cu, iron (Fe), mercury (Hg), Se and Zn above the Federal Interim Groundwater Quality Guidelines for Residential/Parkland land use. If the groundwater results are compared to the Agricultural land use, then manganese (Mn) is also above guideline values. Based on the location of the monitoring wells, As, Cd, Fe, Mn, Se, and Zn have a greater likelihood of being naturally elevated. As a result, those inorganic elements from the groundwater program will be carried forward as part of the soil evaluation.

Detectable naphthalene, phenanthrene, and pyrene were identified upgradient of the existing landfill, and phenanthrene was found upgradient of old dump in the EBA Phase II (EBA 2009), however results were below CCME SQG. The Colombia and Franz 2011 detailed assessment identified naphthalene and phenanthrene above CCME SQG (agricultural) in soil from the borehole for the background monitoring well. PAHs were analyzed for a small number of soil samples in 2014 based on exceedances in groundwater samples in previous reports and on potential naturally elevated occurrences from forest fires in the area.

In 2013, ESG-RMCC conducted a supplementary delineation of petroleum hydrocarbon contamination (PHC) at the airstrip area which concluded that previously identified PHC contamination had attenuated to levels below the CCME Canada Wide Standard for agricultural land use (ESG 2014).

Based on past soil and groundwater results, the inorganic elements reviewed as part of the report include: As, Ba, B, Cd, Cu, Fe, Mn, Se and Zn as contaminants of interest for the development of site specific target levels in soil at the site.

II. GEOLOGY AND GEOCHEMISTRY

A. Bedrock Geology

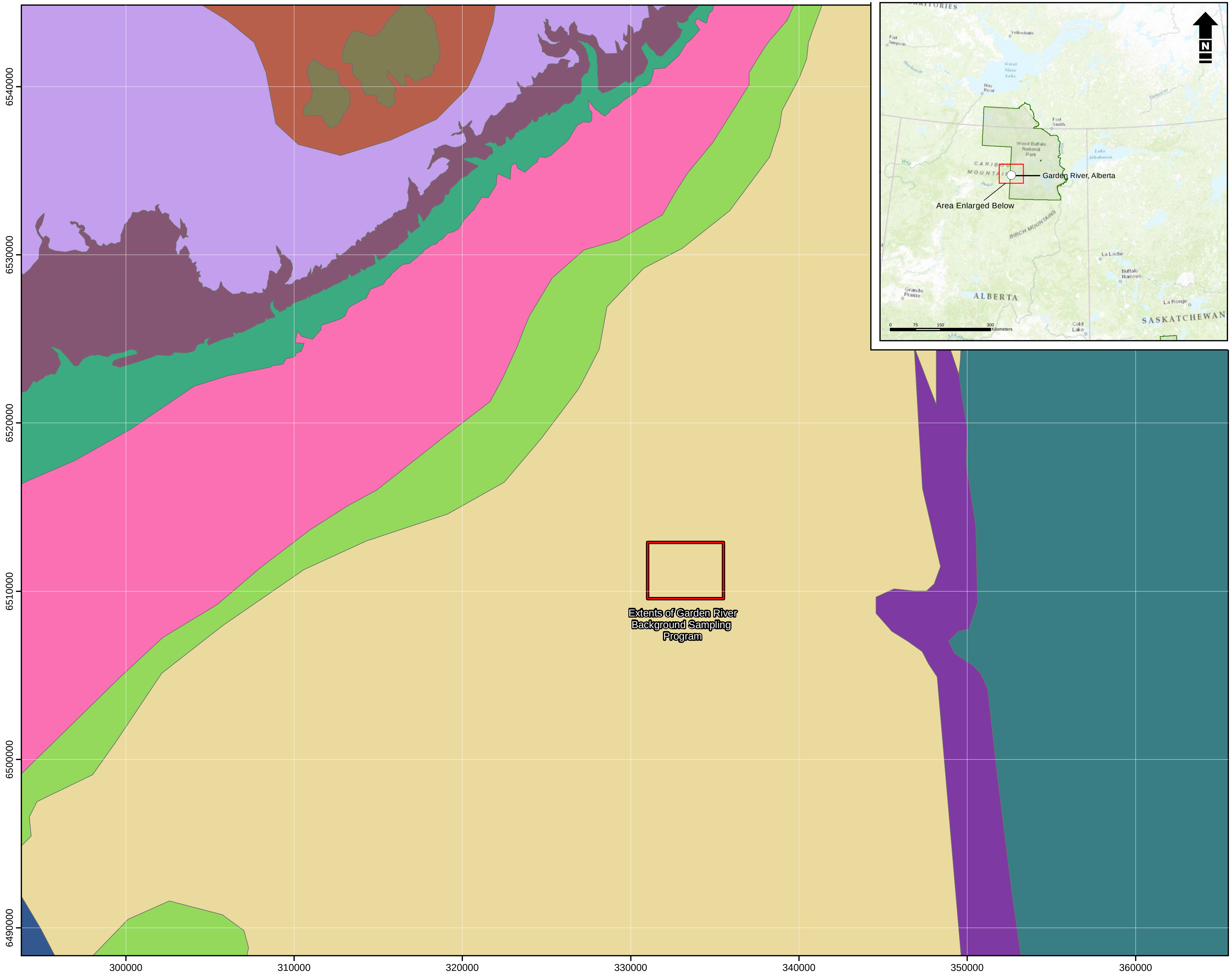
The topography of the study area is predominantly flat with a slight downward slope to the south towards the Peace River, approximately 240 m above sea level. The area is underlain by the Ireton Formation (formed during the Frasnian stage of the Late Devonian, approximately 380 million years ago), a formation that is a maximum of 250 m thick. It ranges from calcareous shale and argillaceous limestone near the surface to fissile grey-green shale with calcirudite beds in the middle to massive and banded limestone with shale partings near the base. In the area of Garden River, the bedrock has been observed to be greenish-grey calcareous shale and siltstone (Hamilton et al. 1999; Map II-1).

B. Surficial Geology

The study area is in the Central Mixedwood physiographic region of Alberta (Natural Regions 2006), containing grasslands and predominately birch and coniferous forests. The area contains numerous small watercourses which drain into the Peace River on the south side of the community of Garden River.

The site is located within a low area that acts as a large drainage basin. The Peace River flows north-easterly towards the Slave River. As a part of the Interior Plains geological province, groundwater flows through sandstone aquifers with occasional sand and gravel channels (Columbia and Franz 2011). With level to depressional cut-off channels and sloughs that are flooded most of the year, the floodplain has a water table that is at or near the surface. Drainage is poor overall (EBA 2013). On the basis of groundwater elevation data collected in December 2010, it is inferred that the on-site groundwater flow direction is south-southeast toward the Peace River (Columbia and Franz 2011).

The soils derived from the Ireton Formation's calcareous shale and siltstone are normally alkaline, specifically containing above-average levels of calcium (Ca) and magnesium (Mg). Located in the Peace River Lowlands, the area consists of an active floodplain, terraces and levee deposits. The surficial material in the site area is comprised of alluvial deposits related to the Peace River, composed of stratified, stone-free, friable silts and sands (EBA 2013; Map II-2). Soils range in particle size from silt to gravel with fine clay stingers (Columbia and Franz 2011).



Map II-1: Background Geology of northern Alberta

Legend

- Bluesky Formation
- Cooking Lake Formation
- Dunvegan Formation
- Dunvegan Formation equivalent
- Grosmont Formation
- Ireton Formation
- Loon River Formation (lower part)
- Peace River Formation
- Shaftesbury Formation (lower part)
- Shaftesbury Formation (upper part)
- Smoky Group
- Waterways Formation

SCALE

0 1.5 3 6 9 Kilometers

DATA RESOURCES

Original Sources:
Government of Canada
Environmental Sciences Group
Image: Google Maps

Datum:
North American Datum 1983 (NAD83)

Projection:
Universal Transverse Mercator (UTM) Zone 12N

Software:
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PHOTO: Wood Buffalo NP Photo Credit: Parks Canada

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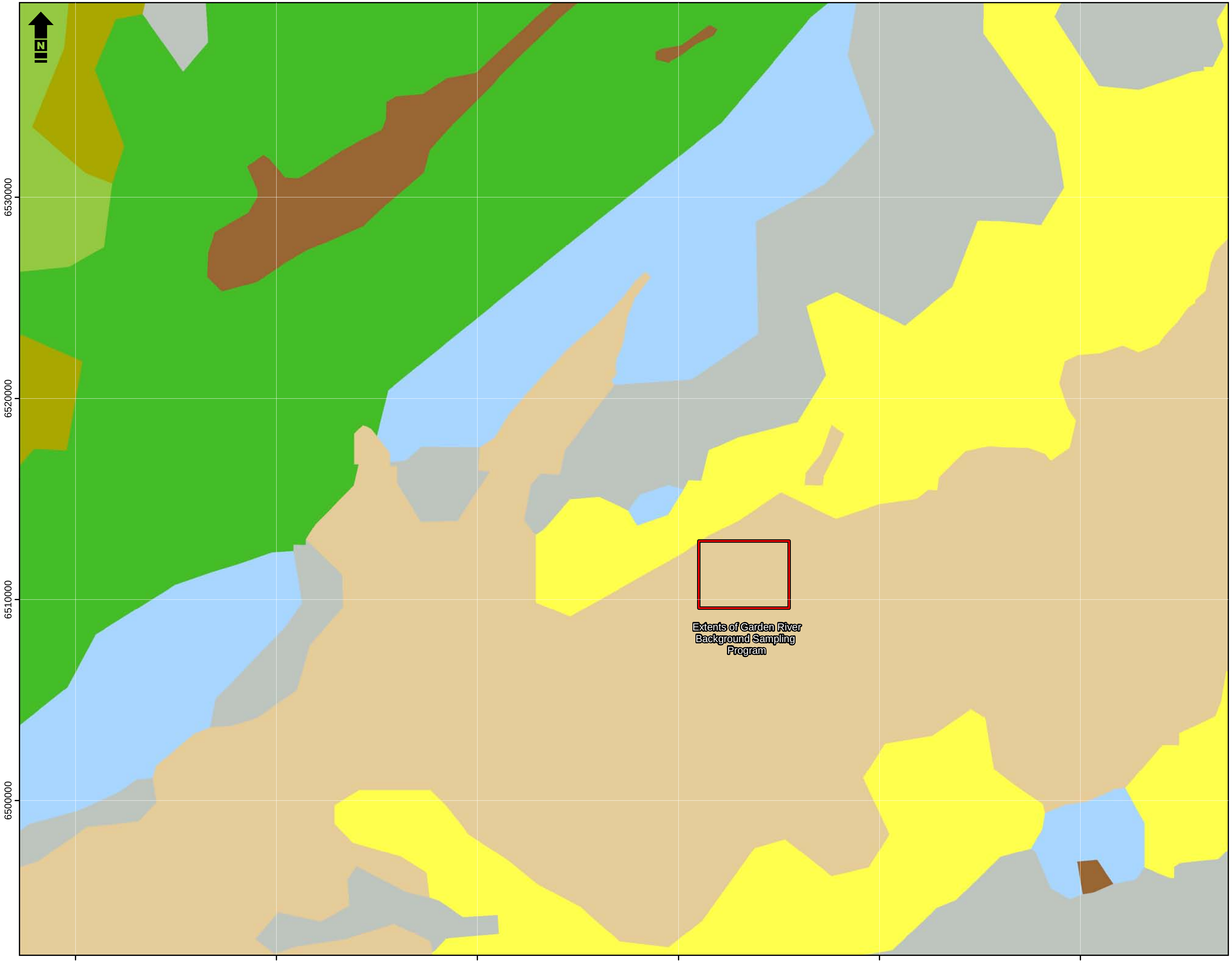

Map II-2: Surficial Geology of northern Alberta

Legend

- Glaciers (G)
- Organic Deposits (O)
- Colluvial Deposits (C)
- Fluvial Deposits (F)
- Lacustrine Deposits (L)
- Eolian Deposits (E)
- Glaciolacustrine Deposits (LG)
- Glaciofluvial Deposits (FG)
- Moraine (M)
- Fluted moraine (MF)
- Stagnant Ice Moraine (MS)
- Ice-thrust moraine (MT)
- Preglacial Fluvial Deposits (RT)
- Bedrock (R)

SCALE

0 1.5 3 6 9 Kilometers

DATA RESOURCES

Original Sources:
Government of Canada
Environmental Sciences Group
Image: Google Maps

Datum:
North American Datum 1983 (NAD83)

Projection:
Universal Transverse Mercator (UTM) Zone 12N

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PHOTO: Wood Buffalo NP
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C. Terrain Units

ESG-RMCC conducted a review of air photos, available soil descriptions and surficial mapping (Mougeot and Fenton 2010) prior to the 2014 field season to identify the possibility of multiple terrain units in the study area at Garden River. Although existing information suggested that only one terrain unit was present, detailed notes on soil characteristics were made during the background soil program, and post-season review of field information and soil analytical results indicated the presence of two terrain units in the Garden River study area (Map II-3).

In accordance with the most recent surficial mapping by Fenton et al. (2013), both terrain units are likely from the same surficial deposit, a glaciolacustrine deposit from the Pleistocene deposited in or along the margins of glacial lakes. These deposits typically consist of laminated or massively deposited fine sand, silt and clay and/or massive stratified well-sorted silty sand, pebbly sand and minor gravel. The description of these deposits is consistent with the soil observed in Garden River. The two terrain units, described below, represent the well-sorted silty sand (Sandy Glaciolacustrine) and the fine sand, silt and clay (Silty/Clayey Glaciolacustrine), respectively.

1. *Sandy Glaciolacustrine Deposits (SG)*

Soil consists predominantly of 75–100% fine- to medium-grained sand (0.125–0.5 mm diameter), light- to medium-brown, homogenous and/or decreasing in grain size with depth. The soil often contains as much as 25% silt and/or clay, with 0–10 centimetres (cm) of overburden (typically leaves, branches, moss and organic material/detritus). It generally occurs in topographically flat or gently sloping areas, with medium to sparse forests of mixed deciduous and coniferous trees. Locally, it is found most commonly in the northern and western areas of the study area.

2. *Silty/Clayey Glaciolacustrine Deposits (CG)*

Soil consists normally of 25–90% clay/silt particles (0.00006–0.0625 mm diameter), dark- to medium-brown in colour. Soil was observed to be generally homogeneous but to gradually increase in grain size with depth in some instances, with 5–25 cm of overburden (organic material, as for SG, although more often moss and organic material/detritus). It is generally found in topographically gently to steeply sloping, moderately to densely forested areas. Forests are comprised of mixed coniferous and deciduous trees, often with more shrubs and coniferous trees. Locally, it is found in the southern and eastern areas of the study area.

Map II-3: Garden River Terrain Unit Identification

Legend

- 50 metre buffer from Disturbed Areas
- 550 metre buffer from Disturbed Area
- Airstrip
- Transportation Roadways
- Soil Terrain Unit Seperation
- Former Community Landfill
- Current Community Landfill
- Terrain Unit - Sandy Glaciolacustrine
- Terrain Unit - Silty/Clayey Glaciolacustrine

SCALE

0 100 200 400 600 Meters

DATA RESOURCES

Original Sources:
Government of Canada
Environmental Sciences Group
Image: Google Maps

Datum:
North American Datum 1983 (NAD83)

Projection:
Universal Transverse Mercator (UTM) Zone 12N

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III. ASSESSMENT OF BACKGROUND SOIL CONCENTRATIONS

Detailed background soil characterization and assessment is not generally required for site investigation and remediation activities when contaminant sources are clearly anthropogenic and there are applicable soil quality guidelines. However, some geologic units have naturally high concentrations of various inorganic elements, potentially resulting in elevated background levels of inorganic elements in the soil and groundwater. Previous ESA's conducted at Garden River indicated that several inorganic elements may be naturally occurring at levels approaching or exceeding applicable soil quality guidelines. In addition, PAHs may be naturally elevated in the area due to the frequent occurrence of forest fires.

The CCME SQGs provide science-based numerical soil quality standards that set out concentrations of contaminants at which it is believed that unacceptable adverse effects on environmental or human health will not occur; these guidelines can be used as a basis for assessment and remediation of federal contaminated sites. The SQGs take into account the intended land use when evaluating site conditions (CCME 2001). For the purposes of this study, the SQGs for residential/parkland land use have been used. There is no residential/parkland land use SQG for B, so the SQG for agricultural land use has been used for comparison in this report. This exception has been noted where applicable.

The SQGs are based on a multi-tier framework that allows for application of the generic guidelines or modification of the guidelines based on site-specific conditions. On sites where the terrestrial and aquatic characteristics differ from the generic site characteristics of other Canadian sites, the guidelines may be modified to SSTLs considering these site-specific characteristics. Further, when use of the generic guidelines may lead to unnecessary excavation and destruction of pristine areas, detailed background characterization becomes necessary.

The purpose of a background inorganic element soil sampling program is to determine whether the generic CCME soil quality guidelines are appropriate for the site. Based on previous work completed in the Garden River community, it is likely that As, B, and Se are naturally occurring at levels approaching or exceeding the generic SQGs, with the possibility that Cd, Cu, Ni, Pb, Sn and Zn could also be naturally elevated. If the generic soil quality guidelines are not applicable, then SSTLs need to be generated to replace the SQGs for future assessment and remediation work to ensure that anthropogenic contaminants at levels above the applicable guidelines are remediated while minimizing unnecessary disturbance of natural areas.

There are several accepted approaches for developing SSTLs based on site-specific background data which vary widely in their application, technical merit, complexity, risk of error, degree of protection and ease of implementation. They include (i) use of the maximum background concentration; (ii) calculation of a mean plus a designated number of standard deviations; (iii) calculation of an upper tolerance limit (UTL); (iv) calculation of an upper prediction limit (UPL); (v) calculation of mild outlier limit (MOL) and extreme outlier limit (EOL) and (vi) the calculations of the upper simultaneous limit (USL) as acceptable methods to establish threshold values for background data sets (Loock et al. 2005, Singh and Singh 2013, Reimann et al. 2005). Selection of the appropriate technique depends on the size of the data set and its distribution characteristics.

The following sections detail the design of the 2014 background sampling field program at Garden River, the statistical evaluation of natural inorganic element concentrations at the site and the approach used for the development of SSTLs.

A. Approach for Characterizing Background Inorganic Element Concentrations in Soil

Characterization of background concentrations of inorganic elements in soil for contaminated site investigation and remediation has been addressed by several environmental regulating bodies (BCMWLAP 2000; CCME 2001; US EPA 1995). Typically, a background soil sampling program is conducted in areas that are comparable to the contaminated site but are free from anthropogenic inputs of contaminants of interest. Significant differences between the population distributions for the inorganic elements from the background sampling areas and those from the potentially contaminated areas are interpreted as indication that an area has been affected by an anthropogenic point-source of contamination.

For the purpose of the background soil assessment of Garden River, the study area for the background program was determined by defining the inclusion zone; the zone that stretches 50 m beyond the area of current or past human activity while extending no further than 500 m beyond the impacted area. The purpose of this inclusion zone is to allow sufficient distance from anthropogenically impacted areas while at the same time preventing sampling at excessive distances from the site where there may be subtle differences in geochemistry even if the soil type does not change. The 500 m inclusion zone was plotted on digital maps and the area was divided into a grid, and sized to yield the approximate number of desired samples.

In the absence of knowledge about the variability of inorganic element concentrations at the site, the number of samples collected is based on the previous information about the site or the geology in the area, budget, and professional judgement. Typically, 100 sampling locations provide sufficient analytical data to calculate average concentrations and upper limits of background concentrations with confidence.

Sampling sites were generated inside each grid cell using a random number generator, which produced a uniform, random data set. This sampling methodology produced 110 potential sampling locations, which were plotted on the property maps and considered for inclusion in the sampling program. Sampling locations in an area unsafe or unfit for sample collection, within 50 m of another sampling location and/or within 50 m of a potentially contaminated area were removed from the sampling set. More sampling sites are drawn in the planning phases than are generally needed to compensate for further eliminations that would be made in the field because of accessibility problems, unforeseen anthropogenic sources and other factors.

Following the logical arguments for sampling location exclusion described above, 10 of the original 110 sampling sites were eliminated. This yielded the final set of 100 sampling sites illustrated on Map III-1.

Inorganic element concentrations typically do not vary much with depth unless there is a distinct change in stratigraphy such as a change in color, texture or organic matter content that suggests otherwise. This is because typically the soil within a terrain unit has developed from the same parent material and been impacted by the same biological and physical weathering processes. (Keller 2002). A limited number of depth samples were collected to test for differences in inorganic element concentrations between surface and depth. Depth sampling locations were selected at approximately every third sampling point so that they would be generally representative of the sample distribution across the property. Test pits were advanced by hand using shovels and generally reached depths of 60 cm. Samples were collected at surface (10-25 cm) and at depth (50–65 cm).

A total of 145 soil samples were collected, 111 at surface and 34 at depth (Table III-1). These included fourteen field duplicates that were collected for quality assurance/quality control (QA/QC) purposes, yielding 131 total data points (as duplicates are combined and averaged into one data point). Details of the QA/QC program are presented in Appendix 2.

The background soil samples were analyzed for a suite of 31 inorganic elements, which include inorganic elements that are commonly found in soil from either natural or anthropogenic sources: silver (Ag), aluminum (Al), As, B, Ba, beryllium (Be), bismuth (Bi), Ca, Cd, cobalt

(Co), chromium (Cr), Cu, Fe, potassium (K), lithium (Li), Mg, Mn, molybdenum (Mo), sodium (Na), Ni, phosphorus (P), Pb, antimony (Sb), Se, Sn, strontium (Sr), titanium (Ti), thallium (Tl), uranium (U), vanadium (V) and Zn (Appendix 1, Table 1). Details of the analytical results are presented in section III-B.

The proposed number of soil samples to be analyzed for PAHs is based on the Federal Contaminated Sites Action Plan (FCSAP) Ecological Risk Assessment Guidance for defining background conditions (Stantec 2013). This method will not allow the calculation of site-specific thresholds for PAHs in background soil, but it will allow confirmation of their presence as a naturally occurring component of background soil. To obtain the required number of analytical results for PAHs, 15 randomly selected samples collected as part of the inorganic element program were analyzed for a suite of 16 PAHs to determine whether PAHs are present naturally in local soils (Table III-1). The suite consists of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthrene, benzo(k)fluoranthrene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, dibenz(a)anthracene and benzo(ghi)perylene (Appendix 1, Table 2). Details of the analytical results are presented in section III-B.

Table III-1: Summary of Background Soil Sampling Program

Analysis type	**Sampling program requirements**	**Number of samples collected**
Inorganic elements (suite of 31)	100 sampling locations: • 100 surface samples • 31 shallow-depth samples (30 to 50 cm) • 14 duplicate samples (~10% frequency)	145
PAHs (suite of 16)	14 samples (co-located with inorganic element samples: • 12 surface samples • 3 shallow-depth samples (30–50 cm) • 1 duplicate sample (~10% frequency)	15

Map III-1: Sampling Locations for the Garden River Background Soil Assessment Program

Legend

- 2014 Background Sampling Location
- 2014 Monitoring Well Location
- 50 metre buffer from Disturbed Areas
- 550 metre buffer from Disturbed Area
- Airstrip
- Transportation Roadways
- Soil Terrain Unit Seperation
- Former Community Landfill
- Current Community Landfill
- Terrain Unit - Sandy Glaciolacustrine
- Terrain Unit - Silty/Clayey Glaciolacustrine

SCALE

0 100 200 400 600 Meters

DATA RESOURCES

Original Sources:
Government of Canada
Environmental Sciences Group
Image: Google Maps

Datum:
North American Datum 1983 (NAD83)

Projection:
Universal Transverse Mercator (UTM) Zone 12N

Software:
ESRI - ArcMAP 10.0

File Path:
J:\Projects\Garden River\2014\ESRI\MXD\Map III-1 Background Sampling Program.mxd

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PHOTO: Wood Buffalo NP   Photo Credit: Parks Canada

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B. Evaluation of Soil Geochemical Results

1. Summary of Background Data

To determine which inorganic elements are present at the site in concentrations that warrant calculation of an SSTL, the data set was examined several different ways. The U.S. Environmental Protection Agency (US EPA) recommends that the 95% upper confidence limit (UCL95) of the arithmetic mean be calculated as a conservative estimate of the average soil concentration at a property and as a means of determining whether a compound or element should be considered a contaminant of potential concern; this takes into account uncertainties caused by limited sample size (US EPA 1992; Kesar and Asti 1999). If the UCL95 of the mean is above the SQG, then the element should be carried forward in the evaluation. Because we are confident that the data collected in this study represent locations that are not impacted by anthropogenic contaminant point sources, this approach has been used to determine which elements would require further evaluation to determine whether the concentrations in the background data set are naturally elevated. The second assessment criterion was whether any single background soil sample result exceeded the SQGs. Finally, any exceedances of the SQGs in past ESAs will be included in the data exploration to establish if previously measured concentrations are naturally elevated or due to anthropogenic inputs.

The number of soil samples with results above the detection limits ranged from 131 (100%) for 19 of the 31 inorganic elements to 0% for Bi, Sb and Tl. The UCL95 values were calculated for 22 of the 31-element suite (Table III-2). The UCL95 was not calculated for Ag, Bi, Cd, Mo, Na, Sb, Se, Sn or Tl because of the high frequency of non-detects (greater than 50%), which would introduce bias into the estimation of means and variances. Of the 22 elements for which the UCL95 was calculated, only the UCL95 for B surpasses the SQG and B is therefore carried forward for further evaluation of its range of background concentrations at the site.

Four of the trace metals were measured at concentrations above the SQG. The following lists the percentage of samples exceeding the SQGs in the entire data set as well as the percentage of samples that exceeded the SQGs out of a data set where all values below the detection limit have been removed: As (three samples, 2.3% of all detectable results), B (83 samples, 100% of all detectable results), Se (10 samples, 100% of all detectable results) and Zn (seven samples, 5.3% of all detectable results). These elements are further evaluated to determine whether they are naturally elevated.

Because of exceedances of SQGs in past ESAs, Ba, Cd, Cu, Fe and Mn will also be included in the data exploration to establish whether the previously measured concentrations are naturally elevated or due to anthropogenic inputs.

As a result, nine inorganic elements — As, B, Ba, Cd, Cu, Fe, Mn, Se, and Zn — will be considered in the detailed data exploration to determine whether they are naturally elevated in the soil at Garden River and warrant the calculation of SSTLs.

Data ranges and detection limits (DLs) for the 31 inorganic elements analyzed for the 131 soil sample locations at Garden River are given in Table III-2. The table also presents the number of results above the DLs, the minimum (min) and maximum (max) values above the DL, the number of results at or above the SQG for residential/parkland land use and the UCL95.

Only one sample contained detectable PAHs (Appendix 1, Table 2). Review of the results showed no samples in exceedance of the SQG, and therefore no analysis was carried out on the PAH data set.

Table III-2: Evaluation of background soil data set against CCME soil quality guidelines for residential/parkland land use.

	Ag	Al	As	B	Ba	Be	Bi	Ca
SQG (ppm)	20	N/A	12	2.0*	750	4.0	N/A	N/A
DL (ppm)	0.2	50	0.2	5.0	1.0	0.5	1.0	100
n>DL	44	131	131	83	131	71	0	131
Min (ppm)	0.20	4100	2.0	5.2	98	0.51	N/A	1700
Max (ppm)	0.37	24000	13	19	570	1.2	N/A	350000
n>SQG	0	N/A	3	83	0	0	N/A	N/A
UCL95 (ppm)	N/A	13000	8.0	12	310	0.98	N/A	6300

	Cd	Co	Cr	Cu	Fe	K	Li	Mg
SQG (ppm)	10	50	64	63	N/A	N/A	N/A	N/A
DL (ppm)	0.5	1.0	1.0	1.0	50	100	1.0	20
n>DL	45	131	131	131	131	131	131	131
Min (ppm)	0.50	4.6	13	4.5	15800	450	4.7	2100
Max (ppm)	1.9	12	40	41	31000	4300	26	7900
n>SQG	0	0	0	0	N/A	N/A	N/A	N/A
UCL95 (ppm)	N/A	8.6	25	21	23000	2300	15	4100

	Mn	Mo	Na	Ni	P	Pb	Sb	Se
SQG (ppm)	N/A	10	N/A	50	N/A	70	20	1.0
DL (ppm)	1.0	1.0	100	1.0	50	1.0	1.0	1.0
n>DL	131	57	16	131	131	131	0	10
Min (ppm)	120	1.0	100	11	400	4.5	N/A	1.0
Max (ppm)	850	2.9	290	43	1900	17.3	N/A	2.4
n>SQG	N/A	0	N/A	0	N/A	0	N/A	10
UCL95 (ppm)	350	N/A	N/A	28	860	11	N/A	N/A

	Sn	Sr	Ti	Tl	U	V	Zn
SQG (ppm)	50	N/A	N/A	1.0	23	130	200
DL (ppm)	5.0	1.0	5.0	0.5	1.0	1.0	5.0
n>DL	1	131	131	0	67	131	131
Min (ppm)	23	11	19	N/A	1.0	29	35
Max (ppm)	23	91	330	N/A	2.7	77	330
n>SQG	0	N/A	N/A	0	N/A	0	7
UCL95 (ppm)	N/A	43	160	N/A	1.6	48	110

DL = detection limit; n>DL = number of values recorded above the DL out of a maximum of 131 sample locations. Min = minimum value above the DL. Max = maximum value above the DL. SQG = CCME Soil Quality Guidelines for residential/parkland land use; * = CCME Soil Quality Guidelines for Agricultural land use; n>SQG = number of times the SQGs were exceeded.

2. Background Data Summary Based on Terrain Units and Sampling Depth

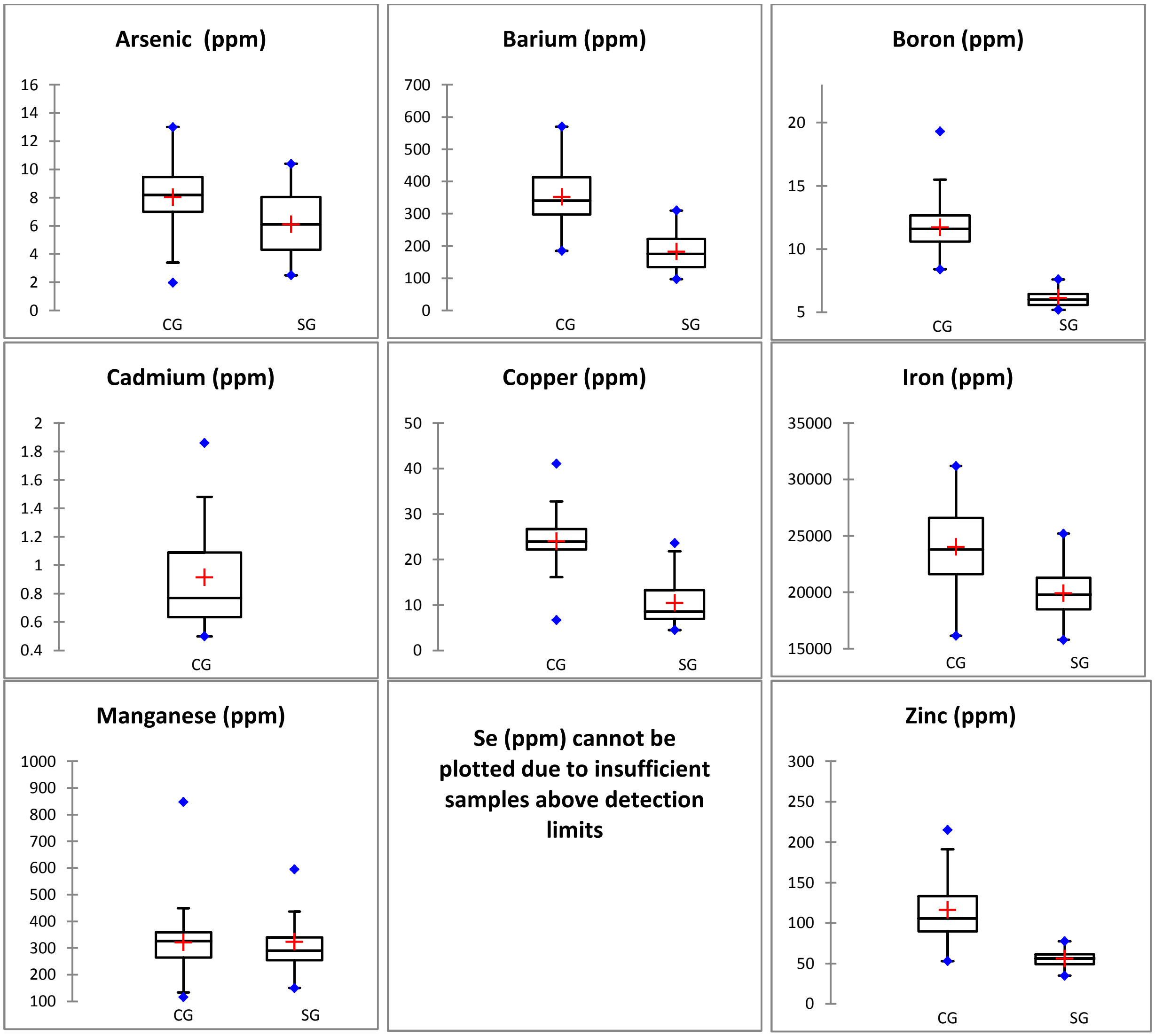
During sample collection, field observations concerning sample site description and soil description were recorded at each sample location. These notes aided in the identification of two terrain units at Garden River. While the site is predominately flat, it was noted that there are local low points and gentle to steep slopes immediately surrounding the small water courses which drain into the Peace River. The CG terrain unit was found to surround these water courses. Further review of the observations showed that in the low laying areas where the CG terrain unit and the SG terrain unit meet, the soil can vary in grain size, colour, and organic content with depth. Of the 131 samples 31 were taken at depth in the range of 50-65 cm, with 100 samples from shallow depths (10-25cm). This created a large data set with two potentially defining factors underlying the data: terrain unit, and sample depth. The first step in the analysis was to decipher whether these two defining factors were of significant importance and therefore require separate consideration for SSTL calculations.

Figure 1 depicts the data using box plots that are split by terrain unit for each of the inorganic elements. Via visual inspection several of the elements seem to vary in concentration between terrain units. In all cases the concentrations are shown to be generally higher in the in the CG terrain unit when compared to the SG terrain unit. There were too few samples with concentrations above the detection limits for Se in either terrain unit, and Cd in the SG terrain unit for representative box and whisker plots to be generated.

Figure 2 and Figure 3 depict the data as split between surface and depth samples for the two different terrain units. As shown in Figure 2, for the SG terrain unit, in most cases concentrations seem to be greater at depth than at the surface except for Ba and Mn where the concentrations appear to be higher near the surface, and Zn where the concentrations do not seem to vary with depth. As shown in Figure 3, for the CG terrain unit, the trends are more varied with As, Cu, Fe concentrations appearing to be higher at depth, with B, Ba, Cd, Mn, Zn concentrations similar at surface or depth. Se concentrations appear to be either slightly higher near the surface or perhaps similar at both depths. With so little data for Se it would be inappropriate to suggest any trend at this point.

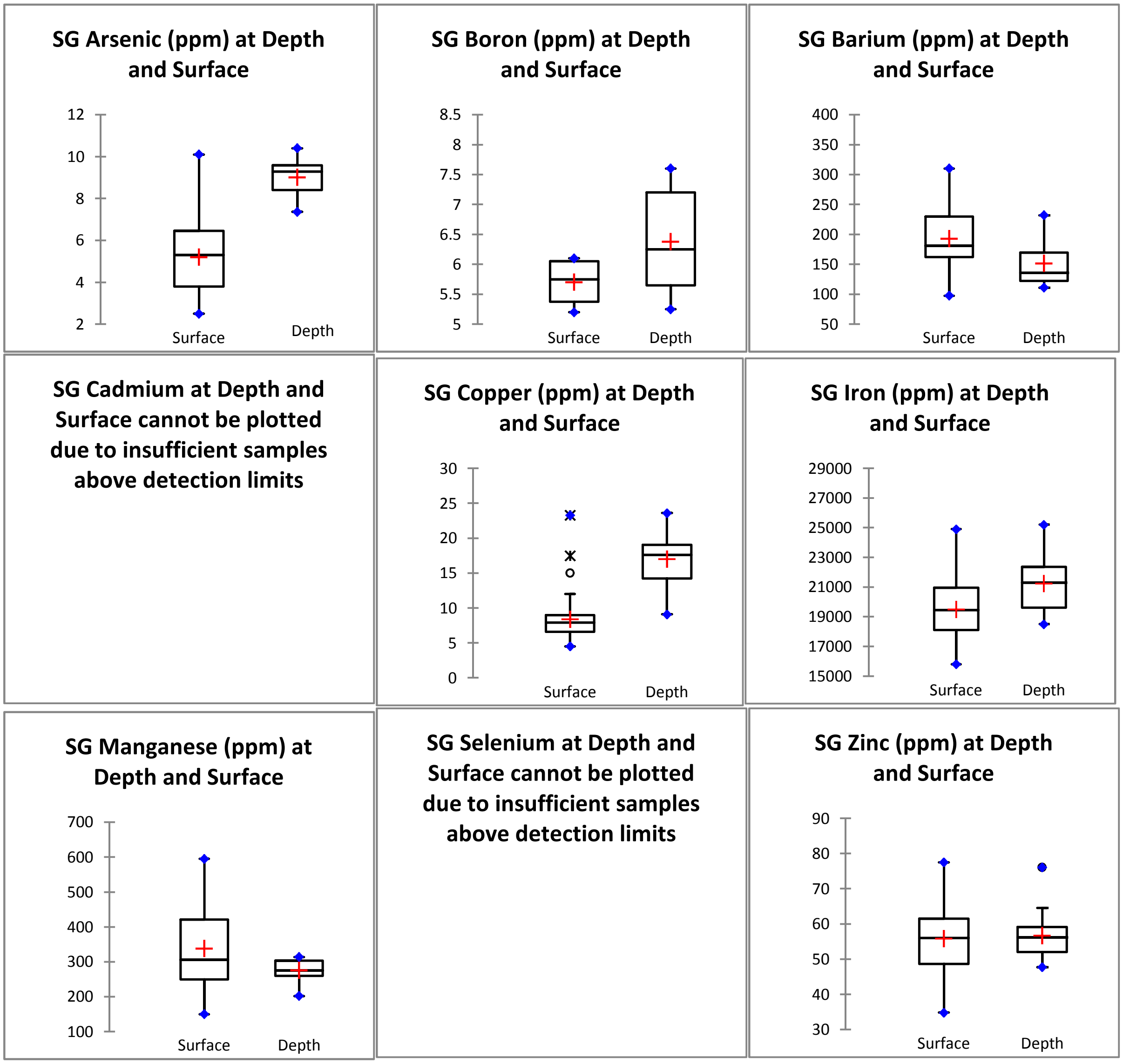
Based on these findings the potential for differences between terrain units is clear. In addition, although varied, depth trends also seem to be present within the data. In order to statistically test for these apparent visual trends two-way ANOVA, completed for each of the inorganic elements, is required. Two-way ANOVA analysis will help direct further analysis steps, specifically whether SSTLs should be calculated for the different terrain units, and whether separate SSTLs should be developed for surface and depth.

Figure 1: Inorganic element concentrations in the Sandy Glaciolacustrine (SG) and Silty/Clayey Glaciolacustrine (CG) terrain units.



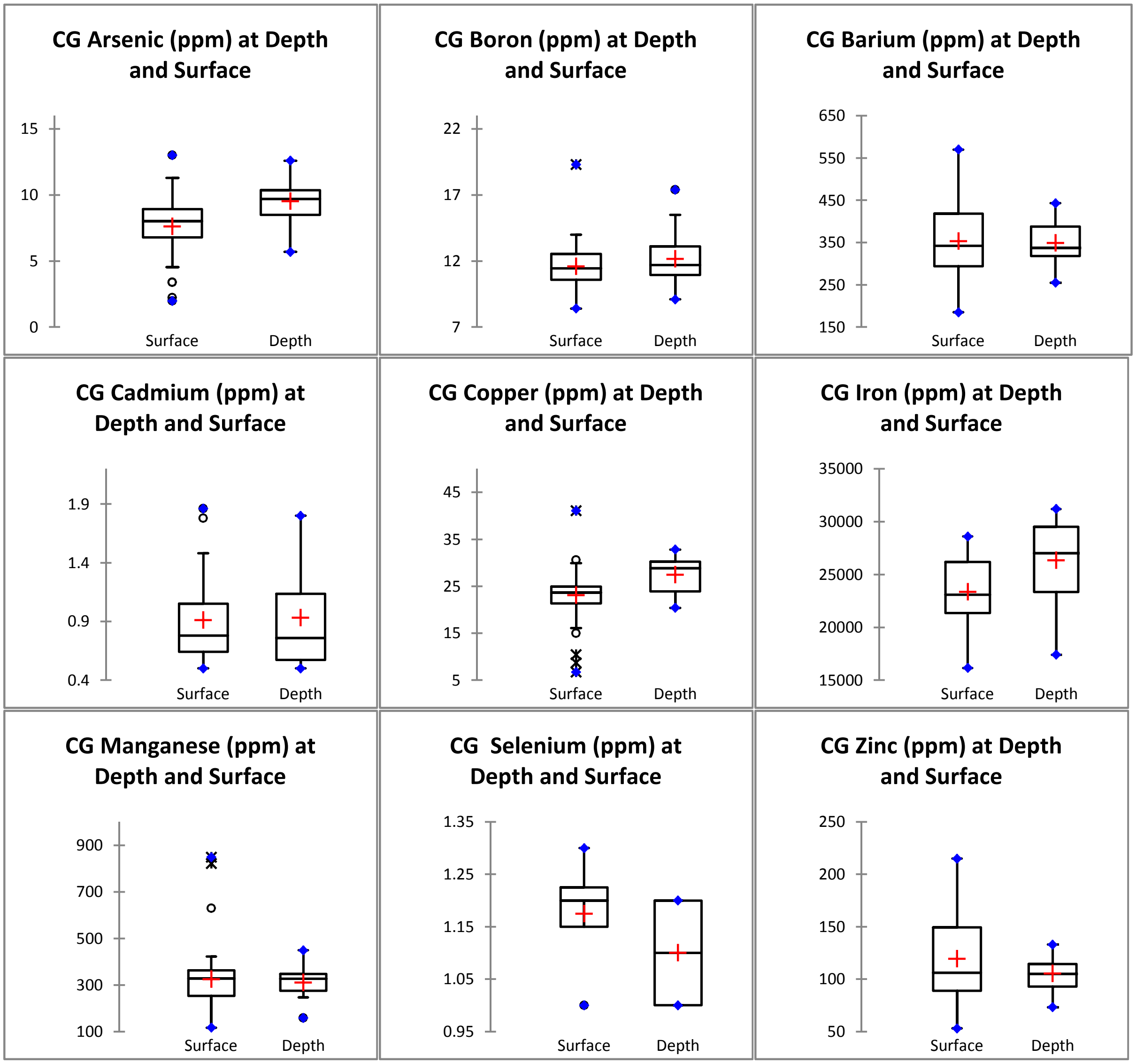
Box and whisker plots representing data distributions for the two terrain units. The centre box line represents the median (50%), with the lower box line identifying the lower quartile (25%), and the upper box line identifying the upper quartile (75%). The red crosshairs represent the mean concentration, with the top extended horizontal line representing the upper mild outlier limit, and the lower extended horizontal line representing the lower mild outlier limit. Where the lower mild outlier limit is calculated as negative the lower limit is then set as the minimum observed value. The blue dots represent the maximum and minimum values in the data set. Generated using XLSTAT 2014.

Figure 2: Surface and depth inorganic element concentrations (in ppm) in the Sandy Glaciolacustrine (SG) terrain unit.



Box and whisker plots representing data distributions for surface and depth samples from the SG terrain unit. The centre box line represents the median (50%), with the lower box line identifying the lower quartile (25%), and the upper box line identifying the upper quartile (75%). The red crosshairs represent the mean concentration, with the top extended horizontal line representing the upper mild outlier limit, and the lower extended horizontal line representing the lower mild outlier limit. Where the lower mild outlier limit is calculated as negative the lower limit is then set as the minimum observed value. The blue dots, unfilled dots, and hashed points represent values outside of the mild outlier limits. Generated using XLSTAT 2014.

Figure 3: Surface and depth inorganic element concentrations (in ppm) in the Silty/Clayey Glaciolacustrine (CG) terrain unit.



Box and whisker plots representing data distributions for surface and depth samples from the CG terrain unit. The centre box line represents the median (50%), with the lower box line identifying the lower quartile (25%), and the upper box line identifying the upper quartile (75%). The red crosshairs represent the mean concentration, with the top extended horizontal line representing the upper mild outlier limit, and the lower extended horizontal line representing the lower mild outlier limit. Where the lower mild outlier limit is calculated as negative the lower limit is then set as the minimum observed value. The blue dots, unfilled dots, and hashed points represent values outside of the mild outlier limits. Generated using XLSTAT 2014.

Before completing in-depth statistical evaluations an initial outlier analysis was completed. Outliers should be eliminated from a background data set as, by definition, they represent values potentially originating from another source and including them in statistical calculations for the determination of SSTLs could distort the derived values. The method used in this study to identify outliers is based on the critical review of methods by Reimann et al. (2005) and does not build on statistical assumptions of a specific distribution. Extreme values represent the values at the tails of a statistical distribution. Upper limit mild outliers (MOs) are higher than the upper mild outlier limit (MOL) which is 1.5 times the interquartile range above the third quartile (the 75th percentile), and upper limit extreme outliers (EOs) are higher than the upper extreme outlier limit (EOL) which is three times the interquartile range above the third quartile. Lower limit MOs are lower than the lower MOL which is 1.5 times the interquartile range below the first quartile (the 25th percentile), and lower limit EOs are lower than the lower EOL which is three times the interquartile range below the first quartile. The 75th percentile represents the level below which 75% of the data points fall. Likewise, the 25th percentile represents the level below which 25% of the data points fall. The interquartile range is the difference between the 75th and 25th percentile, and is the range that contains the middle 50% of the data.

The data sets were compared against the upper and lower EOLs and MOLs for the nine inorganic elements of interest. This comparison identified 27 mild outliers and 11 extreme outliers. For the remainder of the data analysis moving forward, the 11 extreme outliers were removed from the data set. This eliminates the bias that would otherwise be introduced. The remaining mild outliers were included with the data moving forward. A summary of the outlier analysis is found in Table III-3.

Table III-3: Outlier analysis summary for the nine inorganic elements of interest

	As		B		Ba		Cd		Cu	
Terrain unit	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**
SQG (ppm)	12		2*		750		10		63	
DL (ppm)	0.2		5		1		0.5		1	
Surface										
n	47	54	6	52	47	54	0	39	47	54
median (ppm)	5.31	8.02	5.8	11.5	181	342	n/a	0.78	7.9	23.7
upper MOL (ppm)	10.44	12.17	7.1	15.5	332	605	n/a	1.66	12.5	30.2
upper EOL (ppm)	14.42	15.4	8.1	18.4	434	792	n/a	2.27	16.1	35.6
n > upper MOL	0	1	0	1	0	0	n/a	2	3	2
n > upper EOL	0	0	0	1	0	0	n/a	0	2	1
lower MOL (ppm)	<DL	3.56	<DL	7.7	60	107	n/a	<DL	3.0	16.03
lower EOL (ppm)	<DL	0.33	<DL	<DL	<DL	<DL	n/a	<DL	<DL	10.7
n < lower MOL	0	4	0	0	0	0	n/a	0	0	4
n < lower EOL	0	0	0	0	0	0	n/a	0	0	3
Depth										
n	15	15	10	15	15	15	0	6	15	15
median (ppm)	9.29	9.69	6.3	11.7	136	337	n/a	0.76	17.6	28.8
upper MOL (ppm)	11.36	13.15	9.5	16.3	241	493	n/a	1.98	26.3	39.8
upper EOL (ppm)	13.14	15.95	11.9	19.6	312	598	n/a	2.82	33.6	49.3
n > upper MOL	0	0	0	1	0	0	n/a	0	0	0
n > upper EOL	0	0	0	0	0	0	n/a	0	0	0
lower MOL (ppm)	6.62	5.69	<DL	7.7	52	213	n/a	<DL	6.9	14.4
lower EOL (ppm)	4.85	2.89	<DL	<DL	<DL	108	n/a	<DL	<DL	4.9
n < lower MOL	0	0	0	0	0	0	n/a	0	0	0
n < lower EOL	0	0	0	0	0	0	n/a	0	0	0

Table III-3: Outlier analysis summary for the nine inorganic elements of interest cont'd

	Fe		**Mn**		**Se**		**Zn**	
Terrain unit	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**
SQG (ppm)	NA		NA		1		200	
DL (ppm)	50		1		1		5	
Surface								
n	47	54	47	54	0	4	47	54
median (ppm)	19500	23100	306	328	n/a	1.2	57	108
upper MOL (ppm)	25200	33400	679	527	n/a	1.34	82	270
upper EOL (ppm)	29500	40700	936	691	n/a	1.45	101	379
n > upper MOL	0	0	0	3	n/a	0	1	1
n > upper EOL	0	0	0	2	n/a	0	1	0
lower MOL (ppm)	13800	14100	<DL	89	n/a	1.04	29	<DL
lower EOL (ppm)	9600	6900	<DL	<DL	n/a	<DL	10	<DL
n < lower MOL	0	0	0	0	n/a	1	0	0
n < lower EOL	0	0	0	0	n/a	0	0	0
Depth								
n	15	15	15	15	0	6	15	15
median (ppm)	21300	27000	275	326	n/a	1.15	56	105
upper MOL (ppm)	26500	38700	370	456	n/a	1.46	70	147
upper EOL (ppm)	30600	48000	436	565	n/a	1.73	80	180
n > upper MOL	0	0	0	0	n/a	1	1	0
n > upper EOL	0	0	0	0	n/a	1	0	0
lower MOL (ppm)	15500	14000	194	166	n/a	<DL	41	60
lower EOL (ppm)	11400	4900	128	58	n/a	<DL	31	28
n < lower MOL	0	0	0	1	n/a	0	0	0
n < lower EOL	0	0	0	0	n/a	0	0	0

SQG = CCME Soil Quality Guidelines for residential/parkland land use; * = CCME SQGs for agricultural land use. DL = detection limit. SG = sandy glaciolacustrine deposits; CG = silty/clayey glaciolacustrine deposits; n/a = not analyzed as all values were below detection limit. MOL = mild outlier limit; EOL = extreme outlier limit. Lower outlier limits below the DL are marked as such.

Following the outlier analysis, and subsequent removal of extreme outliers, two-way ANOVA's were completed for each element to test if the terrain unit or depth of sampling had a significant effect on the respective concentrations. If the p-value was < 0.05 then it indicated there is a significant difference between the two groups being compared. Table III-4 summarizes the data as separated based on terrain unit and depth of sampling. It can be seen that the terrain unit has an effect on the observed concentrations in a number of cases. For example the difference between the means of the SG and CG terrain unit surface samples for B are 5.7 and 11.4 respectively, with comparatively small standard deviations. The p-value associated with the comparison of terrain units for B is reported as <0.0001 meaning there is a significant difference in terrain unit data sets for B at the 99.99% confidence level. All elements were shown to have significantly different concentrations between terrain units at the 95% confidence level (p<0.05), save Mn (p = 0.325).

Table III-4: Summary of surface and depth sample comparisons by inorganic element for the different terrain units

	As		B		Ba		Cd		Cu	
Terrain unit	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**
Surface										
mean (ppm)	5.19	7.62	5.7	11.4	192.6	353	n/a	0.91	7.9	23.6
st. dev (ppm)	1.69	2.08	0.39	1.4	55.2	82	n/a	0.35	2.0	3.3
n	47	54	6	51	47	54	0	39	45	50
Depth										
mean (ppm)	9.02	9.52	6.38	12.2	151.5	349	n/a	0.93	17	27.4
st. dev (ppm)	0.86	1.76	0.86	2.2	40.5	51	n/a	0.51	3.8	3.9
n	15	15	10	15	15	15	0	6	15	15
2-way ANOVA										
terrain unit p-value	<0.0001		<0.0001		<0.0001		n/a		<0.0001	
depth p-value	<0.0001		0.006		0.042		0.905		<0.0001	

	Fe		Mn		Se		Zn	
Terrain unit	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**	**SG**	**CG**
Surface								
mean (ppm)	19500	23400	338	305	n/a	1.2	55.8	127.7
st. dev (ppm)	2100	3000	122	93	n/a	0.1	10.1	55.6
n	47	54	47	52	0	4	46	54
Depth								
mean (ppm)	21200	26300	276	310	n/a	1.1	56.8	105.5
st. dev (ppm)	1900	4200	31	67	n/a	0.1	7.2	17.5
n	15	15	15	15	0	5	15	15
2-way ANOVA								
terrain unit p-value	<0.0001		0.325		n/a		<0.0001	
depth p-value	<0.0001		0.173		0.351		0.082	

*2-way ANOVA's completed using XLSTAT 2014. st. dev = standard deviation n/a = not analyzed as all values were below detection limit

In some cases the sample depth can also be seen to have an effect on observed concentrations. For example, in Table III-4, the mean concentrations for surface and depth samples for As surface samples are 5.19 and 9.02 respectively, with comparatively small standard deviations. The p-value associated with the As depth comparison is reported as <0.0001 meaning there is a significant difference in depth sample and surface sample data sets for As at the 99.99% confidence level. As, B, Ba, Cu, Fe all had p-values for sample depth comparisons below 0.05 (95% confidence level), indicating a difference in the depth and surface sample data sets. Cd, Mn, Se, Zn all reported p-values above 0.05, which indicates that there is no difference in the two data sets. These results correspond with the visual observations from Figures 1, 2 and 3 discussed earlier. Last it should also be noted that the CG terrain unit in all cases but one (Mn

CG surface samples) had higher standard deviations than the respectively comparative SG terrain unit. This needs to be taken into account when selecting the appropriate SSTL calculations later in this report.

Given the significant effect seen for terrain unit, further analysis separated the data into two different sets, the SG and CG terrain unit data sets. Although the concentrations of Mn were shown to not be significantly different for the separate terrain units it was also carried forward in the analysis via different terrain unit data sets. This did not affect overall outcomes or recommendations regarding SSTL's for Mn as will be seen and discussed later in Section IV. Based on the statistical testing for sampling depth effects As, B, Ba, Cu, Fe were carried forward and analyzed via separate data sets for surface samples and depth samples. As it was seen that depth did not have a significant effect on Cd, Mn, Se, Zn these elements were carried forward as combined data sets (surface and depth samples pooled together).

3. *Data Distribution Testing*

The EPA endorsed software program ProUCL 5.0 (Singh and Singh, 2013) was used to estimate several of the potentially useable SSTLs outlined in this report. A number of different potentially useable SSTLs can be calculated using ProUCL in several different ways depending on the properties of the underlying data set. Testing for data distribution fit is an important step in selecting an appropriate statistical method for calculating SSTLs, as some SSTL calculations assume a normal distribution (e.g. mean + 3Sdev), while others require differing methods of calculation depending on the data distribution. Distribution analysis began with first testing if the data fit a normal distribution, evaluated using the Shapiro-Wilk test. If the Shapiro-Wilk test did not suggest normality of the data set a Lilliefors test was employed as the Lilliefors has been identified as more applicable than the Shapiro-Wilk test for larger data sets (Dudewicz and Misra 1988; Conover 1999). Where in the two-way ANOVA analysis a p-value below 0.05 suggested a significant difference between groups at the 95% confidence level, here a Shapiro-Wilk or Lilliefors test p-value above 0.05 suggests that the data fit a normal distribution at the 95% confidence level.

If the data did not fit a normal distribution then the data was tested for log-normal and gamma distributions. Here, a Kolmogorov-Smirnov (K-S) test was employed to test the fit of the data to the suggested distribution. For the K-S test a p-value above 0.05 suggests that the data fit the respective distribution being tested at the 95% confidence level. K-S p-values for the normal distributions are also reported to further support the findings of the Shapiro-Wilk or Lilliefors tests. Log-normal and gamma distributions are commonly used to fit right skewed data sets. In this case a right skewed data set is one that contains a large proportion of smaller values (the right hand tail is elongated). If the data set did not fit any of the above data distributions it was assumed to be non-parametric. It should be noted that when non-parametric methods are used for small data sets (e.g. <60) calculated SSTLs should be used with caution as they may not provide complete coverage for future samples from background conditions.

Table III-5: Data distribution summary for nine inorganic elements in the Sandy Glaciolacustrine (SG) terrain unit.

	As		**B**		**Ba**		**Cd**	**Cu**	
Sample Depth	**Surf**	**Dept**	**Surf**	**Dept**	**Surf**	**Dept**		**Surf**	**Dept**
Shapiro-Wilk test									
W statistic	0.962	0.968	0.883	0.920	0.962	0.824	n/a	0.938	0.981
p-value	0.124	0.831	0.281	0.355	0.124	0.008	n/a	0.018	0.977
Lilliefors test									
Std. D statistic						0.891	n/a	0.107	
p-value						0.032	n/a	0.660	
K-S test									
D statistic	0.090	0.158	0.194	0.159	0.115	0.222	n/a	0.716	0.155
p-value	0.828	0.812	0.960	0.944	0.539	0.402	n/a	0.223	0.830
Distribution	norm	norm	norm	norm	norm	log-n	n/a	norm	norm

	Fe		**Mn**	**Se**	**Zn**
Sample Depth	**Surf**	**Dept**	**Combined**		**Combined**
Shapiro-Wilk test					
W statistic	0.981	0.951	0.867	n/a	0.975
p-value	0.650	0.546	<0.001	n/a	0.235
Lilliefors test					
Std. D statistic			1.576	n/a	
p-value			<0.001	n/a	
K-S test					
D statistic	0.055	0.158	N/A	n/a	0.078
p-value	0.999	0.817	N/A	n/a	0.835
Distribution	norm	norm	non-para	n/a	norm

Surf = surface; Dept = Depth; Combined = surface and depth combined; Std. D = standardized Lilliefors statistic; K-S = Kolmogorov-Smirnov; norm = normal distribution; log-n = log-normal distribution; non-para = non-parametric distribution; n/a = not analyzed as insufficient values above detection limit. All distributions were calculated for available soil data without substitutions for values that were less than the analytical detection limit.

Table III-6: Data distribution summary for nine inorganic elements in the Silty/Clayey Glaciolacustrine (CG) terrain unit.

	As		B		Ba		Cd	Cu	
Sample Depth	**Surf**	**Dept**	**Surf**	**Dept**	**Surf**	**Dept**	**Combined**	**Surf**	**Dept**
Shapiro-Wilk test									
W statistic	0.952	0.968	0.943	0.925	0.984	0.969	0.882	0.962	0.924
p-value	0.032	0.834	0.278	0.230	0.666	0.843	<0.001	0.111	0.220
Lilliefors test									
Std. D statistic	0.881						1.186		
p-value	0.051						0.001		
K-S test									
D statistic	0.120	0.137	0.146	0.183	0.093	0.152	0.129	0.119	0.189
p-value	0.396	0.920	0.755	0.652	0.720	0.850	0.420	0.455	0.610
Distribution	norm	norm	norm	norm	norm	norm	log-n	norm	norm

	Fe		Mn	Se	Zn
Sample Depth	**Surf**	**Dept**	**Combined**	**Combined**	**Combined**
Shapiro-Wilk test					
W statistic	0.971	0.914	0.951	0.860	0.861
p-value	0.215	0.155	0.011	0.120	<0.001
Lilliefors test					
Std. D statistic			0.107		1.778
p-value			0.412		<0.001
K-S test					
D statistic	0.103	0.211	0.872	0.305	0.148
p-value	0.588	0.468	0.057	0.378	0.088
Distribution	norm	norm	norm	norm	log-n

Surf = surface; Dept = Depth; Combined = surface and depth combined; Std. D = standardized Lilliefors statistic; K-S = Kolmogorov-Smirnov; norm = normal distribution; log-n = log-normal distribution; non-para = non-parametric distribution. All distributions were calculated for available soil data without substitutions for values that were less than the analytical detection limit.

Table III-5 summarizes the statistical testing and distribution outcomes for the nine inorganic elements for both surface and depth samples in the sandy glaciolacustrine (SG) terrain unit, where Table III-6 similarly summarizes the same information for the silty/clayey glaciolacustrine (CG) terrain unit. The majority of the data sets fit a normal distribution with the exception of Ba at depth in the SG terrain unit, Cd in the CG terrain unit, and Zn in the CG terrain unit, all of which fit a log-normal distribution. The data set for Mn in the SG terrain unit was the only data set which could not be fit to any distribution and was therefore analyzed further using non-parametric methodologies. Previously it was mentioned that non-parametric methods for estimating SSTLs should be used with caution where data sets are small ($n<60$). In this case the combined data set for Mn in the SG terrain unit was relatively large with 62 observations (47 surface + 15 depth), therefore a reasonable amount of confidence can be had in further analysis and interpretation.

IV. DEVELOPMENT OF SITE-SPECIFIC TARGET LEVELS

Where inorganic element concentrations naturally approach or exceed soil quality guidelines the derivation of site-specific target levels is required to allow adequate identification and delineation of contaminated soil areas. A uniform random background sampling program has been executed at the Garden River Site to collect sufficient samples to allow statistical inferences to be made with confidence.

This report has identified nine inorganic elements for further evaluation for the need to calculate SSTLs based on calculated means, SQG exceedances from this background assessment and guideline exceedances reported in previous ESAs. The results of this study show that the Garden River site consists of two distinct terrain units based on field observations and analytical results. In addition, for some elements there were significant differences between surface (10-25 cm) and depth (50-65 cm) samples, however this was not true for all elements. Where significant differences between surface and depth samples was observed the data sets were treated separately, where no significant differences were observed between surface and depth samples the data sets were combined. Eleven extreme outliers were eliminated from the data set. The data sets were normally distributed for most elements in both terrain units at either surface or depth with the exception of Ba at depth in the SG terrain unit (log-normal), Cd in the CG terrain unit (log-normal), Zn in the CG terrain unit (log-normal), and Mn in the SG terrain unit (non-parametric). Only one sample contained detectable PAHs and none of the individual compounds in this group exceeded the SQG therefore no statistical analysis was carried out on the PAH data set.

There are several accepted approaches for the calculation of SSTLs (BCMWLAP 2000; CCME 2001; US EPA 1995; Singh and Maichle 2013). These are (i) use of the maximum background concentration; (ii) calculation of a mean plus a designated number of standard deviations; (iii) calculation of an upper tolerance limit (UTL); (iv) calculation of an upper prediction limit (UPL); and (v) calculation of mild outlier limit and extreme outlier limit and (vi) calculation of the upper simultaneous limit (USL).

Use of the maximum measured background concentration is generally not recommended because no calculations are made to determine representative background data ranges and the maxima are sensitive to the distorting effects of outliers.

Calculation of a mean plus a designated number of standard deviations (mean + n Sdev) assumes normal distribution of the data and is sensitive to the distorting effects of outliers. Therefore, the values derived using a mean + n Sdev to establish site-specific threshold levels may be too high to properly distinguish between contamination and background data, that is, values that should be identified as contamination will be classified as background levels.

The UTL represents a value below which a designated percentage of the data will fall. A UTL95-95 is the value below which 95% of the population will fall, with 95% confidence. Use of the UTL is preferable to the use of the mean plus n standard deviations because it varies with the number of samples and therefore takes into consideration the greater uncertainty associated with fewer samples. By definition, the UTL95-95 allows for 5% of background data to be identified as contamination (Singh and Maichle 2013).

The UPL establishes the concentration that will not be exceeded by a specified number of samples, for a given confidence limit and is to be used for point-by-point individual site observation comparisons. The UPL is calculated in a manner similar to that used to calculate a UTL, except that it factors in not only the confidence limit and number of background samples but also the number of future sampling events. Using the UPL95 to compare many future sampling results may result in a relatively high number of false positives where background samples are incorrectly identified as contaminated (Singh and Maichle 2013).

The MOL and EOL do not assume that the data fit a specific distribution model. They are calculated in a robust way, by using measures of location and variability of the data, such as the mean and interquartile range, that are less influenced by the outliers themselves. The median and the mode are more robust measures of location than the mean — that is, they are less influenced by extreme values. Similarly, the interquartile range is a more robust measure of variability of the data than the standard deviation, which is used in the mean + n Sdev, UTL and UPL approaches for normally distributed data. Tukey (1977) describes robust outlier determination and defined mild outliers as 1.5 times the interquartile range above the third quartile (the 75th percentile). Extreme outliers are those above three times the interquartile range above the third quartile. Reimann et al. (2005) reviewed methods of identifying outliers and concluded that the MOL and EOL calculations were better for estimating the threshold values of background data than methods such as mean + n Sdev, UTL and UPL.

The upper simultaneous limit has been added by the US EPA as an alternative and recommended method for the development of background threshold values in order to address the high false positive error rate that results from larger data sets using a UTL or UPL (US EPA 1995). The USL is based on an established background data set free of outliers and representing a single statistical population. The false positive error rate does not change with the number of comparisons, as the USL is designed to perform many comparisons simultaneously. Typically, the use of a USL tends to result in a smaller number of false positives than does a UTL or a UPL, especially with a large background data set (Singh and Maichle 2013).

Where the data distribution was concluded normal or log-normal the UTL95-95, UPL, and USL were then calculated based on the underlying data distribution assumption. Where a non-parametric distribution is identified calculations in ProUCL 5.0 are made based on order statistics that do not take into account the variability of the data set [see David and Nagaraja (2003), Conover (1999) for a complete description], bootstrapping (for the UTL), or the Chebyshev inequality (for the UPL).

ProUCL 5.0 includes methods for the estimation of SSTLs while taking into account the number of non-detect values in the data set and the detection limit itself (Singh and Singh 2013). A large number of non-detects in a data set (e.g. 70%) suggests that the concentrations on site are commonly close to or below the detection limit. If non-detect values are omitted from the analysis the data set is understandably altered/biased towards the high end of the values found on site and estimated SSTLs will be larger than perhaps appropriate. There is no perfect method for estimating SSTLs in the presence of a large number of non-detect values. The historical method of entering non-detect values as half the detection limit (DL/2) is not recommended for use in ProUCL estimations (Singh and Singh 2013). For the present analysis the distribution was first fit without the non-detects present in the data set. Several methods were then employed for SSTL estimations which account for the detection limit and the number of non-detects in the data set including computationally heavy bootstrapping methods and the robust nonparametric methodology known as the Kaplan-Meier (KM) method. Although the KM method accounts for non-detects in SSTL estimations, as we do not know the actual concentration values for any datum reported below the detection limit, there is still a potential for biasing the data set slightly higher than it truly is (not that the true data set can ever be known where non-detects exist). Although the estimation may be slightly high where many non-detects are present, the KM method will however give a more accurate (and appropriately lower) SSTL estimation than if ignoring non-detects altogether.

The maximum background concentration (max), mean + 3 standard deviations, EOL, UTL95-95, UPL and USL have been calculated using the Garden River data and are presented in Table IV-1 for the SG terrain unit and Table IV-2 for the CG terrain unit.

Table IV-1: Site-specific target levels calculated by different statistical methods for the nine inorganic elements of interest for the sandy glaciolacustrine terrain unit at the Garden River Site.

SG terrain unit	As Surf	As Dept	B Surf	B Dept	Ba Surf	Ba Dept	Cd Combined	Cu Surf	Cu Dept
SQG (ppm)	12		2*		750		10	63	
DL (ppm)	0.2		5		1		0.5	1	
Min (ppm)	2.5	7.4	5.2	5.3	98	111	n/a	4.5	9.1
Max (ppm)	10.1	10.4	6.1	7.6	310	232	n/a	15	23.6
n Detects	47	15	6	10	47	15	n/a	45	15
n No Detects	0	0	41	5	0	0	n/a	0	0
Mean (ppm)	5.2	9.0	5.7	6.4	193	152	n/a	7.9	17.0
St. dev (ppm)	1.7	0.9	0.4	0.9	55	41	n/a	2.0	3.8
Mean + 3 St. dev (ppm)	10.3	11.7	6.9	9.1	358	275	n/a	13.9	28.4
EOL (ppm)	14.4	13.1	8.1	11.9	434	312	n/a	15.0	33.6
UTL95-95 (ppm)	8.7	11.2	5.6 [a]	8.3 [a]	307	276	n/a	12.0	26.7
UPL (ppm)	8.1	10.6	5.5 [a]	7.6 [a]	286	230	n/a	11.2	23.9
USL (ppm)	10.2	11.1	5.9 [a]	8.2 [a]	354	266	n/a	13.7	26.1

SG terrain unit	Fe Surf	Fe Dept	Mn Combined	Se Combined	Zn Combined
SQG (ppm)	NA		NA	1	200
DL (ppm)	50		1	1	5
Min (ppm)	15800	18500	117	n/a	35
Max (ppm)	24900	25200	629	n/a	78
n Detects	47	15	62	n/a	61
n No Detects	0	0	0	n/a	0
Mean (ppm)	19506	21233	323	n/a	56
St. dev (ppm)	2107	1920	110	n/a	10
Mean + 3 St. dev (ppm)	25827	26993	653	n/a	86
EOL (ppm)	29500	30600	612	n/a	97
UTL95-95 (ppm)	23876	26160	574	n/a	75
UPL (ppm)	23081	24726	552	n/a	72
USL (ppm)	25686	25859	595	n/a	85

*CCME SQG Agricultural land use. SG = sandy glaciolacustrine. n/a = not analyzed as insufficient values were above detection limit. [a]Accounts for non-detects using the Kaplan-Meier (KM) method.

Table IV-2: Site-specific target levels calculated by different statistical methods for the nine inorganic elements of interest for the silty/clayey glaciolacustrine terrain unit at the Garden River Site.

CG terrain unit	As Surf	As Dept	B Surf	B Dept	Ba Surf	Ba Dept	Cd Combined	Cu Surf	Cu Dept
SQG (ppm)	12		2*		750		10	63	
DL (ppm)	0.2		5		1		0.5	1	
Min (ppm)	2.0	5.7	8.4	9.1	185	255	0.5	15	20
Max (ppm)	13	12.6	14	17.4	570	443	1.9	30	33
n Detects	54	15	51	15	54	15	45	50	15
n No Detects	0	0	2	0	0	0	24	0	0
Mean (ppm)	7.6	9.5	11.4	12.2	353	349	0.9	24	27
St. dev (ppm)	2.1	1.8	1.4	2.2	82	51	0.4	3.3	3.9
Mean + 3 St. dev (ppm)	13.9	14.9	15.6	18.8	599	502	2.1	33.9	38.7
EOL (ppm)	15.4	16.0	18.4	19.6	792	598	2.5	33	49
UTL95-95 (ppm)	11.9	14.0	14.9 [a]	17.7	521	480	1.9	30	37
UPL (ppm)	11.1	12.7	14.3 [a]	16.1	492	442	1.6	29	35
USL (ppm)	13.8[b]	13.8[b]	16.6 [a]	17.4	599	472	3.4	33	37

CG terrain unit	Fe Surf	Fe Dept	Mn Combined	Se Combined	Zn Combined
SQG (ppm)	NA		NA	1	200
DL (ppm)	50		1	1	5
Min (ppm)	16150	17400	150	1.0	53
Max (ppm)	28600	31200	595	1.3	333
n Detects	54	15	67	9	69
n No Detects	0	0	0	60	0
Mean (ppm)	23362	26340	306	1.1	123
St. dev (ppm)	3043	4204	87	0.1	51
Mean + 3 St. dev (ppm)	32491	38952	567	1.4	276
EOL (ppm)	40650	47950	687	1.8	279
UTL95-95 (ppm)	29570	37128	480	1.1[a]	237
UPL (ppm)	28503	33987	453	1.1 [a]	212
USL (ppm)	32450	36468	574	1.2 [a]	354

*CCME SQG Agricultural land use. CG = silty/clayey glaciolacustrine. [a]Accounts for non-detects using the Kaplan-Meier (KM) method, [b]Numbers appear the same due to rounding.

In terms of recommending SSTLs the maximum background concentration is appropriate for sites with low variability in inorganic element concentrations; it is sensitive to the distorting effects of a highly variable range, such as that seen at Garden River, and therefore should not be used for the site. The mean + 3 Sdev assumes that the data are normally distributed. While this is true for most elements for Garden River, not all the data are normally distributed and the SSTLs derived this way are prone to false negatives, i.e. sample points are potentially identified as background data when in truth they are contamination. The UTL and UPL do not have to assume a specific underlying distribution but are prone to producing a higher number of false positives, that is, data are incorrectly identified as contaminated where in truth they are not. To avoid the remediation of pristine soils, they should not be used at Garden River. The EOL does not assume that the data fit any distribution; it does, however, take into account variability in the data set. Because of the large variability in the CG terrain unit and the comparatively low variability in the SG terrain unit, it is not deemed an appropriate method for the site. Since the USL is perhaps the most robust estimation for SSTLs it has recently been suggested by the US EPA as one of the better methods for calculating threshold values of background data (Singh and Maichle 2013). Based on the limitations of some of the other SSTL estimation methods it is recommended that the USL be used to set the SSTLs for Garden River.

Table IV-3 summarizes the SQGs and the calculated USLs for the two terrain units at the different depths. For the SG terrain unit all calculated USL values are below the SQG for residential/parkland land use for both surface and depth, therefore a site specific target level is not recommended for any of the nine elements in the SG terrain unit. If at a later date the land use is revised to agricultural land use, B would then have a SSTL.

Table IV-3: Soil quality guidelines and upper simultaneous limits for the SG and CG terrain units at the Garden River site.

	As	**Ba**	**B**	**Cd**	**Cu**	**Fe**	**Mn**	**Se**	**Zn**
SQG Residential/Parkland (ppm)	12	750	2*	10	63	N/G	N/G	1.0	200
USL_{SG} Sandy Glaciolacustrine - surface (ppm)	10.2	354	5.9	N/G	14	25,700	595	N/G	85
USL_{SG} Sandy Glaciolacustrine - depth (ppm)	5.9	266	8.2	N/G	26	25,900	595	N/G	85
USL_{CG} Silty/Clayey Glaciolacustrine - surface (ppm)	**13.8**	599	16.6	3.4	33	32,450	574	**1.2**	**354**
USL_{CG} Silty/Clayey Glaciolacustrine - depth (ppm)	**13.8**	472	17.4	3.4	37	36,468	574	**1.2**	**354**

*CCME SQG Agricultural land use, N/G = no guideline value.

In the CG terrain unit, USLs were calculated to fall above the SQG for residential/parkland use at both surface and depth for As, Se, and Zn. In all three cases the calculated values for surface and depth are the same. Although there is no SQG for residential/parkland land use for boron the SSTLs are calculated and presented for reference. For As the USL of 13.8 ppm is rounded to the nearest digit and a SSTL of 14 ppm is recommended.

For Se the USL of 1.2 ppm is recommended as the SSTL. For Zn the USL is rounded down from 354 ppm to a recommended SSTL of 350 ppm. Should the future land use of the site change to make the agricultural soil quality guidelines more applicable the USL for boron can be used as a SSTL to prevent unnecessary remediation of naturally elevated soils. As there is no SQG for Fe or Mn and these elements are common, benign components of soil, SSTLs are not required or recommended for these two elements. Since the calculated SSTLs for Ba, Cd and Cu are below the SQG, it is recommended that the SQGs be used. The recommended SSTLs for Garden River are summarized in Table IV-4.

Table IV-4: Recommended site-specific target levels for future management at the Garden River site.

	As	Ba	B	Cd	Cu	Fe	Mn	Se	Zn
Silty/Clayey Glaciolacustrine (ppm)	**14**	750	17*	10	63	N/A	N/A	**1.2**	**350**

*****Values for B are presented for information only in case land-use changes to agricultural scenario. There are no CCME SQG for residential/parkland land use.

Bolded values represent SSTLs based on the USL from background data. Non-bolded values represent the CCME SQG for residential/parkland land-use.

V. Summary and Conclusions

The goal of the background soil assessment at Garden River was to establish the range of natural levels of inorganic elements and PAHs in the surrounding environment and to establish site-specific target levels where required. The 145 soil samples collected as part of the program were analyzed for a suite of 31 inorganic elements. An additional 15 samples were collected and analyzed for PAHs in 2014. However, all PAH results were below guideline values and also below detection in all but one sample. PAHs are not considered to be naturally elevated in the Garden River area in the top 0.70 m of soil.

Because of elevated concentrations of inorganic elements identified in past ESAs, the concentrations exceeding the SQGs in background soil samples, as well as the calculated average background concentrations (UCL95), As, B, Ba, Cd, Cu, Fe, Mn, Se and Zn were identified as contaminants of interest for the development of SSTLs at the site. Observations made during the sample collection coupled with analytical results indicate that there are two geochemically different terrain units on the site, the SG (Sandy Glaciolacustrine) and the CG (Silty/Clayey Glaciolacustrine) terrain units. Samples taken at the surface (10-25 cm) were also initially shown to be different than samples taken at depth (50-65 cm). Extreme outlier limits were calculated for the nine contaminants of interest and those data points removed from the data sets. The distribution of the data was investigated for each element and found to be normally distributed for most inorganic elements with the exception of Ba at depth in the SG terrain unit (log-normal), Cd in the CG terrain unit (log-normal), Zn in the CG terrain unit (log-normal), and Mn in the SG terrain unit (non-parametric). The maximum background concentration, mean + 3 Sdev, UTL95-95, UPL, EOL and USL were calculated. The USL has been selected as most appropriate for use in developing and recommending SSTLs at Garden River.

The calculated SSTLs for all elements in the SG terrain unit and for Ba, Cd and Cu in the CG terrain unit were below the SQGs. In these cases, the SQGs should be used rather than the SSTLs. There is no residential/parkland SQG for B, Fe or Mn, so the SSTLs for these elements have been calculated for reference only in case future land use scenarios require the use of more conservative SQGs. If the agricultural land use is applied to an area at Garden River, the SSTL for B should be used as it is higher than the SQG for agricultural land use. SSTLs have been calculated for As, Se and Zn for the CG terrain unit. Concentrations of As, Se and Zn that surpass the SQG, but do not surpass the SSTLs, should be considered natural and these areas should be excluded from further assessment or remedial action. The recommended SSTLs for the CG terrain unit for Garden River are summarized in Table IV-4.

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Appendix 1: Analytical Results

Table 1: Background Soil Sample Inorganic Element Analytical Results

Sample #	Location	Depth	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
			[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]
CCME Soil Quality Guidelines for Residential/Parkland Land Use			*-*	***20***	***12***	***750***	***4.0***	*-*	***2.0****	***10***	*-*	***64***	***40***	***63***	*-*	***70***	*-*	*-*	*-*	***10***	***50***	*-*	*-*	***1.0***	***20***	*-*	*-*	***1.0***	***50.0***	*-*	***23***	***130***	***200***
1. Silty/Clayey Glaciolacustrine Terrain Unit																																	
14-37240/41	1	10-20	11000	<1.0	8.2	300	0.62	<1.0	***13***	0.74	10000	20	8.8	22	21000	10	14	5100	320	1.2	26	1000	1900	<1.0	<0.20	<100	45	<0.50	<5.0	56	1.2	38	95
14-37242	1	50-60	13000	<1.0	9.7	260	0.77	<1.0	***11***	0.51	8100	24	9.7	23	24000	12	16	4300	300	1.3	33	660	1900	<1.0	0.21	<100	48	<0.50	<5.0	60	1.5	47	86
14-37243	2	10-20	11000	<1.0	9.2	290	0.64	<1.0	***12***	0.97	8300	20	9.2	24	22000	11	16	4200	350	1.3	28	1000	1900	<1.0	0.21	<100	47	<0.50	<5.0	32	1.3	37	98
14-37244	3	10-20	12000	<1.0	9.0	310	0.65	<1.0	***12***	0.58	10000	22	9.6	24	22000	11	17	4900	320	1.2	28	820	1900	<1.0	0.20	120	48	<0.50	<5.0	45	1.2	41	100
14-37245	5	10-20	13000	<1.0	8.1	330	0.70	<1.0	***13***	1.8	11000	23	10	30	23000	13	16	4400	370	1.4	33	880	2300	<1.0	<0.20	<100	58	<0.50	<5.0	35	1.5	44	110
14-37246	6	15-25	11000	<1.0	8.5	290	0.66	<1.0	***12***	0.57	7800	21	8.6	21	22000	11	16	4100	290	1.2	25	860	2000	<1.0	<0.20	<100	45	<0.50	<5.0	42	1.2	40	88
14-37247	7	10-20	11000	<1.0	7.6	320	0.64	<1.0	***13***	<0.50	9200	20	8.2	31	20000	11	12	3900	280	<1.0	30	920	2100	<1.0	<0.20	<100	52	<0.50	<5.0	40	1.3	37	66
14-37248	7	50-60	16000	<1.0	5.7	320	0.86	<1.0	***9.5***	<0.50	5900	28	5.9	28	17000	16	20	4300	160	<1.0	22	760	2300	***1.0***	0.21	100	49	<0.50	<5.0	40	1.7	56	94
14-37249	12	15-25	10000	<1.0	5.3	290	0.62	<1.0	***9.0***	1.2	10000	18	8.1	29	19000	11	13	4300	230	1.2	31	820	1800	<1.0	<0.20	<100	49	<0.50	<5.0	22	1.3	34	110
14-37250/51	13	15-25	12000	<1.0	9.6	280	0.66	<1.0	***10***	<0.50	7200	21	8.0	27	22000	11	14	3500	330	1.8	25	790	1900	<1.0	<0.20	<100	46	<0.50	<5.0	31	1.1	40	65
14-37252	4	5-15	12000	<1.0	8.5	320	0.64	<1.0	***12***	0.62	8400	22	9.0	22	22000	11	16	5100	320	1.1	27	840	2300	<1.0	<0.20	<100	42	<0.50	<5.0	49	1.2	41	88
14-37253	8	20-30	13000	<1.0	11	280	0.70	<1.0	***11***	0.52	5300	23	8.9	19	26000	12	17	4100	180	1.4	25	660	2100	<1.0	<0.20	<100	40	<0.50	<5.0	61	1.2	46	89
14-37254	9	10-20	13000	<1.0	9.4	330	0.72	<1.0	***12***	0.56	8200	24	9.5	24	24000	12	17	4400	330	1.3	30	750	2000	<1.0	<0.20	<100	47	<0.50	<5.0	41	1.2	46	94
14-37255	9	45-55	16000	<1.0	8.4	440	0.85	<1.0	***17***	1.3	12000	27	9.7	29	24000	12	19	4900	360	1.1	37	760	2600	***1.2***	0.25	110	65	<0.50	<5.0	45	1.4	49	130
14-37256	11	10-20	11000	<1.0	8.1	340	0.73	<1.0	***9.6***	0.69	7800	19	7.7	41	21000	12	12	3400	230	1.3	41	770	1900	<1.0	<0.20	<100	45	<0.50	<5.0	30	1.6	37	72
14-37257	11	50-60	15000	<1.0	8.1	310	0.86	<1.0	***12***	0.76	16000	27	10	32	23000	14	17	5800	290	1.1	38	710	1900	***1.2***	0.22	<100	63	<0.50	<5.0	37	1.7	53	87
14-37258	10	10-20	14000	<1.0	9.5	280	0.74	<1.0	***13***	0.77	8100	25	9.6	25	24000	12	18	4500	320	1.4	30	700	2100	<1.0	<0.20	110	49	<0.50	<5.0	42	1.4	47	90
14-37259	14	10-20	12000	<1.0	9.9	260	0.67	<1.0	***11***	<0.50	5700	23	6.4	30	20000	13	14	3400	150	2.3	27	710	2200	<1.0	<0.20	<100	41	<0.50	<5.0	42	1.4	44	53
14-37264	19	5-15	12000	<1.0	6.7	310	0.66	<1.0	***11***	0.70	14000	20	7.4	21	19000	13	13	4300	250	1.4	24	810	2100	<1.0	<0.20	<100	62	<0.50	<5.0	21	1.3	39	93
14-37265	20	20-30	12000	<1.0	8.5	190	0.65	<1.0	***11***	0.67	9600	22	7.9	21	22000	11	15	4900	250	1.4	25	760	1900	***1.2***	<0.20	190	52	<0.50	<5.0	48	1.4	41	88
14-37266	17	20-30	7800	<1.0	***13***	220	0.55	<1.0	***11***	0.65	12000	15	9.8	30	21000	8.5	9.0	3500	200	2.9	31	820	1200	<1.0	<0.20	120	55	<0.50	<5.0	19	1.3	31	64
14-37267	16	10-20	11000	<1.0	8.9	250	0.65	<1.0	***11***	0.57	9900	20	9.9	24	22000	12	16	4200	390	1.2	28	830	1700	***1.0***	<0.20	100	53	<0.50	<5.0	39	1.6	37	100
14-37268	16	25-35	14000	<1.0	8.5	320	0.84	<1.0	***13***	1.8	15000	23	9.5	22	23000	12	15	5200	240	<1.0	34	1100	2200	***2.4***	<0.20	100	76	<0.50	<5.0	28	2.7	43	130
14-37269	18	10-20	11000	<1.0	8.0	220	0.71	<1.0	***10***	0.99	9700	20	11	24	22000	11	15	5100	390	1.3	27	670	1600	<1.0	<0.20	190	54	<0.50	<5.0	23	1.6	38	96
14-37270/71	15	5-15	13000	<1.0	8.7	340	0.71	<1.0	***13***	<0.50	8100	24	9.5	22	23000	12	17	4300	340	1.3	28	580	2000	<1.0	0.21	<100	49	<0.50	<5.0	38	1.3	46	80
14-37272	15	50-60	12000	<1.0	8.9	350	0.61	<1.0	***13***	<0.50	18000	22	9.0	20	22000	11	16	7600	350	1.2	29	800	1700	<1.0	0.23	170	64	<0.50	<5.0	73	1.0	43	73
14-37273	21	5-15	9000	<1.0	2.2	390	<0.50	<1.0	<5.0	<0.50	2600	18	7.1	8.7	17000	6.5	9.2	2300	820	<1.0	14	970	1400	<1.0	<0.20	<100	17	<0.50	<5.0	210	<1.0	32	77
14-37274	22	10-20	9200	<1.0	3.4	340	<0.50	<1.0	<5.0	<0.50	2200	19	7.5	6.7	19000	6.6	10	2500	630	<1.0	14	710	1200	<1.0	<0.20	<100	14	<0.50	<5.0	220	<1.0	36	58
14-37314	65	5-15	18000	<1.0	8.6	380	0.99	<1.0	***11***	<0.50	5300	34	11	20	26000	12	19	4400	410	1.2	28	570	2400	<1.0	0.24	<100	44	<0.50	<5.0	47	1.5	66	88
14-37315	64	5-15	19000	<1.0	7.5	430	1.1	<1.0	***12***	1.2	6400	30	9.7	25	27000	14	18	4200	360	1.0	37	1000	3600	<1.0	0.30	<100	56	<0.50	<5.0	35	1.4	55	190
14-37316	63	15-25	18000	<1.0	7.6	440	0.99	<1.0	***11***	1.0	7000	30	11	25	27000	13	17	4100	350	<1.0	35	1900	3600	<1.0	0.29	<100	57	<0.50	<5.0	28	1.3	54	***200***
14-37317	61	10-15	20000	<1.0	5.9	300	0.98	<1.0	***11***	<0.50	5100	32	7.4	23	23000	13	21	4300	230	<1.0	21	1300	3500	<1.0	<0.20	<100	52	<0.50	<5.0	43	1.6	57	180
14-37318	61	45-55	23000	<1.0	10	300	1.2	<1.0	***16***	<0.50	5400	39	10	31	31000	17	26	5200	250	2.2	32	680	4100	***1.0***	0.21	<100	57	<0.50	<5.0	43	2.2	73	100
14-37319	62	15-25	22000	<1.0	8.2	440	1.0	<1.0	***13***	0.59	5900	33	8.9	24	27000	12	18	4400	340	<1.0	36	1100	3700	<1.0	0.28	<100	51	<0.50	<5.0	38	1.4	64	170
14-37322	60	15-25	20000	<1.0	9.1	370	1.0	<1.0	***11***	<0.50	6500	32	11.2	25	28000	14	20	4700	420	1.2	34	650	2900	<1.0	0.34	<100	51	<0.50	<5.0	34	1.9	61	110
14-37334	78	10-20	20000	<1.0	9.8	340	1.1	<1.0	***10***	<0.50	5500	34	10	23	29000	14	21	4900	360	1.4	35	580	2700	<1.0	0.33	120	55	<0.50	<5.0	41	1.9	64	110
14-37335	78	50-60	22000	<1.0	9.8	340	1.2	<1.0	***11***	<0.50	4500	37	9.8	24	30000	14	25	5300	280	1.6	36	500	2500	<1.0	<0.20	140	51	<0.50	<5.0	38	1.8	69	110
14-37336	79	10-20	19000	<1.0	7.0	270	0.85	<1.0	***13***	<0.50	4000	31	5.1	15	24000	11	21	3900	130	1.1	19	1400	3400	<1.0	<0.20	<100	45	<0.50	<5.0	37	1.2	56	100
14-37337	77	10-20	17000	<1.0	5.9	480	0.90	<1.0	***13***	0.74	9000	27	6.8	24	22000	11	15	3700	280	<1.0	36	1000	3100	<1.0	0.33	<100	62	<0.50	<5.0	37	1.4	50	140
14-37338	76	10-20	22000	<1.0	7.6	430	1.2	<1.0	***8.7***	<0.50	5000	34	10	23	27000	13	20	4400	420	1.1	31	560	2200	<1.0	0.30	<100	47	<0.50	<5.0	25	1.5	66	110
14-37339	76	50-60	24000	<1.0	11	320	1.2	<1.0	***11***	<0.50	4400	40	8.6	24	30000	14	24	5100	250	1.5	31	450	2500	<1.0	<0.20	130	48	<0.50	<5.0	39	1.6	77	92
14-37340/41	80	10-20	20000	<1.0	2.0	420	0.90	<1.0	***13***	0.83	6600	29	4.6	28	16000	8.4	16	3800	120	<1.0	25	1800	4200	<1.0	0.37	<100	54	<0.50	<5.0	35	1.2	44	***330***
14-37342	81	10-20	21000	<1.0	7.0	470	1.1	<1.0	***13***	1.4	7000	32	11	24	28000	13	17	4500	410	<1.0	35	1200	3700	<1.0	0.29	<100	57	<0.50	<5.0	35	1.5	59	***220***
14-37345	82	5-15	19000	<1.0	9.5	430	1.0	<1.0	***14***	0.85	7800	30	9.9	24	28000	13	16	4300	380	1.2	36	1100	3800	***1.2***	0.37	<100	59	<0.50	<5.0	43	1.6	57	160
14-37346	83	5-15	17000	<1.0	7.2	420	0.94	<1.0	***14***	1.4	8000	28	9.3	24	26000	12	14	4100	360	1.1	32	1200	4000	***1.3***	0.27	<100	60	<0.50	<5.0	33	1.2	51	190
14-37347	83	50-60	18000	<1.0	9.7	390	1.1	<1.0	***13***	0.50	6700	32	11	30	29000	14	18	5000	330	1.3	43	700	2900	<1.0	0.35	<100	60	<0.50	<5.0	42	1.8	60	110
14-37352	75	10-20	17000	<1.0	3.4	520	0.77	<1.0	***9.9***	<0.50	2600	27	10	20	24000	11	13	3300	850	<1.0	27	820	2800	<1.0	0.26	<100	23	<0.50	<5.0	100	<1.0	50	110
14-37362	87	20-30	1800	<1.0	10	390	1.0	<1.0	***12***	<0.50	7200	31	11	24	28000	14	19	4300	340	1.1	31	1200	2900	<1.0	0.26	<100	59	<0.50	<5.0	31	1.8	59	140
14-37363	86	20-30	19000	<1.0	9.7	350	0.94	<1.0	***14***	0.50	6400	30	9.6	20	27000	13	18	4100	280	1.1	30	1000	2600	<1.0	0.20	<100	49	<0.50	<5.0	39	1.7	61	110
14-37364	85	20-30	14000	<1.0	5.9	240	0.64	<1.0	***8.4***	<0.50	3400	24	5.4	10	21000	10	15	3600	150	<1.0	16	1300	2500	<1.0	<0.20	<100	34	<0.50	<5.0	42	1.1	43	100
14-37365	85	45-55	17000	<1.0	***12***	320	0.92	<1.0	***9.1***	<0.50	5100	29	11	26	31000	14	18	4100	370	2.2	37	970	3000	<1.0	0.21	<100	48	<0.50	<5.0	23	1.6	53	98
14-37366	84	20-30	16000	<1.0	4.5	340	0.78	<1.0	***9.5***	1.3	5700	26	6.7	22	19000	12	15	3800	170	<1.0	28	1100	3200	<1.0	0.26	<100	48	<0.50	<5.0	22	1.4	45	***200***
14-37367	90	20-30	17000	<1.0	7.0	350	0.90	<1.0	***11***	0.78	6100	29	8.7	29	24000	12	17	4300	270	<1.0	33	1200	3100	<1.0	0.26	<100	52	<0.50	<5.0	30	1.8	53	180
14-37368	91	10-20	18000	<1.0	7.2	410	0.94	<1.0	***12***	0.87	6100	29	10	23	25000	13	16	4300	340	<1.0	30	1400	3200	<1.0	0.24	<100	50	<0.50	<5.0	32	1.4	53	170
14-37369	91	45-55	19000	<1.0	***13***	390	1.1	<1.0	***13***	<0.50	7300	32	12	29	31000	15	21	4700	450	2.1	41	880	3000	***1.1***	0.23	<100	59	<0.50	<5.0	31	2.3	62	110
14-37370/71	88	20-30	16000	<1.0	4.9	350	0.86	<1.0	***9.5***	0.64	4200	27	6.1	23	21000	12	15	3700	160	<1.0	25	1200	3300	<1.0	0.29	<100	41	<0.50	<5.0	24	1.4	46	150
14-37372	93	15-25	17000	<1.0	9.0	410	0.93	<1.0	***11***	1.3	8300	29	9.9	25	27000	12	15	4200	390	1.1	34	990	3200	<1.0	0.31	<100	58	<0.50	<5.0	22	1.4	53	150

* CCME Soil Quality Guidelines for Agricultural Land Use

Table A-1: Background Soil Sample Inorganic Element Analytical Results Continued

Sample #	Location	Depth	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
			[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]
CCME Soil Quality Guidelines for Residential/Parkland Land Use			-	***20***	***12***	***750***	***4.0***	-	***2.0****	***10***	-	***64***	***40***	***63***	-	***70***	-	-	-	***5.0***	***50***	-	-	***1.0***	***20***	-	-	***1.0***	***5.0***	-	***23***	***130***	***200***
1. Silty/Clayey Glaciolacustrine Terrain Unit cont'd																																	
14-37373	94	15-25	18000	<1.0	8.1	430	1.0	<1.0	***12***	1.1	6600	31	11	25	27000	13	17	4600	360	<1.0	32	1300	3000	<1.0	0.35	<100	51	<0.50	<5.0	27	1.3	57	***210***
14-37374	95	15-25	18000	<1.0	8.3	420	0.97	<1.0	***13***	0.92	8200	28	9.6	23	26000	13	18	4300	330	1.1	35	720	3200	<1.0	0.34	<100	59	<0.50	<5.0	32	1.7	53	130
14-37375	95	50-60	20000	<1.0	11	420	1.1	<1.0	***12***	<0.50	8500	33	10	30	29000	14	21	5400	350	1.4	42	780	3100	<1.0	0.29	110	62	<0.50	<5.0	24	2.2	62	110
14-37376	92	15-25	22000	<1.0	6.1	570	0.98	<1.0	***19***	1.5	19000	30	9.8	18	25000	12	13	4700	400	<1.0	32	1600	4300	<1.0	0.21	290	91	<0.50	<5.0	43	1.1	57	***230***
14-37377	89	15-25	19000	<1.0	6.1	500	0.91	<1.0	***11***	1.9	6900	27	9.6	26	24000	12	14	4000	270	<1.0	42	1800	3000	<1.0	0.29	<100	53	<0.50	<5.0	28	1.4	50	***250***
14-37378	89	50-60	18000	<1.0	7.6	370	0.96	<1.0	***11***	0.76	7200	29	9.4	33	25000	13	18	4100	270	1.3	38	970	2900	<1.0	0.31	<100	56	<0.50	<5.0	26	2.2	53	130
14-37379	100	15-25	13000	<1.0	7.1	290	0.67	<1.0	***9.1***	0.76	6100	23	7.8	16	22000	10	14	3300	210	<1.0	24	1100	1800	<1.0	<0.20	<100	39	<0.50	<5.0	35	1.0	44	110
14-37380	100	50-60	18000	<1.0	10	410	1.0	<1.0	***12***	<0.50	8800	30	9.8	30	27000	13	19	4800	330	1.1	38	820	2900	<1.0	0.23	<100	62	<0.50	<5.0	22	1.7	56	120
14-37381	96	15-25	18000	<1.0	6.7	450	0.99	<1.0	***12***	1.0	7500	29	10	23	26000	12	15	4400	330	<1.0	33	1100	3000	<1.0	0.35	<100	59	<0.50	<5.0	25	1.5	52	160
14-37382	97	10-20	16000	<1.0	7.3	380	0.81	<1.0	***9.6***	0.60	5200	26	8.5	20	24000	12	15	3600	260	<1.0	24	1300	2700	<1.0	0.24	<100	44	<0.50	<5.0	26	1.1	46	130
14-37383	98	10-20	11000	<1.0	8.0	310	0.58	<1.0	***11***	1.0	14000	19	8.0	24	21000	10	14	5600	280	1.2	27	890	1900	<1.0	<0.20	<100	54	<0.50	<5.0	28	1.1	37	110
14-37384	99	5-15	12000	<1.0	8.2	350	0.64	<1.0	***13***	0.74	13000	22	9.1	26	22000	11	15	5300	330	1.3	29	750	2000	<1.0	<0.20	100	58	<0.50	<5.0	23	1.5	41	88
2. Sandy Glaciolacustrine Terrain Unit																																	
14-37260/61	40	5-15	9200	<1.0	6.1	170	<0.50	<1.0	<5.0	<0.50	2100	20	6.1	6.9	19000	7.2	13	2900	250	<1.0	14	450	1000	<1.0	<0.20	<100	16	<0.50	<5.0	270	<1.0	37	51
14-37262	40	50-60	8700	<1.0	7.9	230	<0.50	<1.0	***7.3***	<0.50	35000	19	6.8	18	19000	6.8	10	7900	280	<1.0	24	750	920	<1.0	<0.20	<100	71	<0.50	<5.0	160	<1.0	40	57
14-37263	41	5-15	11000	<1.0	8.3	190	<0.50	<1.0	<5.0	<0.50	2300	22	7.7	12	22000	8.9	13	3200	270	<1.0	18	520	1200	<1.0	<0.20	<100	20	<0.50	<5.0	100	<1.0	41	59
14-37275	23	5-15	9600	<1.0	2.8	240	<0.50	<1.0	<5.0	<0.50	1900	19	6.6	5.3	18000	6.5	10	2500	550	<1.0	13	670	1100	<1.0	<0.20	<100	13	<0.50	<5.0	190	<1.0	35	58
14-37276	23	5-15	6400	<1.0	8.1	100	<0.50	<1.0	<5.0	<0.50	2300	15	6.1	15	19000	6.6	7.3	2600	240	1.0	20	540	850	<1.0	<0.20	<100	19	<0.50	<5.0	190	<1.0	35	53
14-37277	29	5-15	9300	<1.0	3.8	130	<0.50	<1.0	<5.0	<0.50	2500	20	6.0	4.5	17000	5.2	12	3300	220	<1.0	14	780	1200	<1.0	<0.20	<100	17	<0.50	<5.0	320	<1.0	35	49
14-37278	30	5-15	8600	<1.0	3.1	180	<0.50	<1.0	<5.0	<0.50	2000	17	5.8	5.2	18000	5.7	10	2500	350	<1.0	12	720	900	<1.0	<0.20	<100	14	<0.50	<5.0	180	<1.0	33	45
14-37279	31	5-15	8700	<1.0	4.7	160	<0.50	<1.0	<5.0	<0.50	2400	18	6.4	7.1	18000	6.5	11	2700	270	<1.0	14	540	1000	<1.0	<0.20	<100	15	<0.50	<5.0	200	<1.0	35	46
14-37280/81	31	55-65	6900	<1.0	9.5	120	<0.50	<1.0	***5.3***	<0.50	3000	18	7.0	17	23000	7.0	7.5	2700	310	1.2	22	630	750	<1.0	<0.20	<100	21	<0.50	<5.0	210	<1.0	40	56
14-37282	35	5-15	11000	<1.0	3.9	230	<0.50	<1.0	<5.0	<0.50	2000	21	7.4	6.6	19000	6.7	12	2600	480	<1.0	15	490	1000	<1.0	<0.20	<100	14	<0.50	<5.0	220	<1.0	39	52
14-37283	36	5-15	11000	<1.0	4.7	220	<0.50	<1.0	<5.0	<0.50	1900	22	7.9	7.7	21000	7.4	11	2700	600	<1.0	16	490	1300	<1.0	<0.20	<100	15	<0.50	<5.0	240	<1.0	41	59
14-37284	37	10-20	8400	<1.0	4.4	170	<0.50	<1.0	<5.0	<0.50	2100	19	6.5	6.9	19000	6.6	11	2800	280	<1.0	15	630	1100	<1.0	<0.20	<100	16	<0.50	<5.0	260	<1.0	34	48
14-37285	37	60-70	8100	<1.0	9.7	120	<0.50	<1.0	***5.6***	<0.50	2500	19	6.6	18	21000	7.4	8.4	2600	240	1.2	25	770	1200	<1.0	<0.20	<100	22	<0.50	<5.0	170	<1.0	40	58
14-37286	39	5-15	9000	<1.0	3.9	240	<0.50	<1.0	<5.0	<0.50	2200	19	6.2	6.6	17000	7.0	10	2700	430	<1.0	13	580	1200	<1.0	<0.20	<100	16	<0.50	<5.0	200	<1.0	34	44
14-37287	24	10-20	9500	<1.0	4.5	170	<0.50	<1.0	<5.0	<0.50	2400	21	7.0	7.3	21000	6.5	13	3300	300	<1.0	16	810	1100	<1.0	<0.20	<100	17	<0.50	<5.0	300	<1.0	37	51
14-37288	25	5-15	7600	<1.0	3.0	210	<0.50	<1.0	<5.0	<0.50	1700	16	5.9	6.4	17000	5.7	7.8	2100	540	<1.0	11	640	850	<1.0	<0.20	<100	11	<0.50	<5.0	140	<1.0	31	50
14-37289	25	5-15	11000	<1.0	10	170	0.51	<1.0	***6.1***	<0.50	2900	25	8.4	23	25000	10	11	3400	310	1.2	30	580	1600	<1.0	<0.20	<100	26	<0.50	***23***	140	<1.0	48	67
14-37290/91	26	5-15	8200	<1.0	2.5	180	<0.50	<1.0	<5.0	<0.50	1800	17	6.4	6.3	16000	5.4	9.1	2400	520	<1.0	12	650	870	<1.0	<0.20	<100	12	<0.50	<5.0	180	<1.0	30	47
14-37292	27	5-15	7800	<1.0	3.8	100	<0.50	<1.0	<5.0	<0.50	2200	17	4.8	5.0	16000	5.1	12	2800	180	<1.0	13	680	720	<1.0	<0.20	<100	15	<0.50	<5.0	290	<1.0	29	35
14-37293	32	5-15	7600	<1.0	3.4	130	<0.50	<1.0	<5.0	<0.50	2100	16	4.8	4.8	16000	5.5	10	2400	230	<1.0	11	670	750	<1.0	<0.20	<100	13	<0.50	<5.0	160	<1.0	29	35
14-37294	32	50-60	7800	<1.0	8.2	120	<0.50	<1.0	<5.0	<0.50	2400	18	6.5	13	20000	6.4	8.3	2800	260	<1.0	21	650	1000	<1.0	<0.20	<100	19	<0.50	<5.0	200	<1.0	38	48
14-37295	34	5-15	10000	<1.0	3.0	270	<0.50	<1.0	<5.0	<0.50	2800	21	7.7	8.3	19000	6.8	11	2900	550	<1.0	16	1100	1500	<1.0	<0.20	<100	17	<0.50	<5.0	250	<1.0	35	78
14-37296	38	5-15	9100	<1.0	5.2	160	<0.50	<1.0	<5.0	<0.50	2200	20	6.8	8.4	18000	6.4	12	2900	280	<1.0	16	470	860	<1.0	<0.20	<100	16	<0.50	<5.0	230	<1.0	35	48
14-37297	33	5-15	8600	<1.0	3.2	170	<0.50	<1.0	<5.0	<0.50	2000	18	6.0	4.6	17000	6.3	11	2800	310	<1.0	13	730	1100	<1.0	<0.20	<100	14	<0.50	<5.0	220	<1.0	33	51
14-37298	33	50-60	7200	<1.0	9.5	120	<0.50	<1.0	<5.0	<0.50	2500	18	6.4	19	21000	7.5	8.1	2500	200	1.4	24	750	1100	<1.0	<0.20	<100	20	<0.50	<5.0	140	<1.0	37	61
14-37299	42	5-15	10000	<1.0	5.7	260	<0.50	<1.0	<5.0	<0.50	2300	21	7.2	8.6	21000	7.5	12	3100	330	<1.0	16	480	1200	<1.0	<0.20	<100	17	<0.50	<5.0	100	<1.0	40	63
14-37300/31	43	5-15	8600	<1.0	6.5	180	<0.50	<1.0	<5.0	<0.50	2100	19	7.2	9.7	20000	7.0	10	2800	270	<1.0	15	580	1300	<1.0	<0.20	<100	18	<0.50	<5.0	220	<1.0	39	49
14-37302	43	55-65	9200	<1.0	9.3	140	<0.50	<1.0	***6.2***	<0.50	2700	20	7.1	19	22000	7.7	8.9	2800	270	<1.0	26	650	1200	<1.0	<0.20	<100	24	<0.50	<5.0	180	<1.0	44	54
14-37303	44	5-15	8400	<1.0	6.6	120	<0.50	<1.0	<5.0	<0.50	2200	20	6.1	6.6	19000	7.7	13	3200	230	<1.0	14	480	810	<1.0	<0.20	<100	16	<0.50	<5.0	330	<1.0	35	41
14-37304	45	5-15	9000	<1.0	5.6	230	<0.50	<1.0	<5.0	<0.50	2500	20	7.4	8.5	20000	7.2	12	3100	440	<1.0	17	500	1000	<1.0	<0.20	<100	16	<0.50	<5.0	220	<1.0	36	57
14-37305	46	5-15	12000	<1.0	5.6	230	<0.50	<1.0	***5.2***	<0.50	2500	24	7.8	7.6	21000	7.2	13	3100	320	<1.0	17	570	1500	<1.0	<0.20	<100	18	<0.50	<5.0	260	<1.0	45	68
14-37306	46	50-60	4100	<1.0	7.4	140	<0.50	<1.0	<5.0	<0.50	26000	13	5.0	9.1	19000	4.5	4.7	5400	270	1.2	16	600	450	<1.0	<0.20	<100	56	<0.50	<5.0	280	<1.0	29	49
14-37307	47	5-15	11000	<1.0	6.1	160	<0.50	<1.0	<5.0	<0.50	2100	22	7.4	9.5	20000	6.8	13	3300	250	<1.0	18	450	1200	<1.0	<0.20	<100	17	<0.50	<5.0	230	<1.0	38	59
14-37308	48	5-15	7200	<1.0	5.4	130	<0.50	<1.0	<5.0	<0.50	2000	15	5.7	5.8	17000	6.1	9	2400	270	<1.0	13	690	910	<1.0	<0.20	<100	15	<0.50	<5.0	210	<1.0	33	42
14-37309	49	5-15	10000	<1.0	4.3	180	<0.50	<1.0	<5.0	<0.50	2000	21	6.3	8.5	19000	7.0	11	2800	310	<1.0	15	520	1200	<1.0	<0.20	<100	14	<0.50	<5.0	210	<1.0	36	69
14-37310/11	49	60-70	9700	<1.0	9.9	230	<0.50	<1.0	***7.3***	<0.50	12000	22	7.8	24	23000	9.3	11	5200	310	1.3	33	860	1100	<1.0	0.27	<100	40	<0.50	<5.0	130	<1.0	44	76
14-37312	66	5-15	13000	<1.0	7.4	200	<0.50	<1.0	<5.0	<0.50	2700	26	8.9	10	24000	8.0	14	3600	340	<1.0	21	870	1600	<1.0	<0.20	<100	19	<0.50	<5.0	270	<1.0	47	75
14-37313	66	50-60	9100	<1.0	8.7	160	<0.50	<1.0	***5.5***	<0.50	2500	20	7.4	21	22000	7.9	9	3000	280	1.1	25	610	1200	<1.0	<0.20	<100	24	<0.50	<5.0	150	<1.0	42	60
14-37320/21	59	10-20	11000	<1.0	7.4	190	<0.50	<1.0	<5.0	<0.50	2300	23	7.8	10	22000	7.5	12	3100	260	<1.0	18	610	1300	<1.0	<0.20	<100	18	<0.50	<5.0	260	<1.0	43	57
14-37323	50	5-15	10000	<1.0	4.6	200	<0.50	<1.0	<5.0	<0.50	2000	20	7.5	7.8	19000	6.4	12	2900	540	<1.0	15	530	1100	<1.0	<0.20	<100	14	<0.50	<5.0	250	<1.0	39	63
14-37324	51	5-15	10000	<1.0	7.0	170	<0.50	<1.0	<5.0	<0.50	2100	21	7.4	9.6	21000	7.3	12	3000	320	<1.0	16	590	1300	<1.0	<0.20	<100	16	<0.50	<5.0	220	<1.0	38	61
14-37325	52	5-15	9600	<1.0	6.3	140	<0.50	<1.0	<5.0	<0.50	2100	22	7.2	9.0	22000	7.1	13	3100	260	<1.0	17	650	1200	<1.0	<0.20	<100	16	<0.50	<5.0	310	<1.0	39	60
14-37326	52	50-60	9000	<1.0	9.4	150	<0.50	<1.0	***6.3***	<0.50	2100	19	7.7	17	21000	7.8	9.1	2800	290	1.1	24	680	1300	<1.0	<0.20	<100	21	<0.50	<5.0	180	<1.0	39	56
14-37327	53	5-15	9500	<1.0	6.2	140	<0.50	<1.0	<5.0	<0.50	1800	21	7.1	7.6	21000	6.1	12	3100	210	<1.0	16	400	1100	<1.0	<0.20	<100	14	<0.50	<5.0	290	<1.0	36	54
14-37328	54	10-20	9200	<1.0	6.6	130	<0.50	<1.0	<5.0	<0.50	2300	22	7.3	8.5	21000	6.6	13	3400	250	<1.0	17	540	1200	<1.0	<0.20	<100	16	<0.50	<5.0	320	<1.0	38	55
14-37329	55	10-20	13000	<1.0	3.8	310	<0.50	<1.0	***6.1***	<0.50	2400	25	8.4	9.7	22000	7.8	12	2800	570	<1.0	17	610	1600	<1.0	0.22	<100	17	<0.50	<5.0	190	<1.0	45	120

* CCME Soil Quality Guidelines for Agricultural Land Use

Table A-1: Background Soil Sample Inorganic Element Analytical Results Continued

Sample #	Location	Depth	Aluminum	Antimony	Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Magnesium	Manganese	Molybdenum	Nickel	Phosphorus	Potassium	Selenium	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc
			[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]
CCME Soil Quality Guidelines for Residential/Parkland Land Use			***-***	***20***	***12***	***750***	***4.0***	***-***	***2.0****	***10***	***-***	***64***	***40***	***63***	***-***	***70***	***-***	***-***	***-***	***5.0***	***50***	***-***	***-***	***1.0***	***20***	***-***	***-***	***1.0***	***5.0***	***-***	***23***	***130***	***200***
2. Sandy Glaciolacustrine Terrain Unit cont'd																																	
14-37330/31	55	50-60	9900	<1.0	8.8	180	<0.50	<1.0	***6.9***	<0.50	2700	21	7.3	18	22000	7.8	10	2900	310	1.1	26	590	1400	<1.0	<0.20	<100	22	<0.50	<5.0	190	<1.0	45	56
14-37329	56	10-20	11000	<1.0	5.5	200	<0.50	<1.0	<5.0	<0.50	2300	22	7.3	8.7	21000	7.2	13	3000	330	<1.0	16	580	1400	<1.0	<0.20	<100	17	<0.50	<5.0	240	<1.0	42	61
14-37333	58	5-15	10000	<1.0	2.9	300	<0.50	<1.0	***5.3***	<0.50	2400	20	6.4	8.7	18000	6.9	12	2600	480	<1.0	14	780	1500	<1.0	<0.20	<100	18	<0.50	<5.0	140	<1.0	37	63
14-37343	57	5-15	9400	<1.0	5.5	180	<0.50	<1.0	<5.0	<0.50	2100	20	5.0	6.3	20000	6.2	12	2900	150	<1.0	13	580	890	<1.0	<0.20	<100	16	<0.50	<5.0	240	<1.0	38	51
14-37344	57	50-60	6500	<1.0	9.9	110	<0.50	<1.0	<5.0	<0.50	2600	18	6.2	14	23000	6.6	6.2	2300	300	<1.0	22	750	780	<1.0	<0.20	<100	18	<0.50	<5.0	270	<1.0	39	57
14-37348	73	5-15	9900	<1.0	6.4	130	<0.50	<1.0	<5.0	<0.50	2400	21	6.6	8.5	21000	6.2	14	3300	200	<1.0	16	580	1200	<1.0	<0.20	<100	18	<0.50	<5.0	290	<1.0	40	61
14-37349	73	50-60	7100	<1.0	8.6	120	<0.50	<1.0	***5.8***	<0.50	2600	16	6.2	13	19000	6.7	7.5	2400	250	<1.0	22	780	960	<1.0	<0.20	<100	20	<0.50	<5.0	170	<1.0	35	50
14-37350/51	74	5-15	8200	<1.0	6.5	110	<0.50	<1.0	<5.0	<0.50	2300	19	6.3	8.3	20000	5.7	13	3000	180	<1.0	15	570	930	<1.0	<0.20	<100	16	<0.50	<5.0	310	<1.0	35	47
14-37353	67	5-15	10000	<1.0	3.0	250	<0.50	<1.0	***5.6***	<0.50	2300	18	5.3	6.5	16000	5.9	11	2600	340	<1.0	12	760	1100	<1.0	<0.20	<100	17	<0.50	<5.0	180	<1.0	34	51
14-37354	67	50-60	12000	<1.0	10	210	0.59	<1.0	***7.6***	<0.50	2800	26	8.1	22	25000	9.4	11	3200	310	1.1	27	690	1500	<1.0	<0.20	<100	26	<0.50	<5.0	140	1.0	51	65
14-37355	68	10-20	14000	<1.0	6.5	300	0.61	<1.0	***5.9***	<0.50	2800	24	8.1	18	23000	8.7	13	3000	420	<1.0	20	500	1700	<1.0	0.26	<100	21	<0.50	<5.0	78	<1.0	45	76
14-37356	72	10-20	9700	<1.0	5.2	240	<0.50	<1.0	<5.0	<0.50	3100	20	7.7	9.0	20000	7.7	11	2800	410	<1.0	14	610	1400	<1.0	<0.20	<100	18	<0.50	<5.0	100	<1.0	37	62
14-37357	71	5-15	13000	<1.0	5.3	280	0.51	<1.0	<5.0	<0.50	2900	23	6.8	7.9	20000	7.3	13	2900	240	<1.0	15	460	1300	<1.0	<0.20	<100	20	<0.50	<5.0	92	<1.0	45	62
14-37358	71	60-70	7100	<1.0	8.1	120	<0.50	<1.0	<5.0	<0.50	2300	17	6.5	15	19000	6.8	6.8	2300	260	<1.0	23	510	720	<1.0	<0.20	<100	19	<0.50	<5.0	140	<1.0	36	48
14-37359	69	5-15	10000	<1.0	3.2	310	<0.50	<1.0	<5.0	<0.50	2500	19	6.9	7.7	17000	6.9	11	2700	550	<1.0	14	830	1200	<1.0	<0.20	<100	18	<0.50	<5.0	160	<1.0	35	60
14-37360/61	70	5-15	11000	<1.0	6.6	210	<0.50	<1.0	<5.0	<0.50	2600	23	7.9	9.0	23000	7.8	13	3200	290	<1.0	18	610	1400	<1.0	<0.20	<100	18	<0.50	<5.0	200	<1.0	42	75

* CCME Soil Quality Guidelines for Agricultural Land Use

Table 2: Background Soil Sample Polycyclic Aromatic Hydrocarbons Analytical Results

Sample #	Location	Depth	Napthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(ghi)perylene	Total
		[cm]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]	[ug/g]
CCME Soil Quality Guidelines for Residential/Parkland Land Use			***0.60***	***320***	***21.5***	***15.4***	***0.10***	***2.5***	***15.4***	***0.10***	***0.10***	***6.2***	***0.10***	***0.10***	***0.7***	***0.10***	***0.10***	***-***	***-***
1. Background Soil Samples																			
14-37249	12	15-25	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37260/61	40	5-15	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37265	20	20-30	<0.030	<0.0050	<0.0050	<0.020	0.040	<0.040	0.070	0.070	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	0.0350
14-37276	23	5-15	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37293	32	5-15	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37303	44	5-15	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37316	63	15-25	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37328	54	10-20	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37335	78	50-60	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37342	81	10-20	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37355	68	10-20	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37365	85	20-30	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37368	91	10-20	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250
14-37375	95	50-60	<0.030	<0.0050	<0.0050	<0.020	<0.040	<0.040	<0.050	<0.050	<0.030	<0.050	<0.050	<0.050	<0.030	<0.10	<0.00050	<0.030	<0.250

APPENDIX 2: QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

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APPENDIX 2: QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

ESG follows an internal quality assurance/quality control program that was implemented to allow data quality to be monitored on an ongoing basis. This program is described in the Quality Assurance Project Plan (QAPP) (ESG, 2013). The points relevant to the discussion of QA/QC sample collection and analysis of soil samples at Garden River in 2014 are summarized here. Samples for the background soil program were collected by ESG and anlayzed by ALS for inorganic elements and ASG for polycyclic aromatic hydrocarbons.

Analytical firms are accredited by the Canadian Association for Laboratory Accreditation Inc. (CALA) to the standards of ISO/IEC 17025.

All samples are given sequential, numerical codes before submission to the analytical firms; these codes mask any information concerning site location, sample type or possible concentration of the sample.

Accuracy is measured and controlled by instrument calibration, the use of control standards, control spikes and analytical blanks.

Control standards and control spikes are reference materials with known concentrations. After analysis of a control standard or spike, the instrument calibration is evaluated based on comparison of the results with the target concentration.

Precision is measured and controlled by the analysis of field and analytical duplicates. Samples of the same material that are collected in the field and submitted blind as separate samples for analysis are field duplicates. Analytical duplicates are replicate preparations and analyses of the same sample. Comparison of the average relative percent difference (RPD%) – which are calculated as the absolute difference divided by the mean – are used to evaluate laboratory precision. Acceptable limits are generally considered to be less than 30 percent RPD for inorganics and PHC solids analyses and less than 50 percent for some other analyses (eg PAH in solids), with 20 percent or less considered good agreement. Inorganic analytical water duplicates are expected to be less than or equal to 20% RPD.

Organic analyses include surrogate spikes. All samples are spiked with compounds not found in environmental samples but representative of the analytes to be determined. The surrogates are spiked into the samples early in the sample preparation and are measured at the end of the analytical process. Acceptable recoveries are ± 40 percent.

The results of the QA/QC program for the 2014 sampling program at Garden River are discussed below in order of analysis type. The laboratory associated with each analysis type is also listed.

A. Inorganic Element Analysis of Soil Samples Analyzed for 31 Elements at ALS Environmental, London, ON

1. Accuracy

Soil samples were analyzed for inorganics (30 elements) at ALS along with Internal Reference Material (IRM), Laboratory Control Spikes (LCS) and Matrix Spikes (MS) (Tables 1, 2 and 3).

Internal Reference Material recoveries ranged from 86 percent to 106 percent (Table 1) and from 82 percent to 104 percent for Laboratory Control Spikes (Table 2). Matrix spike recoveries ranged from 95 percent to 169 percent (Table 3). Notes from ALS indicate that the recovery for several elements in the Matrix spikes (anonymous samples) could not be accurately calculated due to high analyte background in the samples (Table 3). Results were below detection for all elements in the analytical blanks (method blanks) (Table 4). All analyses were conducted within ALS recommended hold times.

2. Precision

Fifteen soil sample field duplicates were analyzed for inorganic elements and the resulting average RPDs were below 20 percent for all elements indicating good agreement between replicates (Table 5).

Nine soil sample analytical duplicates were analyzed by ALS for inorganic elements and the resulting average RPDs were below 20 percent for all elements and less than 10 percent for most, indicating very good agreement (Table 6).

B. Polycyclic Aromatic Hydrocarbons (PAHs) in Soil Samples – Analytical Services Group (ASG), RMC

1. *Accuracy*

One control spiked sample was analyzed for PAHs and the reported Recoveries ranged from 59 percent to 130 percent (Table 7). CCME guidelines for PAH analysis recommend that control recoveries be within 50-140% for solids.

2. Precision

Two field duplicates were analyzed for PAHs and all results were below detection in the replicate soils (Table 8). ASG reported that all results were corrected for recoveries of the deuterated surrogates naphthalene, phenanthrene, anthracene and benzo(a)anthracene.

Table 1: Inorganic Element Results for Soil IRM Samples, ALS

Analyte	IRM	IRM Target	Recovery		IRM	IRM Target	Recovery		IRM	IRM Target	Recovery
	[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)
Internal Reference Material (IRM)											
Aluminum (Al)	25800	27200	95		26600	27200	98		26300	27200	97
Antimony (Sb)	13.3	14.1	94		13.9	14.1	99		13.7	14.1	97
Arsenic (As)	32	34	94		32	34	96		33	34	97
Barium (Ba)	73	76	96		78	76	103		76	76	100
Beryllium (Be)	4.3	4.3	100		4.2	4.3	97		4.3	4.3	100
Boron (B)	14.8	15.7	94		16.4	15.7	104		15.2	15.7	97
Cadmium (Cd)	6.1	6.4	96		6.3	6.4	99		6.3	6.4	100
Calcium (Ca)	26800	27300	98		27300	27300	100		27100	27300	99
Chromium (Cr)	59.0	62.0	95		62.0	62.0	100		62.0	62	100
Cobalt (Co)	14.9	15.5	96		15.5	15.5	100		15.5	15.5	100
Copper (Cu)	45	47.0	96		47	47	99		47	47.0	99
Iron (Fe)	26700	27000	99		27800	27000	103		27500	27000	102
Lead (Pb)	19.1	19.4	98		19.9	19.4	103		19.1	19.4	98
Lithium (Li)	35	34	104		36	34	106		35	34	103
Magnesium (Mg)	15400	15500	99		15700	15500	101		15700	15500	101
Manganese (Mn)	720	780	94		740	780	96		760	780	97
Molybdenum (Mo)	1.7	2.1	81		1.8	2.1	86		1.9	2.1	90
Nickel (Ni)	46	48	96		47	48	100		48	48	100
Phosphorus (P)	1240	1300	95		1280	1300	99		1260	1300	97
Potassium (K)	1540	1580	97		1900	1580	120		1740	1580	109
Selenium (Se)	7	6.9	101		6.7	6.9	97		6.8	6.9	99
Silver (Ag)	11.1	12	93		11.7	12	98		12.1	12	101
Sodium (Na)	180	170	106		190	170	112		190	170	112
Strontium (Sr)	428	456	94		439	456	96		447	456	98
Thallium (Tl)	5.4	5.7	96		5.8	5.7	102		5.6	5.7	99
Tin (Sn)	9	9.4	96		9.7	9.4	103		9.4	9.4	100
Titanium (Ti)	600	660	90		720	660	111		680	660	105
Uranium (U)	1.7	1.8	94		1.8	1.8	100		1.7	1.8	94
Vanadium (V)	50	53	95		53	53	101		52	53	99
Zinc (Zn)	80	82	97		82	82	100		82	82	100

Table 1: Inorganic Element Results for Soil IRM Samples, ALS (cont'd)

Analyte	IRM [ppm]	IRM Target [ppm]	Recovery (%)		IRM [ppm]	IRM Target [ppm]	Recovery (%)		IRM [ppm]	IRM Target [ppm]	Recovery (%)
Internal Reference Material (IRM)											
Aluminum (Al)	25700	27200	94		25200	27200	93		26800	27200	99
Antimony (Sb)	13.2	14.1	94		13.3	14.1	94		13.1	14.1	93
Arsenic (As)	32	34	96		31	34	91		31	34	91
Barium (Ba)	68	76	90		73	76	96		73	76	97
Beryllium (Be)	4.3	4.3	101		3.9	4.3	92		4.2	4.3	99
Boron (B)	15	15.7	96		15.1	15.7	96		15	15.7	96
Cadmium (Cd)	6.4	6.4	100		5.9	6.4	93		6.3	6.4	99
Calcium (Ca)	26400	27300	97		25800	27300	95		26400	27300	97
Chromium (Cr)	62.0	62	99		57.0	62	92		62.0	62	100
Cobalt (Co)	15.3	15.5	99		14.4	15.5	93		15.3	15.5	99
Copper (Cu)	47	47	99		44	47	92		47	47	100
Iron (Fe)	27100	27000	100		25300	27000	94		27400	27000	101
Lead (Pb)	19.6	19.4	101		18.3	19.4	94		19.3	19.4	99
Lithium (Li)	35	34	104		32	34	95		35	34	103
Magnesium (Mg)	14600	15500	94		14300	15500	92		15300	15500	99
Manganese (Mn)	720	780	94		680	780	89		740	780	97
Molybdenum (Mo)	1.7	2.1	81		1.7	2.1	81		2.1	2.1	100
Nickel (Ni)	47	48	100		44	48.0	92		47	48	99
Phosphorus (P)	1200	1300	93		1180	1300	91		1240	1300	95
Potassium (K)	1500	1580	94		1680	1580	106		1640	1580	103
Selenium (Se)	7.1	6.9	103		6.7	6.9	97		6.7	6.9	97
Silver (Ag)	11.4	12	95		10.7	12	89		11.4	12	95
Sodium (Na)	170	170	100		170	170	100		180	170	106
Strontium (Sr)	441	456	97		411	456	90		437	456	96
Thallium (Tl)	5.7	5.7	100		5.2	5.7	92		5.5	5.7	97
Tin (Sn)	9.4	9.4	100		8.8	9.4	94		8.8	9.4	94
Titanium (Ti)	600	660	90		640	660	97		620	660	94
Uranium (U)	1.7	1.8	94		1.7	1.8	94		1.7	1.8	94
Vanadium (V)	56	53	106		49	53	93		52	53	99
Zinc (Zn)	80	82	98		76	82	93		81	82	99

Table 1: Inorganic Element Results for Soil IRM Samples, ALS (cont'd)

Analyte	IRM	IRM Target	Recovery			Average Recovery	Std Dev		Limits
	[ppm]	**[ppm]**	**(%)**			**(%)**	**[ppm]**		**(%)**
Internal Reference Material (IRM)									
Aluminum (Al)	26800	27200	99			**96**	**± 2.3**		70-130
Antimony (Sb)	13.7	14.1	97			**95**	**± 2.2**		70-130
Arsenic (As)	32	34	96			**94**	**± 2.6**		70-130
Barium (Ba)	77	76	101			**98**	**± 4.6**		70-130
Beryllium (Be)	4.3	4.3	100			**99**	**± 3.2**		70-130
Boron (B)	15.9	15.7	101			**98**	**± 3.7**		70-130
Cadmium (Cd)	6.2	6.4	97			**98**	**± 2.6**		70-130
Calcium (Ca)	26800	27300	98			**98**	**± 1.8**		70-130
Chromium (Cr)	62	62	100			**98**	**± 3.0**		70-130
Cobalt (Co)	15.2	15.5	98			**98**	**± 2.5**		70-130
Copper (Cu)	46	47	99			**98**	**± 2.6**		70-130
Iron (Fe)	27500	27000	102			**100**	**± 3.1**		70-130
Lead (Pb)	19	19.4	98			**99**	**± 2.6**		70-130
Lithium (Li)	35	34	104			**103**	**± 3.7**		70-130
Magnesium (Mg)	15400	15500	99			**98**	**± 3.5**		70-130
Manganese (Mn)	760	780	99			**95**	**± 3.2**		70-130
Molybdenum (Mo)	1.7	2.1	81			**86**	**± 7.3**		70-131
Nickel (Ni)	46	48.0	97			**98**	**± 3.1**		70-130
Phosphorus (P)	1280	1300	99			**96**	**± 3.1**		70-130
Potassium (K)	1760	1580	111			**106**	**± 8.6**		70-130
Selenium (Se)	6.3	6.9	91			**98**	**± 3.7**		70-130
Silver (Ag)	11.6	12	97			**95**	**± 3.7**		70-130
Sodium (Na)	180	170	106			**106**	**± 4.8**		70-130
Strontium (Sr)	452	456	99			**96**	**± 3.0**		70-130
Thallium (Tl)	5.5	5.7	97			**98**	**± 3.2**		70-130
Tin (Sn)	9.4	9.4	100			**98**	**± 3.7**		70-130
Titanium (Ti)	660	660	102			**99**	**± 7.8**		70-130
Uranium (U)	1.7	1.8	94			**95**	**± 2.1**		70-131
Vanadium (V)	53	53	101			**99**	**± 4.2**		70-130
Zinc (Zn)	80	82	98			**98**	**± 2.3**		70-130

Table 2: Inorganic Element Results for Soil LCS Samples, ALS

Analyte	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	LCS Recovery (%)	Average Recovery (%)	Std Dev	Limits (%)
Laboratory Control Spike (LCS)												
Aluminum (Al)	110	110	110	102	113	110	110	113	113	**110**	**± 3.4**	70-130
Antimony (Sb)	102	98	100	100	103	104	94	97	98	**100**	**± 3.1**	80-120
Arsenic (As)	94	98	97	98	100	96	99	98	100	**98**	**± 1.9**	80-120
Barium (Ba)	96	101	99	90	107	103	104	101	101	**100**	**± 4.9**	80-120
Beryllium (Be)	91	91	89	96	98	89	89	97	97	**93**	**± 3.9**	80-120
Bismuth (Bi)	95	97	96	98	104	96	96	99	113	**99**	**± 5.8**	80-120
Boron (B)	98	96	92	102	103	94	89	98	98	**97**	**± 4.6**	80-120
Cadmium (Cd)	95	100	101	101	104	101	102	103	102	**101**	**± 2.5**	80-120
Calcium (Ca)	97	97	114	96	100	90	100	97	100	**99**	**± 6.4**	80-120
Chromium (Cr)	96	101	99	101	103	99	102	100	102	**100**	**± 2.1**	80-120
Cobalt (Co)	94	99	97	100	102	96	99	100	102	**99**	**± 2.8**	80-120
Copper (Cu)	95	99	99	101	103	98	101	102	102	**100**	**± 2.5**	80-120
Iron (Fe)	98	105	101	102	106	104	106	106	106	**104**	**± 2.8**	80-120
Lead (Pb)	95	98	100	97	100	97	100	99	104	**99**	**± 2.7**	80-120
Lithium (Li)	91	89	87	96	96	87	90	94	97	**92**	**± 4.0**	80-120
Magnesium (Mg)	99	100	101	101	100	98	100	100	100	**100**	**± 0.9**	80-120
Manganese (Mn)	94	97	97	94	102	96	99	117	100	**99**	**± 7.0**	80-120
Molybdenum (Mo)	99	97	96	98	99	98	96	96	96	**97**	**± 1.4**	80-120
Nickel (Ni)	96	101	100	101	104	98	102	101	103	**101**	**± 2.4**	80-120
Phosphorus (P)	89	92	96	95	97	90	95	97	99	**94**	**± 3.4**	80-120
Potassium (K)	79	82	85	78	85	80	81	83	83	**82**	**± 2.5**	80-120
Selenium (Se)	100	104	104	105	103	103	105	103	105	**104**	**± 1.6**	80-120
Silver (Ag)	100	96	99	99	101	101	92	96	96	**98**	**± 2.9**	80-120
Sodium (Na)	96	102	102	96	101	102	104	102	101	**101**	**± 2.7**	80-120
Strontium (Sr)	98	99	103	99	101	98	100	103	99	**100**	**± 2.0**	80-120
Thallium (Tl)	92	93	93	95	95	95	95	97	94	**94**	**± 1.3**	80-120
Tin (Sn)	98	97	98	99	102	101	94	96	96	**98**	**± 2.6**	80-120
Titanium (Ti)	96	92	91	95	96	97	93	93	92	**94**	**± 2.2**	80-120
Uranium (U)	99	103	101	101	105	98	103	98	113	**102**	**± 4.6**	80-120
Vanadium (V)	98	102	100	101	106	100	104	103	105	**102**	**± 2.7**	80-120
Zinc (Zn)	96	101	103	100	100	105	99	106	101	**101**	**± 3.0**	80-120

Table 3: Inorganic Element Results for Soil MS Samples, ALS

Analyte	MS Recovery (%)	MS Recovery (%)	MS Recovery (%)	MS Recovery (%)	MS Recovery (%)	MS Recovery (%)	MS Recovery (%)	Limits (%)
Matrix Spike (MS)								
Aluminum (Al)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Antimony (Sb)	85	92	88	85	110	96	88	70-130
Arsenic (As)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	70-130
Barium (Ba)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Beryllium (Be)	96	115	97	119	114	110	101	70-130
Bismuth (Bi)	109	109	108	104	105	103	100	70-130
Boron (B)	MS-B	174	MS-B		181	192	117	70-130
Cadmium (Cd)	97	109	98	102	116	104	98	70-130
Calcium (Ca)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Chromium (Cr)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Cobalt (Co)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Copper (Cu)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Iron (Fe)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Lead (Pb)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Lithium (Li)	95	104	102	100	105	98	97	70-130
Magnesium (Mg)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Manganese (Mn)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Molybdenum (Mo)	129.2	121	120.8	98	102	130	119	70-130
Nickel (Ni)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Phosphorus (P)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Potassium (K)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Selenium (Se)	128	106	97	112	121	113	102	70-130
Silver (Ag)	95	104	95	98	97	102	103	70-130
Sodium (Na)	139	130	148	124	138	131	119	70-130
Strontium (Sr)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Thallium (Tl)	94	102	99	98	100	102	93	70-130
Tin (Sn)	108	104	107	100	110	104	102	70-130
Titanium (Ti)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Uranium (U)	96	124	99	121	129	126	110	70-130
Vanadium (V)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	
Zinc (Zn)	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	MS-B	

Table 3: Inorganic Element Results for Soil MS Samples, ALS (cont'd)

Analyte	**MS Recovery (%)**	**MS Recovery (%)**	**MS Recovery (%)**	**MS Recovery (%)**		**Average Recovery (%)**	**Std Dev**	**Limits (%)**
Matrix Spike (MS)								
Aluminum (Al)	MS-B	MS-B	MS-B	MS-B				
Antimony (Sb)	96	105	110	85		**95**	**± 9.8**	70-130
Arsenic (As)	100	MS-B	MS-B	MS-B		**100**	**-**	70-130
Barium (Ba)	MS-B	MS-B	MS-B	MS-B				
Beryllium (Be)	108	97	114	119		**108**	**± 9.1**	70-130
Bismuth (Bi)	96	100	105	104		**104**	**± 4.1**	70-130
Boron (B)	MS-B	MS-B	181			**169**	**± 30**	70-130
Cadmium (Cd)	100	98	116	102		**104**	**± 6.9**	70-130
Calcium (Ca)	MS-B	MS-B	MS-B	MS-B				
Chromium (Cr)	MS-B	MS-B	MS-B	MS-B				
Cobalt (Co)	MS-B	MS-B	MS-B	MS-B				
Copper (Cu)	MS-B	MS-B	MS-B	MS-B				
Iron (Fe)	MS-B	MS-B	MS-B	MS-B				
Lead (Pb)	MS-B	MS-B	MS-B	MS-B				
Lithium (Li)	102	96	105	100		**100**	**± 3.5**	70-130
Magnesium (Mg)	MS-B	MS-B	MS-B	MS-B				
Manganese (Mn)	MS-B	MS-B	MS-B	MS-B				
Molybdenum (Mo)	114	97	102	98		**112**	**± 13**	70-130
Nickel (Ni)	MS-B	MS-B	MS-B	MS-B				
Phosphorus (P)	MS-B	MS-B	MS-B	MS-B				
Potassium (K)	MS-B	MS-B	MS-B	MS-B				
Selenium (Se)	105	127	121	112		**113**	**± 10**	70-130
Silver (Ag)	100	104	97	98		**99**	**± 3.4**	70-130
Sodium (Na)	MS-B	103	138	124		**129**	**± 13**	70-130
Strontium (Sr)	MS-B	MS-B	MS-B	MS-B				
Thallium (Tl)	92	95	100	98		**98**	**± 3.6**	70-130
Tin (Sn)	108	107	110	100		**105**	**± 3.8**	70-130
Titanium (Ti)	MS-B	MS-B	MS-B	MS-B				
Uranium (U)	118	93	129	121		**115**	**± 14**	70-130
Vanadium (V)	MS-B	MS-B	MS-B	MS-B				
Zinc (Zn)	MS-B	MS-B	MS-B	MS-B				

MS-B = Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Table 4: Inorganic Element Results for 2014 Soil Sample Method Blanks (MB)

Analyte	MB	MB	MB	MB	MB	MB	MB	MB	MB	MB
	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]	[ppm]
Method Blank (MB)										
Aluminum (Al)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Antimony (Sb)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Arsenic (As)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Barium (Ba)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Beryllium (Be)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Bismuth (Bi)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Boron (B)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmium (Cd)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Calcium (Ca)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Chromium (Cr)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Cobalt (Co)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Copper (Cu)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Iron (Fe)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Lead (Pb)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lithium (Li)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Magnesium (Mg)	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Manganese (Mn)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Molybdenum (Mo)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Nickel (Ni)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Phosphorus (P)	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Potassium (K)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Selenium (Se)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Silver (Ag)	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sodium (Na)	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Strontium (Sr)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Thallium (Tl)	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Tin (Sn)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Titanium (Ti)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Uranium (U)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium (V)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Zinc (Zn)	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0

Table 5: Inorganic Element Results for 2014 Soil Field Duplicates, ALS

Analyte	14-37240	14-37241	RPD	14-37250	14-37251	RPD	14-37260	14-37261	RPD	14-37270	14-37271	RPD
	[ppm]	[ppm]	(%)	[ppm]	[ppm]	(%)	[ppm]	[ppm]	(%)	[ppm]	[ppm]	(%)
Field Duplicates												
Aluminum (Al)	11300	10200	10	11600	12200	5.0	9660	8800	9.3	12500	13300	6.2
Antimony (Sb)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Arsenic (As)	8.3	8.2	1.1	10	9.2	7.9	6.1	6.0	2.5	8.7	8.7	0.5
Barium (Ba)	302	294	2.7	281	278	1.1	217	131	49	327	344	5.1
Beryllium (Be)	0.6	0.6	3.2	0.6	0.7	4.6	<0.50	<0.50		0.71	0.71	0
Bismuth (Bi)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Boron (B)	12.6	13.3	5.4	9.9	10.4	4.9	<5.0	<5.0		12.4	13.3	7.0
Cadmium (Cd)	0.72	0.76	5.4	<0.50	<0.50		<0.50	<0.50		<0.50	0.52	0
Calcium (Ca)	10300	10500	1.9	7120	7360	3.5	2080	2080	0	7720	8480	9.3
Chromium (Cr)	21	20	2.5	21	22	3.8	20	19.4	4	23	24	2.1
Cobalt (Co)	8.9	8.7	2.3	7.9	8.1	2.5	6.5	5.7	13	9.4	9.5	1.1
Copper (Cu)	23	22	5.4	27	26	5.2	6.6	7.2	8.7	22	23	6.3
Iron (Fe)	21200	20900	1.4	22000	21600	1.8	19100	19000	0.5	22700	23500	3.5
Lead (Pb)	10.4	10.5	0.96	10.9	11.8	7.9	7.5	6.8	9.8	12.1	11.4	6.0
Lithium (Li)	14.7	13.9	5.6	13	14	6.6	13.8	13.1	5.2	16.4	16.8	2.4
Magnesium (Mg)	5280	4920	6.9	3420	3500	2.3	2900	2960	2.1	4300	4320	0.5
Manganese (Mn)	318	316	0.6	331	334	0.9	309	198	44	329	341	3.6
Molybdenum (Mo)	1.2	1.1	8.7	1.9	1.6	17	<1.0	<1.0		1.3	1.3	0
Nickel (Ni)	27	26	3.8	26	24	8.8	14.1	14.8	4.8	27	29	5.4
Phosphorus (P)	1000	1060	4.9	820	760	6.3	435	469	7.5	580	580	1.2
Potassium (K)	1860	1840	1.1	1860	1920	3.2	1240	840	38	2020	1980	2.5
Selenium (Se)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Silver (Ag)	<0.20	<0.20		<0.20	<0.20		<0.20	<0.20		0.21	0.2	4.9
Sodium (Na)	100	<100		<100	<100		<100	<100		<100	<100	
Strontium (Sr)	44	46	3.8	46	47	2.2	16.8	15.9	5.5	50	49	0.8
Thallium (Tl)	<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50	<0.50	
Tin (Sn)	<5.0	<5.0		<5.0	<5.0		<5.0	<5.0		<5.0	<5.0	
Titanium (Ti)	60	52	14	32	30	7.8	252	292	15	38	37	2.7
Uranium (U)	1.1	1.2	8.7	1.1	1.1	0	<1.0	<1.0		1.3	1.3	0
Vanadium (V)	38	38	0.5	39	42	5.7	39	34	15	45	46	2.2
Zinc (Zn)	93	98	6.2	63	68	7.7	54	49	8.7	81	79	3.6

Table 5: Inorganic Element Results for 2014 Soil Field Duplicates, ALS (cont'd)

Analyte	**14-37280**	**14-37281**	**RPD**	**14-37330**	**14-37331**	**RPD**	**14-37320**	**14-37321**	**RPD**	**14-37300**	**14-37301**	**RPD**
	[ppm]	**[ppm]**	**(%)**	**[ppm]**	**[ppm]**	**(%)**	**[ppm]**	**[ppm]**	**(%)**	**[ppm]**	**[ppm]**	**(%)**
Field Duplicates												
Aluminum (Al)	6960	6800	2.5									
Antimony (Sb)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Arsenic (As)	9.5	9.5	0.6	9.0	8.6	4.8	7.3	7.5	2.7	6.8	6.2	8.2
Barium (Ba)	123	121	1.6	179	174	2.8	192	187	2.6	180	182	1.1
Beryllium (Be)	<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50	<0.50	
Bismuth (Bi)	<1.0	<1.0										
Boron (B)	5	5.5	9.5	7.0	6.8	2.9	<5.0	<5.0		<5.0	<5.0	
Cadmium (Cd)	<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50	<0.50	
Calcium (Ca)	2880	3180	9.9									
Chromium (Cr)	18.4	18.4	0	21	21	0.9	23	23	2.2	19.3	18.2	5.9
Cobalt (Co)	6.9	7.0	1.4	7.4	7.2	2.7	7.8	7.8	0	7.4	6.9	7.0
Copper (Cu)	16.7	17	2.4	18.3	18	2.2	10.3	10.4	1.0	10	9.4	6.2
Iron (Fe)	23500	23200	1.3									
Lead (Pb)	7.1	6.8	4.3	7.8	7.7	1.3	7.5	7.5	0	7.2	6.8	5.7
Lithium (Li)	7.5	7.5	0									
Magnesium (Mg)	2720	2780	2.2									
Manganese (Mn)	308	302	2									
Molybdenum (Mo)	1.2	1.2	0	1.1	1.1	0	<1.0	<1.0		<1.0	<1.0	
Nickel (Ni)	22	22	0	26	25	2.7	18.1	18.1	0	15.7	15	4.6
Phosphorus (P)	620	640	1.9									
Potassium (K)	780	740	5.3	1400	1340	5.1	1280	1260	2.4	1340	1280	5.4
Selenium (Se)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Silver (Ag)	<0.20	<0.20		<0.20	<0.20		<0.20	<0.20		<0.20	<0.20	
Sodium (Na)	<100	<100		<100	<100		<100	<100		<100	<100	
Strontium (Sr)	21	20	1.9	22	23	0.9	17.7	17.4	1.7	18.3	17.2	6.2
Thallium (Tl)	<0.50	<0.50		<0.50	<0.50		<0.50	<0.50		<0.50	<0.50	
Tin (Sn)	<5.0	<5.0		<5.0	<5.0		<5.0	<5.0		<5.0	<5.0	
Titanium (Ti)	211	203	3.9	184	190	3.2	260	253	2.7	222	220	0.9
Uranium (U)	<1.0	<1.0		<1.0	<1.0		<1.0	<1.0		<1.0	<1.0	
Vanadium (V)	41	39	4.0	45	44	2.5	43	43	0.9	39	38	3.6
Zinc (Zn)	55	57	3.0	57	55	2.0	56	58	3.9	50	48	3.9

Table 5: Inorganic Element Results for 2014 Soil Field Duplicates, ALS (cont'd)

Analyte	**14-37310**	**14-37311**	**RPD**		**14-37290**	**14-37291**	**RPD**		**14-37340**	**14-37341**	**RPD**		**14-37350**	**14-37351**	**RPD**
	[ppm]	**[ppm]**	**(%)**		**[ppm]**	**[ppm]**	**(%)**		**[ppm]**	**[ppm]**	**(%)**		**[ppm]**	**[ppm]**	**(%)**
Field Duplicates															
Aluminum (Al)									19700	19300	2.1		7660	8680	13
Antimony (Sb)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Arsenic (As)	9.8	10.1	3.1		2.6	2.5	4.0		2	1.9	6.1		6.7	6.4	4.7
Barium (Ba)	202	243	18		171	181	5.7		413	425	2.9		108	115	6.3
Beryllium (Be)	<0.50	0.5			<0.50	<0.50			0.9	0.9	5.6		<0.50	<0.50	
Bismuth (Bi)									<1.0	<1.0			<1.0	<1.0	
Boron (B)	8.3	6.4	26		<5.0	<5.0			12.2	13.5	10		<5.0	<5.0	
Cadmium (Cd)	<0.50	<0.50			<0.50	<0.50			0.8	0.86	7.2		<0.50	<0.50	
Calcium (Ca)									6300	6880	8.8		2520	2160	16
Chromium (Cr)	21	23	8.8		17	16.6	2.4		29	29	1.7		18.6	18.8	1.1
Cobalt (Co)	7.3	8.3	13		6.3	6.4	1.6		4.6	4.6	0		6.4	6.2	3.2
Copper (Cu)	22	26	17		6.2	6.3	1.6		27	28	3.3		8.5	8.1	4.8
Iron (Fe)									16400	15900	3.1		19900	19700	1.0
Lead (Pb)	9.1	9.4	3.2		5.4	5.4	0		8.7	8	8.4		5.7	5.6	1.8
Lithium (Li)									16.2	15.1	7		13	13	0
Magnesium (Mg)									3800	3820	0.8		3060	2940	4.3
Manganese (Mn)									119	114	4.3		181	185	2.2
Molybdenum (Mo)	1.3	1.3	0		<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Nickel (Ni)	29	37	25		11.6	11.5	0.87		25	25	2.4		14.9	14.7	1.4
Phosphorus (P)									1780	1780	0.6		560	600	6.5
Potassium (K)	1120	1140	0.9		880	880	0.0		4020	4380	8.6		900	980	8.6
Selenium (Se)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Silver (Ag)	0.24	0.29	19		<0.20	<0.20			0.34	0.39	14		<0.20	<0.20	
Sodium (Na)	120	<100			<100	<100			<100	<100			<100	<100	
Strontium (Sr)	46	34	30		11.7	12	4.2		53	56	3.9		15.4	16	1.3
Thallium (Tl)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50			<0.50	<0.50	
Tin (Sn)	<5.0	<5.0			<5.0	<5.0			<5.0	<5.0			<5.0	<5.0	
Titanium (Ti)	174	87	67		176	180.0	2.2		32	38	17		302	311	2.9
Uranium (U)	<1.0	<1.0			<1.0	<1.0			1.2	1.2	0		<1.0	<1.0	
Vanadium (V)	43	45	4.4		31	30	3.3		44	44	0.9		35	36	2.3
Zinc (Zn)	75	77	3.4		48	47	1.5		332	333	0.3		47	48	3.0

Table 5: Inorganic Element Results for 2014 Soil Field Duplicates, ALS (cont'd)

Analyte	14-37360	14-37361	RPD		14-37370	14-37371	RPD		14-37380	14-37381	RPD		Average RPD	Std Dev
	[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)		(%)	
Field Duplicates														
Aluminum (Al)	10500	11100	5.6		16500	15800	4.3		18100	17900	1.1		**5.9**	**± 3.8**
Antimony (Sb)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0				
Arsenic (As)	6.3	6.9	9.4		5.2	4.5	15		10.2	6.7	41		**7.4**	**± 10**
Barium (Ba)	212	209	1.4		346	349	0.9		406	453	11		**7.5**	**± 13**
Beryllium (Be)	<0.50	<0.50			0.9	0.8	7.0		1.0	1.0	1.0		**3.6**	**± 2.7**
Bismuth (Bi)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0				
Boron (B)	5.1	<5.0	0		10.2	8.7	16		11.7	12.2	4.2		**9.5**	**± 7.3**
Cadmium (Cd)	<0.50	<0.50			0.62	0.65	4.7		<0.50	1	0		**5.8**	**± 1.3**
Calcium (Ca)	2700	2520	6.9		4180	4200	0.5		8780	7480	16		**7.2**	**± 5.8**
Chromium (Cr)	23	24	2.2		27	26	3.7		30	29	3.0		**3.0**	**± 2.2**
Cobalt (Co)	7.9	7.9	0		6.4	5.7	12		9.8	10.1	3		**4.2**	**± 4.7**
Copper (Cu)	8.6	9.3	7.8		24	23	3.0		30	23	26		**6.7**	**± 6.6**
Iron (Fe)	22300	22800	2.2		21800	19700	10		27000	25800	4.5		**3.0**	**± 2.8**
Lead (Pb)	7.8	7.8	0		11.5	11.6	0.9		13.2	12.1	8.7		**3.9**	**± 3.6**
Lithium (Li)	13.1	13.0	0.8		14.9	14.3	4.1		18.6	14.7	23		**5.5**	**± 6.8**
Magnesium (Mg)	3280	3220	2.2		3800	3540	7.1		4800	4440	8.0		**3.6**	**± 2.8**
Manganese (Mn)	298	282	5.5		169	141	18		328	331	0.9		**8.2**	**± 14**
Molybdenum (Mo)	<1.0	<1.0			<1.0	<1.0			1.1	<1.0			**4.3**	**± 7.2**
Nickel (Ni)	18.1	18.4	1.6		26	24.0	5.6		38	33.0	15		**5.5**	**± 6.7**
Phosphorus (P)	600	620	3.1		1260	1100	14		820	1100	28		**7.3**	**± 8.2**
Potassium (K)	1400	1420	1.4		3440	3240	6.0		2860	2980	4.1		**6.2**	**± 9.3**
Selenium (Se)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0				
Silver (Ag)	<0.20	<0.20			0.3	0.27	11		0.23	0.35	41		**18**	**± 14**
Sodium (Na)	<100	<100			<100	<100			<100	<100				
Strontium (Sr)	18.6	18	5.5		41	40	2.5		62	59	5.0		**5.0**	**± 7.1**
Thallium (Tl)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50				
Tin (Sn)	<5.0	<5.0			<5.0	<5.0			<5.0	<5.0				
Titanium (Ti)	232	167	33		29	19.4	39		22	25	14		**15**	**± 18**
Uranium (U)	<1.0	<1.0			1.4	1.4	0		1.7	1.5	13		**3.5**	**± 5.6**
Vanadium (V)	42	42	0		48	44	10		56	52	6.8		**4.1**	**± 4.0**
Zinc (Zn)	74	76	1.7		154	143	7.4		115	163	35		**6.1**	**± 8.3**

Table 6: Inorganic Element Results for 2014 Soil Analytical Duplicates, ALS

Analyte	Replicate 1	Replicate 2	RPD		Replicate 1	Replicate 2	RPD		Replicate 1	Replicate 2	RPD		Replicate 1	Replicate 2	RPD
	[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)		[ppm]	[ppm]	(%)
Analytical Duplicates - Anonymous															
Aluminum (Al)	6900	7120	3.1		10800	11100	2.7		7760	7700	0.9		10100	10600	4.8
Antimony (Sb)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Arsenic (As)	9.9	9.3	6.6		7.3	7.5	3.0		3.9	4.0	0.8		8.3	8.2	0.9
Barium (Ba)	118	119	0.8		192	196	2.1		101	100	1.4		176	180	2.2
Beryllium (Be)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50			<0.50	<0.50	
Bismuth (Bi)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Boron (B)	<5.0	<5.0			<5.0	<5.0			<5.0	<5.0			<5.0	5.1	
Cadmium (Cd)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50			<0.50	<0.50	
Calcium (Ca)	3040	3020	0.3		2260	2420	7.3		2120	2140	1.4		2340	2280	3.0
Chromium (Cr)	18.5	18.5	0		23	24	4.3		16.9	16.8	0.6		21	22	3.7
Cobalt (Co)	6.9	6.9	0		7.6	8.0	5.1		4.8	5.0	4.1		7.6	7.6	0
Copper (Cu)	16.8	17	0.6		10.2	11	4.8		4.9	5	2.0		12.1	12	0.8
Iron (Fe)	23600	23300	1.3		21900	22500	2.7		16400	16500	0.6		21600	21500	0.5
Lead (Pb)	7.2	7	2.8		7.3	7.8	6.6		5.2	5.2	0		8.6	8.6	0.0
Lithium (Li)	7.3	7.6	4.0		12.1	13	4.0		11.6	11.4	1.7		12.9	12.9	0
Magnesium (Mg)	2740	2820	3.2		3060	3200	4.2		2820	2740	2.9		3200	3300	3.4
Manganese (Mn)	288	293	1.7		259	267	3.0		184	190	3.2		269	268	0.4
Molybdenum (Mo)	1.3	1.2	8.0		<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Nickel (Ni)	22	21	1.4		18	19	3.3		13.3	13.8	3.7		18.4	17.7	3.9
Phosphorus (P)	620	580	5.0		600	620	3.7		700	720	2.8		520	500	3.7
Potassium (K)	720	760	5.5		1280	1360	5.3		720	660	10		1220	1280	4.0
Selenium (Se)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Silver (Ag)	0.37	<0.20			<0.20	<0.20			<0.20	<0.20			<0.20	<0.20	
Sodium (Na)	<100	<100			<100	<100			<100	<100			<100	<100	
Strontium (Sr)	21	21	1.0		17.7	18	2.2		15	13.3	12		19.3	19.3	0
Thallium (Tl)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50			<0.50	<0.50	
Tin (Sn)	<5.0	<5.0			<5.0	<5.0			<5.0	<5.0			<5.0	<5.0	
Titanium (Ti)	196	220	12		277	269	2.9		304	229	28		98	104	6.1
Uranium (U)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Vanadium (V)	41	39	4.0		42	44	4.4		30	28	5.6		41	41	1.2
Zinc (Zn)	57	54	6.0		56	58	3.3		36	36	1.4		60	57	3.8

Table 6: Inorganic Element Results for 2014 Soil Analytical Duplicates, ALS (cont'd)

Analyte	**Replicate 1 [ppm]**	**Replicate 2 [ppm]**	**RPD (%)**		**Replicate 1 [ppm]**	**Replicate 2 [ppm]**	**RPD (%)**		**Replicate 1 [ppm]**	**Replicate 2 [ppm]**	**RPD (%)**		**Replicate 1 [ppm]**	**Replicate 2 [ppm]**	**RPD (%)**
Analytical Duplicates - Anonymous															
Aluminum (Al)					13800	13900	0.7		21400	20800	2.8		10200	11600	13
Antimony (Sb)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Arsenic (As)	1.6	1.6	0		9.5	9.5	0.4		7	7.1	0.9		6.9	7.1	2.8
Barium (Ba)	35	35	0		333	336	0.9		453	467	3.0		207	208	0.5
Beryllium (Be)	<0.50	<0.50			0.7	0.8	8.2		1.1	1.1	2.7		<0.50	<0.50	
Bismuth (Bi)					<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Boron (B)	6.3	6.9	9.1		12.8	13.7	6.8		12	13.1	8.8		<5.0	5.2	
Cadmium (Cd)	<0.50	<0.50			0.57	0.57	0		1.4	1.4	0.7		<0.50	<0.50	
Calcium (Ca)					8340	8080	3.2		6640	6760	1.9		2500	2640	5.1
Chromium (Cr)	10.2	10.8	5.7		25	25	2.8		32	32	0.6		23	24	5.1
Cobalt (Co)	3.3	3.3	0		9.5	9.7	2.1		10.5	10.6	1.0		8	8.2	2.5
Copper (Cu)	7.8	8	1.3		24	24	0.4		23	24.0	1.7		9.3	9.4	1.1
Iron (Fe)					24600	24700	0.4		27700	28200	1.8		22800	23400	2.6
Lead (Pb)	3.6	3.7	2.7		12.2	12	1.7		13.4	13.7	2.2		7.8	8	2.5
Lithium (Li)					17.9	18	1.1		17	17.1	0.6		13	13.6	4.5
Magnesium (Mg)					4520	4480	0.9		4400	4360	1.1		3220	3300	2.5
Manganese (Mn)					338	337	0.3		412	411	0.2		282	286	1.4
Molybdenum (Mo)	<1.0	<1.0			1.3	1.3	0		<1.0	<1.0			<1.0	<1.0	
Nickel (Ni)	6.8	7	1.5		30	30	0.3		35	35	1.4		18.4	18.9	2.7
Phosphorus (P)					740	740	0.8		1160	1180	0.9		640	640	1.6
Potassium (K)					2080	2140	3.3		3660	3720	1.6		1360	1480	8.5
Selenium (Se)	<1.0	<1.0			<1.0	<1.0			<1.0	<1.0			<1.0	<1.0	
Silver (Ag)	<0.20	<0.20			<0.20	<0.20			0.27	0.26	3.8		<0.20	<0.20	
Sodium (Na)					110	100.0	9.5		<100	<100			<100	<100	
Strontium (Sr)					48	49	2.9		56	56	0.5		17.6	18.7	6.1
Thallium (Tl)	<0.50	<0.50			<0.50	<0.50			<0.50	<0.50			<0.50	<0.50	
Tin (Sn)					<5.0	<5.0			<5.0	<5.0			<5.0	<5.0	
Titanium (Ti)					41	41	0		35	32	8.4		163	220	30
Uranium (U)	<1.0	<1.0			1.3	1.2	8.0		1.5	1.5	0		<1.0	<1.0	
Vanadium (V)	19.1	19.4	1.6		47	48	2.5		58	59	1.2		41	44	7.6
Zinc (Zn)	20	20	0.5		95	97	1.9		211	216	2.3		76	78	2.6

Table 6: Inorganic Element Results for 2014 Soil Analytical Duplicates, ALS (cont'd)

Analyte	**Replicate 1**	**Replicate 2**	**RPD**		**Average RPD**	**Std Dev**
	[ppm]	**[ppm]**	**(%)**		**(%)**	
Analytical Duplicates - Anonymous						
Aluminum (Al)	18300	17700	3.3		**3.9**	**± 3.8**
Antimony (Sb)	<1.0	<1.0				
Arsenic (As)	6.8	6.6	3.5		**2.1**	**± 2.1**
Barium (Ba)	448	457	2.0		**1.4**	**± 1.0**
Beryllium (Be)	1.0	0.9	5.2		**5.4**	**± 2.8**
Bismuth (Bi)	<1.0	<1.0				
Boron (B)	12	10.3	15		**10**	**± 3.7**
Cadmium (Cd)	1.0	0.99	2.0		**0.9**	**± 1.0**
Calcium (Ca)	7440	7620	2.4		**3.1**	**± 2.2**
Chromium (Cr)	30	29	2.4		**2.8**	**± 2.1**
Cobalt (Co)	10.1	10.1	0		**1.6**	**± 1.9**
Copper (Cu)	24	24	1.3		**1.6**	**± 1.3**
Iron (Fe)	26300	26700	1.5		**1.4**	**± 0.91**
Lead (Pb)	12.4	12.4	0		**2.1**	**± 2.1**
Lithium (Li)	14.4	14.3	0.7		**2.1**	**± 1.8**
Magnesium (Mg)	4260	4400	3.5		**2.7**	**± 1.2**
Manganese (Mn)	331	336	1.5		**1.5**	**± 1.2**
Molybdenum (Mo)	<1.0	<1.0			**4.0**	**± 5.7**
Nickel (Ni)	33	33	1.8		**2.2**	**± 1.2**
Phosphorus (P)	1080	1080.0	0		**2.3**	**± 1.8**
Potassium (K)	3040	2940	3.3		**5.2**	**± 2.9**
Selenium (Se)	1.0	<1.0				
Silver (Ag)	0.35	0.35	0		**1.9**	**± 2.7**
Sodium (Na)	<100	<100			**9.5**	**-**
Strontium (Sr)	56	55	0.9		**3.2**	**± 4.0**
Thallium (Tl)	<0.50	<0.50				
Tin (Sn)	<5.0	<5.0				
Titanium (Ti)	31	21	38		**16**	**± 14**
Uranium (U)	1.5	1.5	0		**2.7**	**± 4.6**
Vanadium (V)	54	51	4.0		**3.6**	**± 2.2**
Zinc (Zn)	167	167	0		**2.4**	**± 1.8**

Table 7: Polycyclic Aromatic Hydrocarbon Results for Soil Control Spikes

Sample	Control Sample	Control Target	Recovery		Blank
	[ppm]	[ppm]	(%)		[ppm]
	Control Spike				*Analytical Blank*
Naphthalene	0.17	0.22	77		< 0.03
Acenaphthylene	0.65	0.5	130		< 0.005
Acenaphthene	0.31	0.27	115		< 0.005
Fluorene	0.32	0.36	89		< 0.02
Phenanthrene	0.17	0.23	74		< 0.04
Anthracene	0.25	0.22	114		< 0.04
Fluoranthene	0.15	0.18	83		< 0.05
Pyrene	0.16	0.2	80		< 0.05
Benzo(a)anthracene	0.22	0.37	59		< 0.03
Chrysene	0.2	0.21	95		< 0.05
Benzo(b)fluoranthene	0.16	0.19	84		< 0.05
Benzo(k)fluoranthene	0.27	0.36	75		< 0.05
Benzo(a)pyrene	0.18	0.22	82		< 0.03
Indeno(1,2,3-cd)pyrene	0.12	0.11	109		< 0.1
Dibenz(a,h)anthracene	0.31	0.27	115		< 0.005
Benzo(ghi)perylene	0.19	0.18	106		< 0.03
Total	3.8	4.1	93		< 0.25

Table 8: Polycyclic Aromatic Hydrocarbon Results for Soil Duplicates

Sample	14-37260	14-37261		14-37375	Duplicate
	[ppm]	[ppm]		[ppm]	[ppm]
	Field Duplicate			*Analytical Duplicate*	
Naphthalene	< 0.03	< 0.03		< 0.03	< 0.03
Acenaphthylene	< 0.005	< 0.005		< 0.005	< 0.005
Acenaphthene	< 0.005	< 0.005		< 0.005	< 0.005
Fluorene	< 0.02	< 0.02		< 0.02	< 0.02
Phenanthrene	< 0.04	< 0.04		< 0.04	< 0.04
Anthracene	< 0.04	< 0.04		< 0.04	< 0.04
Fluoranthene	< 0.05	< 0.05		< 0.05	< 0.05
Pyrene	< 0.05	< 0.05		< 0.05	< 0.05
Benzo(a)anthracene	< 0.03	< 0.03		< 0.03	< 0.03
Chrysene	< 0.05	< 0.05		< 0.05	< 0.05
Benzo(b)fluoranthene	< 0.05	< 0.05		< 0.05	< 0.05
Benzo(k)fluoranthene	< 0.05	< 0.05		< 0.05	< 0.05
Benzo(a)pyrene	< 0.03	< 0.03		< 0.03	< 0.03
Indeno(1,2,3-cd)pyrene	< 0.1	< 0.1		< 0.1	< 0.1
Dibenz(a,h)anthracene	< 0.005	< 0.005		< 0.005	< 0.005
Benzo(ghi)perylene	< 0.03	< 0.03		< 0.03	< 0.03
Total	< 0.25	< 0.25		< 0.25	< 0.25

All results corrected for the recoveries of the deuterated surrogates naphthalene, phenanthrene, anthracene and benzo(a)anthracene